IMPACT EVALUATION OF THE KENYA RESILIENT ARID LANDS PARTNERSHIP FOR INTEGRATED DEVELOPMENT (KENYA RAPID)

Summary of Findings and Recommendations

SEPTEMBER 2021

This publication was produced for review by the United States Agency for International Development. It was prepared by Tetra Tech.

ACKNOWLEDGEMENTS

The evaluation team thanks the families, water managers, and local leaders in the counties who shared their time to participate in this study. The National Drought Management Authority and the Kenyan Ministry of Water and Sanitation both deserve praise for their assistance, cooperation, and patience with the evaluation process and team members. Special thanks go to the data collection teams from Ipsos Public Affairs Kenya for conducting the water borehole surveys and downloading data from each borehole. The team is grateful to the Kenya Resilient Arid Lands Partnership for Integrated Development Activity staff for their continued collaboration, cooperation, and communication. The team could not have implemented the evaluation without the ongoing and patient cooperation of SweetSense staff, particularly Evan Thomas and Styvers Kathuni, as well as Pranav Chintalapati from the University of Colorado at Boulder. The team also acknowledges Mary Gichuhi for her quality oversight during data collection, translation support, and general guidance as the local coordinator for this evaluation. Finally, the evaluation team appreciates the technical review and support for this report from Tetra Tech's Siobhan Girling and Morris Israel. The team also thanks Elizabeth Jordan (USAID Bureau for Resilience and Food Security/Center for Water Security, Sanitation and Hygiene), Vicky Liyai (USAID/Kenya and East Africa [KEA]), Martin Mulongo (USAID/KEA), Walter Ong'eng'a (USAID/KEA), Amanda Robertson (USAID/KEA), Albert Waudo (USAID/KEA), and Nicholas Owuor (USAID/KEA) for their continued support of this study.

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Cover Photo: *Camels drink from strategic borehole in Kenya*, Jacob Patterson-Stein, MSI.

Prepared for the United States Agency for International Development by the Water, Sanitation, and Hygiene Partnerships and Learning for Sustainability (WASHPaLS) project under Task Order number AID-OAA-TO-16-00016 of the Water and Development Indefinite Delivery Indefinite Quantity Contract (WADI IDIQ), contract number AID-OAA-I-14-00068.

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INTRODUCTION

The Kenya Resilient Arid Lands Partnership for Integrated Development (RAPID) was a US$35.5 million public-private partnership/Global Development Alliance activity implemented from 2015 to 2020 and funded jointly by USAID, Swiss Agency for Development and Cooperation (SDC), private sector partners, and Millennium Water Alliance members. One piece of Kenya RAPID's broader suite of activities involved the installation of sensors on water borehole pumps to transmit information to data dashboards in real time to improve water management. This information and communication technology (ICT) intervention was paired with budget facilitation for borehole pump repairs and clarification of roles and responsibilities to create dedicated pump maintenance teams. Of the 400 sensors installed on water borehole pumps, a subset of 69 were installed on "strategic" water boreholes, or boreholes that local authorities identified as important due to the risk of drought in the borehole area.

The USAID/Kenya and East Africa mission in conjunction with SDC commissioned a quasi-experimental impact evaluation to understand the effect of Kenya RAPID's ICT intervention on strategic borehole pump use and functionality during drought periods. The evaluation team used a propensity score matching design to match strategic boreholes in Kenya RAPID's five implementation counties with a set of 132 strategic boreholes across eight comparison counties. The evaluation team installed sensors on the comparison county borehole pumps to compare how long borehole pumps ran in a given day on average. The evaluation team supplemented this quantitative analysis with qualitative interviews and focus group discussions (FGDs) to understand how water managers perceived the impact of the sensor-based system and to determine whether or not user perceptions of borehole pump functionality and access changed.

SUMMARY OF FINDINGS

Strategic boreholes that received the Kenya RAPID ICT intervention performed similarly to strategic boreholes in comparison counties. Across multiple analyses, results suggest that, on average, Kenya RAPID did not have a statistically significant or meaningful impact on borehole pump functionality during the drier months of the intervention, from 2018 to 2020, relative to comparison county strategic boreholes. At most, analyses suggest that the sensor-based intervention resulted in less than an hour of additional borehole pump on-time per day in Kenya RAPID counties as compared to comparison counties. It is important to note that Kenya experienced historical rainfall during the intervention period, which qualitative interviews and government reports suggest affected water borehole use with people using non-borehole water sources during higher rainfall periods, as well as the operational status of strategic boreholes.

Water managers reported similar timelines for borehole repairs in Kenya RAPID and comparison countries, but officials in Kenya RAPID counties had a positive perception of the ICT intervention. County- and sub-county-level water managers in Kenya RAPID counties viewed the sensor-based system favorably and said it provided useful data to support water management activities. However, these officials also pointed out that lack of access to resources for repairs continues to limit borehole functionality in Kenya RAPID counties. Officials in Garissa, a Kenya RAPID county, reported that they did not yet have full access to the data dashboard, and others reported that a lack of office internet and issues with network connectivity for using mobile devices limited access to the data dashboard. A lack of dedicated resources for borehole repairs remains a key barrier to improved functionality in both Kenya RAPID and comparison counties.

The sensor-based intervention did not improve users' perceptions of borehole functionality and water access in Kenya RAPID counties relative to comparison counties. All strategic borehole users continued to identify a range of water access and supply issues not directly addressed by the intervention, including breakages in distribution pipes and taps bringing water from boreholes to people's homes and villages. Crowding and congestion at boreholes lead to long waiting times. Access issues vary seasonally and have a particularly large effect on vulnerable groups, including women and the elderly.

KEY USAID PROGRAMMING RECOMMENDATIONS

The Kenya RAPID borehole sensor intervention was unable to compensate for inadequate investment in the areas that pose the biggest constraints facing water managers for achieving major improvements in functionality and improving water users' experience. The evaluation team offers the following recommendations to USAID:

1. Continue to focus on water system governance, clarifying roles and responsibilities for water management and establishing dedicated and sustainable funding sources for water system maintenance and repairs.
2. Address community concerns carefully in planning for delivery of water services. Evaluation results identified a number of problems cited by users that were not directly addressed by the sensor-based intervention.
3. Consider rural water ICT intervention costs and context. Use of ICT to collect and share information in some contexts may be worthwhile. USAID should consider implementation costs and systemic challenges in thinking about the theory of change for ICT interventions given large structural constraints, such as limited budgets and climate change.
4. For future evaluation efforts, make sure that implementation monitoring is included as a key, funded component. Sparse implementation data on specific activities outside of the ICT intervention and detailed budget information limited the evaluation team's ability to track progress over time. These data are key to understanding how and why impacts (or lack of impacts) are observed.

KENYA RAPID BACKGROUND AND IE DESIGN

Over the past decade, Kenya has gone through a period of major institutional reform, including the devolution of authority and resources from the national government to newly elected county governments. County governments now have the political mandate and greater autonomy over use of funds to provide water to their communities; however, they are relatively new institutions with limited operational capacity. As part of these developments, the Government of Kenya launched its "Common Programme Framework to End Drought Emergencies," which arose from a series of meetings with development partners between 2013 and 2014.[1] The institutional framework for water management in Kenya consists of multiple stakeholders, with counties operating at the regional and local levels. The Common Programme includes the Ending Drought Emergencies Initiative to better align stakeholders involved in drought mitigation and water management across all levels of government.

[1] See: http://www.ndma.go.ke/index.php/resource-center/ede-reports/send/43-ending-drought-emergencies/4251-common-programme-framework

Kenya RAPID's theory of change for this activity envisioned that improved functionality of strategic boreholes would result from 1) installation of sensors, with data sharing through mobile applications and online dashboards as well as accompanying training on sensor data use; 2) establishment of county borehole operations and maintenance teams; and 3) a dedicated budget for strategic borehole repairs. A key assumption of the sensor intervention's theory of change was that the main constraints to improved water borehole pump management and access are informational. By making information easily accessible while also clearly defining management roles and responsibilities and supporting budget allocation for repairs, the sensor intervention sought to improve water management and access.

The team designed the impact evaluation to answer three specific evaluation questions (EQs):

- ***EQ1:*** *Does the intervention using real-time remote sensing data of water points for strategic borehole management in Kenya RAPID counties lead to increased on-time of strategic boreholes during the drought season?*[2]
- ***EQ2:*** *How do water managers perceive the impact of sensor-based systems on their ability to address borehole functionality, and how does this compare to perceptions of borehole functionality in non-Kenya RAPID counties?*
- ***EQ3:*** *Do Kenya RAPID's sensor-based systems affect user perceptions of borehole functionality and access?*

METHODS

To answer EQ1, the team employed a quasi-experimental matching study design that compared Kenya RAPID and non-Kenya RAPID county strategic borehole pump on-times. The selection of Kenya RAPID counties was not random, but instead based on their aridity, and the selection of boreholes for the sensor intervention was based on their "strategic" designation. USAID worked with the evaluation team to identify eight non-Kenya RAPID counties that were similarly arid or semi-arid.

To understand how borehole pumps operate in the absence of Kenya RAPID's sensor-based system, the evaluators used data from sensors on 69 "treatment" boreholes in Kenya RAPID counties (Turkana, Marsabit, Wajir, Isiolo, and Garissa) and installed sensors on 132 "comparison" strategic boreholes in eight counties not covered by Kenya RAPID, as shown in Figure 1 (Baringo, Kitui, Laikipia, Mandera, Meru, Samburu, Tana River, and West Pokot). The non-RAPID boreholes were chosen to create a comparison sample similar to the treatment boreholes in key observable characteristics, such as power type, tariff scheme, and livestock use.[3] To estimate the sensor-based intervention's effects, the team ran statistical models comparing the on-time of Kenya RAPID boreholes to the comparison boreholes. The underlying assumption of this approach was that if Kenya RAPID and non-Kenya RAPID boreholes are

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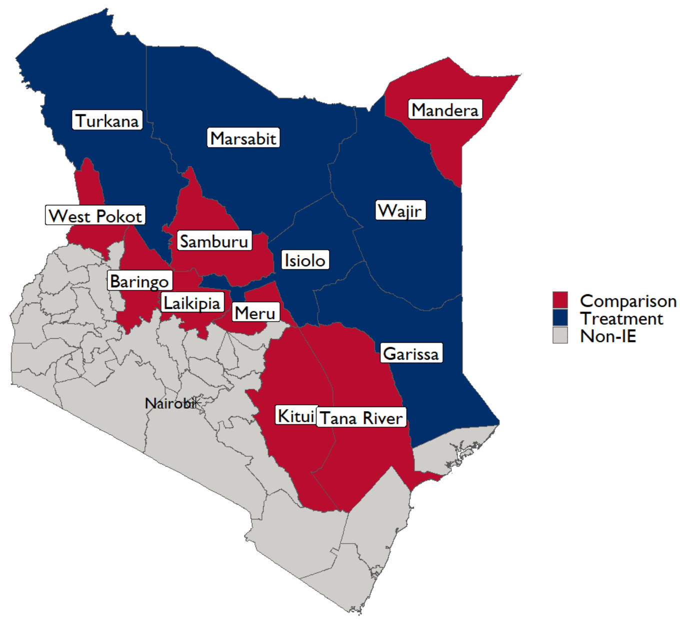
[2] "On-time" is a measure of the borehole pump running. It is defined as the time within a 24-hour period that the borehole pump sensor recorded the borehole pump as running: for example, a value of 50 percent would indicate the borehole pump ran for 12 out of 24 hours.

[3] More formally, this was a propensity score matching approach that took a set of observable characteristics to generate a probability based on those characteristics that a given borehole would receive the RAPID sensor intervention. This probability, or propensity score, is then used to create a sample of matched Kenya RAPID and non-Kenya RAPID boreholes. The evaluation team then conducted tests to assess the degree to which the matched Kenya RAPID and non-Kenya RAPID boreholes were similar, or balanced. Three matching routines were used for sensitivity testing: optimal, many-to-one, and nearest neighbor.

statistically similar on key characteristics, then the comparison sensors can serve as a counterfactual group for what would have happened without Kenya RAPID's sensor information sharing intervention.

DATA

FIGURE 1: MAP OF COUNTIES BY ASSIGNMENT GROUP



Data collection for this evaluation took place in three rounds, with the last two including comparison sensor data download. The RAPID team implemented a structured observation asset inventory survey of the borehole context (Round I) and installed sensors across the comparison boreholes in October 2018. The borehole asset inventory survey largely collected information about the borehole pump, such as date of construction, power source (e.g., solar power), and self-reported questions from borehole operators and sub-county officials (e.g., whether or not a tariff scheme was in place). Round II in September 2019 consisted of downloading data from the sensors installed during Round I. Kenya RAPID shared data from the sensors with the evaluation team in September 2019. A shorter version of the borehole asset survey was also applied to track any changes to the borehole context between Rounds I and II. In August 2020, the evaluation team again downloaded data from the comparison sensors, reapplied the shortened borehole pump survey, and received data from the treatment group sensors. There was no pure baseline data collection round. The ICT intervention was already underway when the evaluation team initiated the first round of data collection.

To answer EQs 2 and 3, the evaluators conducted: i) 16 key informant interviews (KIIs) with water officers, operations and maintenance managers, water engineers and technicians, and borehole operators; and ii) eight FGDs among water users. Both the KIIs and FGDs took place in two Kenya RAPID counties (Garissa and Turkana) and two comparison counties (Tana River and West Pokot). Within the counties selected for qualitative data collection, the evaluation team sampled boreholes with relatively high and low pump on-time based on the Round II data, as well as with other similar characteristics such as livestock use. The team followed this approach in order to capture a range of borehole use and user experience within and across counties.

LIMITATIONS

The matching process attempts to create as rigorous a comparison group as possible to provide a sense of what would have happened to borehole pump on-time in the absence of Kenya RAPID's ICT intervention. However, there are several key limitations to this evaluation design:

- **County Sample:** The counties in which Kenya RAPID operated are the most arid in Kenya. While the evaluation team and USAID sought to select counties that have similar levels of rainfall, the remaining counties do differ geographically and climatologically. The model estimation approach attempts to control for county differences, but there are almost certainly unobserved variables that influence water management.
- **Measurement Challenges:** The main measure of pump on-time does not equate to direct use of the water supply source. For example, a borehole pump could be turned on to fill a tank and turned off once the tank is full, while users draw down the tank water level regardless of whether the pump is on or off. The evaluation team added a binary measure of *any* borehole pumping based on a rolling weekly average to smooth out pump use and account for regular periods of pump off-time. Qualitative findings provide additional context to understand borehole use and operation.
- **Borehole Sample:** The number of strategic boreholes designated to address drought-prone areas is limited in each county. As a result, the total population of available boreholes for consideration in this study was limited ex ante. This limited sample size presents a challenge to reliably estimating an impact across treatment and comparison counties, particularly where impacts are small.
- **Lack of Drought:** The evaluation was designed to test a theory of change based around boreholes that serve a strategic drought mitigation role. However, Kenya experienced record rainfall during the 2018–2020 evaluation period, with 2020 seeing an increase in flooding and overall high levels of rainfall compared to the September 2018–September 2019 period. While the evaluation analysis and design attempted to account for rainfall and borehole substitutes, it is difficult to completely control for unanticipated changes in use, access, and management.

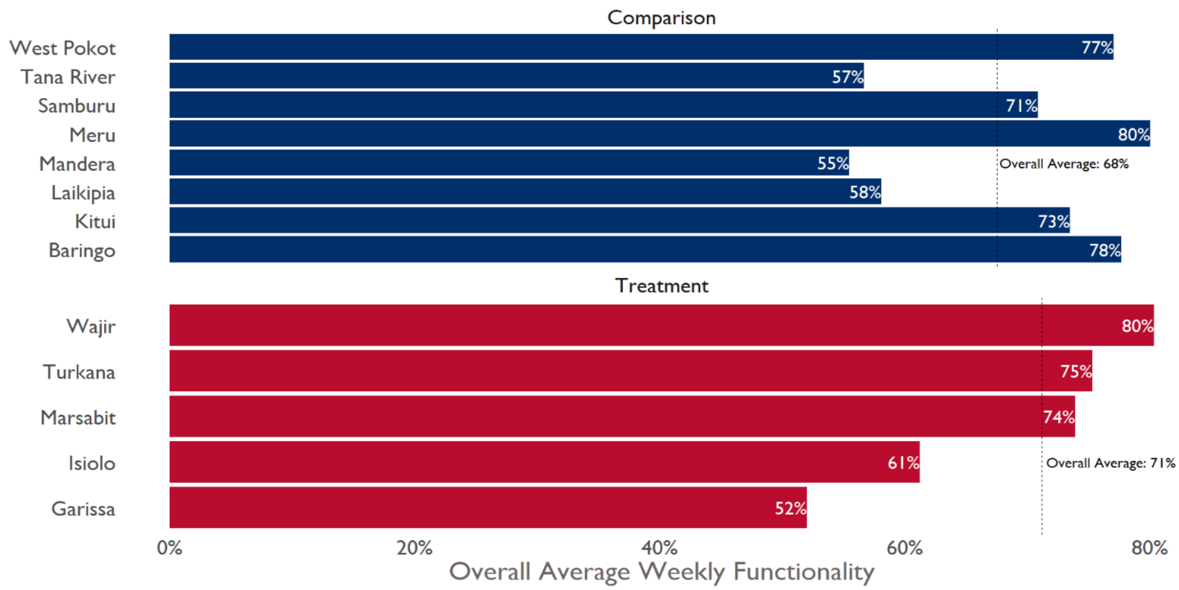
DETAILED FINDINGS

EVALUATION QUESTION 1: DOES THE INTERVENTION USING REAL-TIME REMOTE SENSING DATA OF WATER POINTS FOR STRATEGIC BOREHOLE MANAGEMENT IN KENYA RAPID COUNTIES LEAD TO INCREASED ON-TIME OF STRATEGIC BOREHOLES DURING THE DROUGHT SEASON?

Strategic borehole pump on-time percentage is the main outcome measure for EQ1. This metric is the percentage of a 24-hour period for which the borehole pump was on; for example, 0.5, or 50 percent, is equivalent to 12 hours in a 24-hour day. The overall borehole pump daily on-time was 21.4 percent on average in Kenya RAPID counties and 15 percent on average in comparison counties for the period August 2018 through August 2020. While the sensors do not capture direct use, the measure of borehole pump on-time does provide a helpful proxy for borehole pump use since extended periods of downtime are a sign of pump breakages, particularly after controlling for rainfall.

A different estimate of performance is the rolling seven-day average of on-time, which better distinguishes between temporary and extended downtimes. Discussions with Kenya RAPID suggested that looking at a rolling weekly average of on-time provides a measure that is less sensitive to temporary off periods due to water tank use; for example, a borehole pump might be used to fill a tank, which then lasts for several days, resulting in pump off-time, but with full water access for users. The evaluation team created a binary measure of whether there was any borehole pump use based on the rolling weekly average. For example, if a borehole had a rolling weekly average of zero (i.e., no on-time on average for a week, implying no pump use), then this is recorded as zero; otherwise, the on-off binary is coded as one. This allows the evaluation team to capture general functionality. As shown in Figure 2, RAPID counties reported about 71 percent weekly average functionality while comparison counties reported 68 percent weekly functionality based on this binary measure. Notably, five comparison counties had average weekly functionality at or above the Kenya RAPID average. Weekly functionality during the dry months was 70.3 percent for the comparison counties and 71.7 percent for Kenya RAPID counties.

FIGURE 2: AVERAGE WEEKLY FUNCTIONALITY PERCENTAGE BY ASSIGNMENT



IMPACT ESTIMATION

The evaluation team used two main outcomes for its regression models to estimate the impact of the Kenya RAPID intervention:

- **Model 1:** Daily borehole pump on-time percentage (i.e., the percentage of the day a borehole pump was on); and
- **Model 2:** A binary, on-off measure based on a weekly rolling average that captures whether a borehole pump was on at any point in a week.

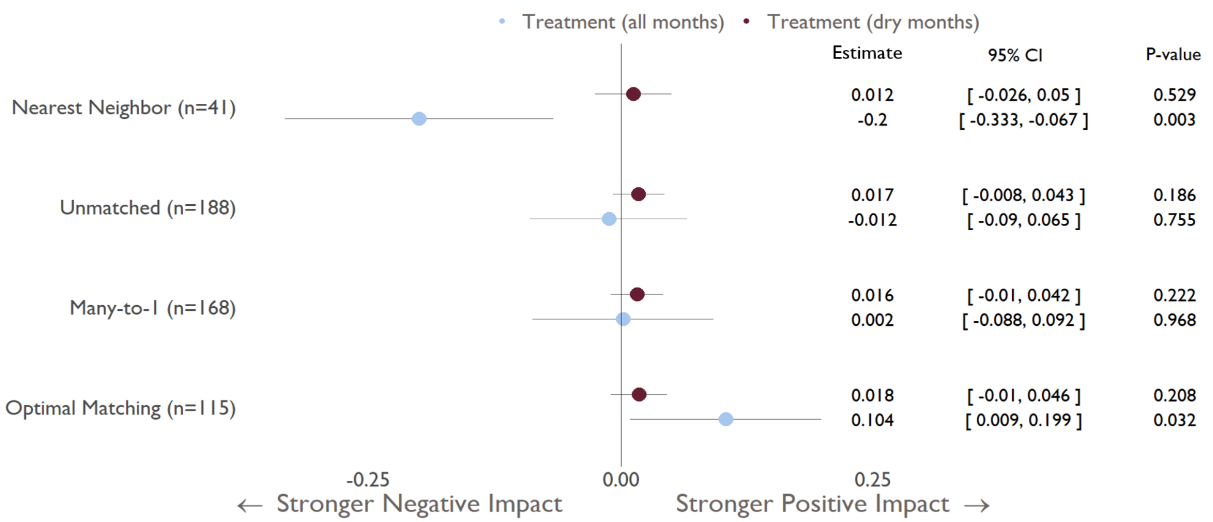
For the first outcome (Model 1), the evaluation team used a general linear model with county fixed effects. The evaluation team used a logistic regression model for the binary outcome measure. Both models include the same set of control variables from the borehole asset survey, such as borehole age and type of power, as well as third-party data, such as rainfall, to control for differences in the main outcomes of interest: daily and binary weekly borehole pump on-time. For both models, the evaluation team also investigated the impact of Kenya RAPID in 2019 only, since there was less rainfall during this year than in 2020. This brief only details the findings from the first model, but the second model results provide similar findings.

The evaluation team used three distinct matching approaches—nearest neighbor, optimal matching, and many-to-one matching—to create different comparison samples. Each of these approaches applies slightly different criteria to create a comparison group.

As indicated in Figure 3, Kenya RAPID's sensor intervention does not appear to have increased borehole pump on-time during the dry months[4] (January, February, June, and September). The model estimates that Kenya RAPID either slightly reduced dry season on-time or increased it 1–5 percent depending on the matched sample.[5] The fact that the confidence intervals for these estimates cross zero (i.e., are both positive and negative) suggests no real impact during the dry months. Logistic regression results for the optimally matched sample suggest that Kenya RAPID and comparison counties had almost equal odds of being on (OR 0.91) during dry months. Put simply, the models suggest that, after accounting for rainfall, county clustering effects (i.e., the fact that borehole use within counties is related), and borehole characteristics, there is not statistical or meaningful difference in average borehole pump performance.

Limiting the analysis to the 2019 dry months results in point estimates that are similar in magnitude to the full sample (3 percent increase in strategic borehole pump on-time). In contrast to the full data estimates reported above, the unmatched and many-to-one estimates are statistically significant at the 5 percent level (Figure 3). However, the lower bounds of these effects at the 95 percent confidence intervals are very close to 0 (upper bounds around 6 percent), and the overall takeaway is similar to the full sample: any observed increases in strategic borehole pump on-time are small.

FIGURE 3: DAILY ON-TIME PERCENTAGE IMPACT ESTIMATES FOR ALL AND DRY MONTHS



Estimates presented with robust 95% confidence intervals and with county fixed effects

EQ1 CONCLUSIONS

Kenya RAPID did not have a significant impact on borehole pump on-time during the drier months of the intervention from 2018 to 2020. Regardless of the analytical approach, the

[4] These months had the lowest average rainfall across both treatment and comparison groups, as well as low differences between assignment groups. Additional sensitivity testing is included in the final report. The sensitivity testing changes the drought variable to include the months with the highest rainfall.

[5] Nearest neighbor matching was implemented as a sensitivity test but resulted in a very small overall sample (n=41).

evaluation team consistently found that Kenya RAPID boreholes had an average of around 2 percent more on-time compared to non-RAPID county boreholes for 2018–2020, controlling for key contextual variables and applying the optimally matched sample during the drought season. Similarly, across the optimally matched, unmatched, and many-to-one matched samples, the team estimates a consistent 3 percent increase in borehole pump on-time during the dry months for Kenya RAPID counties relative to comparison counties for the 2019 subset.

The absence of major benefits is not necessarily a finding that Kenya RAPID interventions did not "work," but the effect sizes are small enough that the team cannot attribute the difference between the average functionality rates in Kenya RAPID counties and the non-Kenya RAPID counties to the sensor intervention. Indeed, several non-Kenya RAPID counties had average functionality above Kenya RAPID county levels.

Evaluation results suggest that information constraints alleviated through sensor information sharing may not have been the primary challenge facing strategic borehole functionality or pump on-time. Additional context from EQs 2 and 3 help fill in the reasons why sensors alone may not substantially improve functionality.

EVALUATION QUESTION 2: HOW DO WATER MANAGERS PERCEIVE THE IMPACT OF SENSOR-BASED SYSTEMS ON THEIR ABILITY TO ADDRESS BOREHOLE FUNCTIONALITY AND HOW DOES THIS COMPARE TO PERCEPTIONS OF BOREHOLE FUNCTIONALITY IN NON-KENYA RAPID COUNTIES?

According to the Kenya RAPID theory of change, the ICT intervention was designed to facilitate a faster response to fix broken boreholes and increase borehole functionality by 1) increasing the speed with which information about borehole breakages reaches service providers at the sub-county and county level; 2) clarifying roles and responsibilities for operations and maintenance; and 3) setting aside dedicated budgets and resources to address strategic borehole breakages.

The team conducted KIIs with 16 individuals across the four selected counties (Garissa and Turkana in the treatment group and Tana River and West Pokot in the comparison group) during Round III data collection. Key informants included water officers, operations and maintenance managers, water engineers and technicians, and borehole operators. Most of these participants (14/16) were male; Turkana and West Pokot each had one female interviewee. On average, these individuals had been employed in their current role for 8.2 years (range: 1–20 years). The final evaluation report contains more detailed information on respondent characteristics.

There were four main thematic areas of inquiry for EQ2. This section summarizes the in-depth qualitative data and analysis.

PERCEPTIONS OF THE SENSOR-BASED SYSTEM

Within this theme, KIIs reported the following:

- Perceptions of Kenya RAPID's ICT intervention were positive among respondents who were familiar with the activity, even in cases where implementation or access to sensor information faced challenges.

- Local borehole operators had limited knowledge of the sensor-based system, while sub-county and county officials in both counties were highly knowledgeable about this system.
  - Kenya RAPID has noted, however, implementation challenges in Garissa due to security concerns, which may explain the lack of familiarity.
- County and sub-county officials highlighted internet access and mobile connectivity challenges for accessing the sensor data.
  - In Turkana, a single sub-county officer said that he had the app and used it regularly to get information on borehole issues.
  - This same officer noted that "some places need a stronger network for you to use the app."
- Sensor removals (e.g., by borehole operators unfamiliar with the devices) were also highlighted as a common challenge in Kenya RAPID counties.

WATER MANAGERS' PERCEPTIONS OF WATER SYSTEM FUNCTIONALITY

Within this theme, KIIs reported the following:

- Respondents mentioned seasonal variation of borehole use and functionality issues. In Garissa, West Pokot, and Tana River, water managers said that borehole use was substantially higher during the dry season, when other sources of surface water (rivers, impoundments, ponds) were not available. In Turkana, borehole use was frequent throughout the year.
  - Breakages were also reportedly seasonal, with more breakages occurring during the drier months due to higher use.
- The most commonly mentioned issues involved broken pipes used in pumping and water delivery, particularly in Turkana and West Pokot.
- All water managers said that the time needed to repair breakages depends on the circumstances and type of breakage. The reported repair times for strategic boreholes in treatment and comparison counties, based on recall of the last breakage, ranged from a few days to several months.
  - Minor issues are typically handled locally and can sometimes be fixed within hours or days.
  - The longest repair time recorded was at a selected borehole in Garissa (treatment) that the local borehole operator said had been broken for seven months at the time of the interview, because users had access to an alternative source.
- Across both Kenya RAPID and comparison counties, operators noted that information about breakages reached them quite quickly (within hours) either through their own observations or through communication from local users.
  - KII respondents in all counties said that information about breakages travels quickly from the local level up to the county or sub-county level, typically through phone calls from the local operator or water committee.
- Respondents noted that breakage diagnosis can delay information sharing and the response process and highlighted lack of funds for repairs as a key barrier to addressing breakages.

PERCEPTIONS OF WATER SYSTEM MANAGEMENT STRUCTURE AND ROLES

Part of the ICT intervention involved clarifying roles and responsibilities for water system management. Within this theme, KIIs reported the following:

- Of the eight boreholes selected for qualitative data collection, seven were managed by local water committees. The size of these committees ranged from 4 to 17 individuals.

  - Local water committees handle day-to-day operations and minor repairs and seek the assistance of the county or sub-county government for larger repairs.
- Across all counties, local borehole operators expressed frustration with perceived slow response times from county governments.
- Several respondents noted that nongovernmental organizations (NGOs) play a large role in building boreholes and many also step in to help when boreholes break. However, their roles are also often informal and not clearly defined.
- Awareness of strategic borehole designation was high among sub-county and county officials, but only two local operators were aware of it.
- All KIIs reported that the management structure for strategic boreholes did not differ from that of other boreholes.

RESOURCES FOR BOREHOLE REPAIRS

User fees are one of the main ways local operators fund small repairs. Within this theme, KIIs yielded the following information:

- Multiple operators reported that their ability to collect fees varied throughout the year, with dry month fees being more difficult to collect due to lack of funds among users.
  - In Garissa and Tana River, operators noted difficulty collecting fees. In West Pokot, neither of the sampled borehole requires routine user fees, and both operators noted this as a key barrier to better maintenance.
- When user fees are not sufficient to address a given issue, funding must be requested from the county, national government, and/or NGOs. All KII respondents noted significant challenges with this process as well as recurring financial challenges.
  - KIIs respondents from both Kenya RAPID and comparison counties mentioned the timing of funding provision and confusion over where money was coming from as presenting challenges.
- In addition to budget challenges, respondents mentioned difficulty accessing parts, tools, and trained staff in Tana River, Garissa, and Turkana.

EQ2 CONCLUSIONS

Changing systems is a long-term process. While water managers see the ICT intervention as a positive and welcome addition to their management toolkits, their ability to take advantage of the system's potential benefits is limited by other significant barriers to faster repair times and increased water service reliability across treatment and comparison counties.

County and sub-county water managers in Garissa and Turkana had positive perceptions of the Kenya RAPID intervention and described the data provided by sensors as highly relevant and useful for water management decision-making. Qualitative data indicate that confusion remains on the part of water managers about roles and responsibilities.

Kenya's devolved system of water governance is complex; in most (but not all) cases, local water committees manage rural boreholes and are responsible for minor repairs, while larger breakages must be addressed by some combination of sub-county, county, or national governments and/or NGOs. Water managers are not always sure who to turn to when a borehole breaks. Along with lack of clarity around responsibility for water management, KIIs confirmed a continuing shortage of dedicated resources for borehole repairs. Water fees vary widely and are not routinely collected in three of the eight sampled boreholes; even where they are collected, they are not sufficient to cover the costs of large repairs.

EVALUATION QUESTION 3: DO KENYA RAPID'S SENSOR-BASED SYSTEMS AFFECT USER PERCEPTIONS OF BOREHOLE FUNCTIONALITY AND ACCESS?

In September 2020 as part of Round III data collection, the evaluation team held eight FGDs with local users of the selected strategic boreholes (two FGDs per county). Both Garissa FGDs were male only, given that these boreholes were used primarily for watering livestock; the remaining six FGDs were held with women regarding boreholes mainly used for domestic purposes. In total, 69 people participated in the FGDs, with an average of 8.6 people per discussion. FGD participants were 42 years old on average, with ages ranging from 22 to 78. The final evaluation report provides further details on age and village of FGD participants.

There were three main thematic areas of inquiry for EQ3. This section summarizes the FGD qualitative data and analysis.

USERS' PERCEPTIONS OF WATER SYSTEM FUNCTIONALITY

The ultimate objective of the ICT intervention was to meet water users' diverse needs more reliably through the use of information sharing on pump functionality. FGD participants highlighted several continuing challenges in this area, cutting across both treatment and comparison boreholes.

- Participants in all counties mentioned borehole breakages as an ongoing issue. In Garissa, male livestock owners complained that long repair times caused challenges and hardship: *"Most of the times, the borehole will take a week to be repaired and that causes a lot of inconvenience and suffering. It will be better if less time is taken to repair when it breaks down."*
- Pipe breakages were some of the most commonly reported functionality issues in Turkana and were mentioned as a key challenge in West Pokot.
- Water users in all four counties raised concerns about both the number and volumetric capacity of water storage tanks, expressing a desire for more and larger tanks.
- Respondents in all counties said that the current system does not supply enough water for all users and use types.
  - Male livestock owners in Garissa and female water users in West Pokot highlighted challenges supplying sufficient water for both people and livestock.
  - Users in Turkana and Tana River said that population growth over time was contributing to water shortages.

BOREHOLE ACCESS AND USE

- In Garissa, Tana River, and West Pokot, FGD respondents reported that they primarily use surface water (rivers, streams, dams) during the rainy season and rely on the boreholes only during the dry season. By contrast, boreholes in Turkana were reported to be the main water source year-round.
- Water users noted a number of challenges affecting water access and use. Chief among these were issues related to excessive demand, leading to water shortages during the dry season. Several water users mentioned traffic and congestion around boreholes.

- Water users also explained that shortages of water sources cause them to travel long distances during the dry season.
  - One water user in Turkana reported that people journey up to three hours to reach the strategic borehole.
  - Conflict and violence were also cited as posing access challenges.
- FGDs revealed how impacts of water shortages and queuing were particularly difficult for certain vulnerable groups, such as pregnant women, children, and the elderly.

PERCEPTIONS OF MANAGEMENT STRUCTURE

- Fees and affordability were a major theme in users' discussions of water management systems, with many FGD participants reporting that fees were too high.
- In response to water shortages, several water users reported that water managers enacted rationing schemes at certain times of the year.
  - In Garissa, livestock owners explained that in times of shortage, priority is given to home consumption first and then to certain types of livestock (goats and cattle), while camels are supposed to go to the river.
  - In Turkana, users described a system for allocating water from one borehole to multiple villages in turns.
- Water users' satisfaction with the current system varied by individual and across counties.
  - With the exception of one borehole in Tana River, users said it was easy to contact borehole operators and officials to communicate borehole issues and alert them to repairs.
  - In West Pokot, users of one borehole managed by a local water committee expressed some confusion around the water management structure as well as some distrust of the water committee.

EQ3 CONCLUSIONS

The sensor-based intervention does not appear to have had a major impact on water users' perceptions of water access and reliability. This likely is due in large part to limited impacts on borehole on-time (see EQ1), as well as to a suite of other continuing water access challenges highlighted by users across treatment and comparison counties.

The Kenya RAPID sensor-based intervention was designed to facilitate water system management at the county level, aiming to provide water managers with better and faster information about borehole breakages to facilitate the allocation of resources for repairs. Meanwhile, nearly all of the selected boreholes for FGDs were managed by local water committees whose members are locally elected and widely seen as accountable to the people they serve. These committees lack sufficient resources to maintain and repair boreholes adequately, necessitating intervention from the higher-level actors the Kenya RAPID intervention targeted. However, somewhat lost in this discussion is the wide range of local challenges that are not within the scope of this ICT intervention—issues such as overcrowding and congestion, as well as "last-mile" infrastructure that carries water from boreholes to people and livestock.

DISCUSSION AND RECOMMENDATIONS

Improving water service delivery is a challenge that includes technical, social, economic, and political components. The ICT intervention component of Kenya RAPID introduced an innovative technological solution to one component of the problem: lack of timely information about strategic borehole breakages. Taken together, the results of this evaluation show that information provision alone, without effective solutions to a broader range of budgetary, operational, and professional management challenges, had at best a minor impact on strategic borehole functionality. After controlling for borehole characteristics, county fixed effects, and rainfall, the evaluation team found a very modest effect of the sensor intervention; at best, the team's model estimates suggest that the ICT intervention increased borehole pump on-time by roughly an hour per day in Kenya RAPID counties compared to comparison counties, and the actual effect may well have been lower. Meanwhile, EQs 2 and 3 illuminate the broader context surrounding this intervention, one in which users often substitute away from water boreholes when it rains, some strategic boreholes do not operate during certain periods of heavier rainfall, responsibility for water management is distributed across multiple actors in inconsistent and unclear ways, and maintenance reserves to repair broken boreholes are inadequate. ICT interventions like the one evaluated here may be an effective tool for improving water service delivery and increasing resilience in the face of drought, but only as part of an integrated strategy that also addresses basic operational and maintenance challenges, including the proper budgeting for repairs.

The evaluation team offers the following recommendations for future USAID rural WASH programming:

1. Continue to focus on water system governance by clarifying roles and responsibilities for water management and establishing dedicated and sustainable funding sources for water system maintenance and repairs. Evaluate and rethink the role of NGOs in this ecosystem. While donors provide crucial sources of funds in low-income countries, their lack of accountability and clearly delineated roles contribute to disjointed and unsustainable systems. How can we ensure that NGO priorities match local and national priorities? How can these actors be engaged to support not just initial infrastructure development but also sustainable maintenance and—crucially—good governance systems?
2. Ensure community concerns are addressed in planning for delivery of water services. The evaluation highlighted several issues and concerns expressed by users that were not directly addressed by the sensor-based intervention. While water management necessarily involves multiple actors at different scales, the perspectives and expertise of local water users should be central to any effort to improve water service delivery. Walking the line between giving communities agency and voice and providing the necessary resources and support from higher levels of government to support user needs may be challenging but is necessary.
3. Consider cost-effectiveness for ICT interventions in the future. This impact evaluation was not designed to consider cost implications, but these should be part of any interpretation of the findings. The small effect sizes estimated here may still be worthwhile if they are cost effective; evaluating this question requires additional data on program costs (in comparison to other approaches to water service delivery improvement).
4. For evaluation efforts, ensure that implementation monitoring is included as a key, funded component, following established guidelines such as the Reach, Effectiveness, Adoption,

Implementation, and Maintenance (RE-AIM) framework.[6] A lack of good implementation data was a challenge in this evaluation study, and a lack of budget for implementation monitoring limited the team's ability to track progress over time. These data are key to understanding how and why impacts (or lack of impacts) are observed.

[6] Glasgow, R.E., Vogt, T.M., Boles, S.M. Evaluating the public health impact of health promotion interventions: the RE-AIM framework. American Journal of Public Health. 1999; 89(9): 1322–1327.

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