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Water system hardware and management rehabilitation: qualitative evidence from Ghana, Kenya, and Zambia

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Abstract

Background—Sufficient, safe, continuously available drinking water is important for human health and development, yet one in three handpumps in sub-Saharan Africa are non-functional at any given time. Community management, coupled with access to external technical expertise and spare parts, is a widely promoted model for rural water supply management. However, there is limited evidence describing how community management can address common hardware and management failures of rural water systems in sub-Saharan Africa.

Methods—We identified hardware and management rehabilitation pathways using qualitative data from 267 interviews and 57 focus group discussions in Ghana, Kenya, and Zambia. Study participants were water committee members, community members, and local leaders in 18 communities (six in each study country) with water systems managed by a water committee and supported by World Vision (WV), an international non-governmental organization (NGO). Government, WV or private sector employees engaged in supporting the water systems were also interviewed. Inductive analysis was used to allow for pathways to emerge from the data, based on the perspectives and experiences of study participants.

Results—Four hardware rehabilitation pathways were identified, based on the types of support used in rehabilitation. Types of support were differentiated as community or external. External support includes financial and/or technical support from government or WV employees. Community actor understanding of who to contact when a hardware breakdown occurs and easy access to technical experts were consistent reasons for rapid rehabilitation for all hardware rehabilitation pathways. Three management rehabilitation pathways were identified. All require the involvement of community leaders and were best carried out when the action was participatory.

Conclusions—The rehabilitation pathways show how available resources can be leveraged to restore hardware breakdowns and management failures for rural water systems in sub-Saharan Africa. Governments, NGOs, and private sector actors can better build capacity of community

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actors by focusing on their role in rehabilitating hardware and management and to ensure that they are able to quickly contact external support actors when needed for rehabilitation. Using qualitative and participatory methods allows for insight into rapid rehabilitation of hardware and management.

Keywords

community water management; low- and middle-income countries (LMIC); post-construction support; rural water systems; water committee; sustainability

Introduction

Sufficient, safe, and continuously available drinking water is important for human health and development (Bain et al., 2014b; Bartram and Cairncross, 2010). However, 26% of water sources in sub-Saharan Africa contain fecal contamination (Bain et al., 2014a). In rural sub-Saharan Africa nearly 60,000 handpumps and other types of water systems are installed every year; however, one in three handpumps are non-functional at any given time (Rural Water Supply Network, 2009; Sansom and Koestler, 2009). Water system breakdowns force users to use other, often contaminated water sources; and even a few days of consuming water from unimproved sources during a water system breakdown can undermine the health benefits provided by an improved water source (Hunter et al., 2009).

Identifying the causes of rural water system breakdowns and how to address them requires an understanding of rural water supply management (Amjad et al., 2015; Bonsor et al., 2015). Management factors associated with water system non-functionality arise within a community-based management paradigm for rural water supplies that was embraced in the late 20th century (Chowns, 2015; Lockwood et al., n.d.; Whittington et al., 2009). Specifically, community management with access to external technical expertise and spare parts has been implemented for rural water system management (Hutchings et al., 2015). External support for community-managed water systems is provided through post-construction support programs, which often focus on technical and administrative guidance and assistance (Kayser, Moomaw, Miguel, Portillo, & Grif, 2014; Whittington et al., 2009).

Because most water systems will fail, effective and rapid rehabilitation is vital to ensuring continued access to safe drinking water. While the community management model, coupled with access to spare parts and external technical expertise, has been championed in rural water supply, there is a limited understanding of how the community management model facilitates the rehabilitation of broken water supplies in sub-Saharan Africa. Literature on rural water system sustainability describes factors associated with functionality, including the availability of tools, fee collection, and distance to spare parts (Alexander et al., 2015; Fisher et al., 2015; Foster, 2013). In order to increase the functionality of community-managed water systems, it is important to understand not only what factors are associated with non-functionality, but also how non-functional water systems are rehabilitated. As effective management can efficiently address technical breakdowns, it is also important to understand how to address management failures. To address these gaps, we identified rehabilitation pathways for broken water systems and for management failures, the actors

involved in these pathways, and barriers to complete rehabilitation steps using qualitative data from Ghana, Kenya, and Zambia.

Methods

Data were collected in eighteen study communities – six each in Ghana, Kenya, and Zambia. Study setting, data collection, and general data analysis are described in Behnke et al., n.d. .

Study communities had a water system that had been implemented by World Vision (WV) and that was reported to be functional and managed by a water committee at the time of a representative survey of water systems supported by WV (Kayser et al., 2015). Water systems included handpumps, mechanized pump systems (solar-powered or generator-powered), or gravity-fed piped systems. Data were collected between June and August 2015. Researchers spent one week in each study community conducting interviews, focus group discussions, and participatory activities with water committee members, community members, and local leaders. WV employees, government employees, and private sector employees engaged in supporting the water systems were also interviewed. All participants gave verbal consent to be included in the study and to have the interview or FGD in which they participated recorded. Audio recordings were transcribed in English.

Dedoose (“Dedoose,” 2015) was used to code the data. A two-stage coding process was used to allow themes to emerge from the data. Excerpts within groups of codes were examined to analyze themes. Water system hardware and management breakdowns were broadly identified during coding. Further analysis of coded excerpts was focused on identifying type of support used, generalized steps for rehabilitation, the actors involved at each step, and barriers to rehabilitation. Constraints were separated into: those that slow the rehabilitation, resulting in a longer breakdown period; and those that halt rehabilitation, resulting in a terminal failure of the water system.

A broad definition of hardware breakdown that includes anything but complete functionality was used. This includes systems that were not functional or at reduced functionality (e.g. functional but turbid water or functional but hard to pump) as defined by Leclert's classification of the operational status of a borehole (Leclert, 2012). As there were occasions when a water committee was mostly serving its purpose but could be improved, a similar approach is taken for management rehabilitation: anything less than complete functionality was considered amenable to rehabilitation.

Ethics statement

Ethical approval and all relevant research permits or exemptions from the US university (exemption, project 15-0902), Ghanaian Ministry of Water Resources, Works and Housing (physical project approval letter, reference number SCR/JQ-52/173/049), Kenyan National Commission for Science, Technology and Innovation (physical permits, NACOSTI/P/15/8498/6556 and NACOSTI/P/15/8024/6557) and Zambian Ministry of Housing and Local Government (physical approval letter, reference number MLGH/101/18/22) were received.

Results

Hardware rehabilitation

Four pathways were identified between the recognition of a hardware breakdown and the return of a water system to functional status, based on the types of support actions involved in rehabilitation: community support actions; community support with external financial support actions; community support with external technical support actions; or community support with both external technical and external financial support actions.

Support actions carried out by the community are involved in all successful rehabilitation pathways; in no case in the data did an external actor rehabilitate the water system without involvement of the water committee or other community leaders in the study communities.

While data on the frequency of each pathway were not collected, analysis involved counting excerpts that mentioned a specific rehabilitation pathway. The two pathways that occurred most frequently were those involving only community support actions and involving community support with external technical support. The pathway involving community support with external financial support actions occurred least frequently, accounting for less than 10% of excerpts that referenced a specific rehabilitation pathway. Of the three study countries, the pathway including both external financial and technical support was more common in Kenya than in Ghana and Zambia. Most of the water systems in study communities in Kenya were mechanized as compared to handpumps in most study communities in Ghana or Zambia; water committees more frequently accessed both external financial and technical support for the more complex mechanized systems in Kenya than for the handpumps in Ghana and Zambia.

Functional roles necessary for rehabilitation are defined and examples are given for each functional role in Table 1. Several actors fulfill multiple functional roles.

Figure 1 shows the steps for each rehabilitation pathway and the functional roles in each step. The step of contacting technical support requires the same functional role – referrers – regardless of pathway, although the referrers connect with different actors depending on the pathway. System users often help with the actual repair of hardware when external technical support is not involved.

Table 2 shows the constraints that slow or halt rehabilitation at each rehabilitation step, which are discussed with each pathway description below.

For all pathways, specific rehabilitation steps are shown with the functional roles commonly involved and the constraints that slow or halt rehabilitation at each step. Our data show that before support actions for rehabilitation can be undertaken, a community must recognize and diagnose a breakdown. Subsequent steps are contacting technical support, acquiring financial resources, acquiring materials, and repairing hardware. In some cases, completion of one or more rehabilitation steps involve meetings of the water committee, community members, and/or mechanics or technicians to discuss the nature of the problem; which technical or financial support actors should be contacted; which materials should be purchased; or who should participate in repair.

Community support actions—Hardware rehabilitation requiring only community support occurs for less complex technical repairs that require funds that water committees have either saved from regular resource mobilization or can raise in reaction to a breakdown. Resource mobilization mechanisms include fee collection as well as non-monetary and non-fee resource mobilization mechanisms that are described in Behnke et al., n.d.. In the case that a mechanic or water committee member with technical knowledge diagnoses the problem, the second step of contacting technical support is sometimes combined with the first. Technical support for this pathway is provided by a mechanic within the community or a neighboring community or by a member of the water committee who has been trained or has the skills to repair a system.

In one community in Ghana, a pump maintenance volunteer described the process of rehabilitating a handpump when part of the pump had “broken down and fell inside” while it was being used: *“We contributed money and called our mechanic and he came and said the part is in [the capital city of the region] so we should bring money and he will go and buy.”* Other repairs that use only community support actions include pipes bursting (for systems with piped networks to homes or water kiosks) and a handpump handle breaking.

Problem diagnosis prompts the rest of the rehabilitation process. One water system caretaker in Zambia stated that he learned from a training with WV that, *“they have to take a 10-liter container and start pumping. They were taught that if you pump 14 times then the container is filled up – meaning the borehole is ok – but if you pump 14, the container is not filled – meaning the borehole is not ok, there's a problem.”* Such knowledge related to problem diagnosis was not commonly seen in study communities; this corresponds to the constraint (Table 2) of limited knowledge of how the water system should operate. Women, as the most frequent collectors of water, were sometimes cited as more aware of the status of the water system and more likely to detect hardware breakdowns. Many study participants indicated that women inform the committee when there is a hardware breakdown, thus triggering rehabilitation. A male water committee member in Ghana described that *“the women are so important because before the borehole will spoil, they will detect it more than a man because a man, as for here, the men we don't go to the borehole.”*

When a community does not use or rely on a system, problem diagnosis is not completed, as there is a lack of interest in rehabilitating it. One reason for lack of interest in rehabilitation identified from our data is the existence of more than one water system in a community. For example, during the rainy season, when study participants often collect water captured by nearby dams instead of using an installed water system, study participants stated a lack of interest in rehabilitating a broken water system.

The constraints that slow rehabilitation at each step mostly involve poor communication with technical support providers, limited funds, or transportation to acquire tools and spare parts. When one community member in Ghana was asked what caused repair delays up to a month-long, they responded, *“It is always about the money. We have to contribute and go and buy the spare parts but they are also expensive.”*

The constraints that halt rehabilitation include complete lack of knowledge of, or ability to acquire, needed technical support and materials.

While the actors involved in each step vary between types of water systems and breakdowns, water committee members are involved in every step of rehabilitation for this pathway. The one exception in our data is a community whose water committee had been dissolved by a local leader; where former water committee members and local leaders took action to rehabilitate broken hardware.

Community support with external financial support actions—Hardware rehabilitation carried out through community support with external financial support occurs for repairs of relatively low technical complexity for which the water committee is unable or unwilling to raise funds within the community. Referrers play an essential functional role in connecting to sources of financial support. Generally, water committee members submit proposals to, or directly contact, government or WV offices for external financial support. Regional water committee associations are sometimes formed to connect nearby water committees and to help address technical challenges and support the management activities of member committees. Member committees sometimes contact water committee associations to solicit help in contacting external financial support actors. Financial support is often made in the form of in-kind contributions of water system components such as pipes, pump handles, or fittings; and, for mechanized systems, pumps or solar panels. In this case, acquiring financial resources and materials happen at the same time.

Cost of repair as well as availability of water committee funds determine whether external financial support actions would be solicited. One water committee member in Kenya described how external financial support enabled rehabilitation, *“When the motor broke down, we wrote an application to the CDF [Constituency Development Fund] and they responded positively and allocated KSH [Kenyan Shilling] 300,000 for repair of the motor. We could not afford KSH 300,000.”* In this case, community actors were aware of relevant financial support options and they were able to write a proposal. However, in other cases, rehabilitation is slowed or halted because community actors were unaware of which support actor to contact or unable to write an effective proposal for support.

Community support with external technical support actions—Hardware rehabilitation using community support with external technical support actions occurs for repairs of higher technical complexity for which water committees have already saved from regular resource mobilization or can raise quickly in reaction to a breakdown.

One WV employee in Zambia described the process of contacting external technical support, *“It goes beyond the community's capability of fixing so they send a report and then we come as World Vision and inform our partners like the municipal government or department of water affairs to go and work on the borehole.”* This is one of many possible methods identified for engaging technical support.

Another WV employee described differences between hardware breakdowns that require only community technical support and those that require external technical support:

“I think the help of some aspects of it are very simple to repairs so the community members having the ability to remove some of the parts and be able to fix the pump or even just routine maintenance of it – looking at the chain. There has to be that awareness within the communities but I think it is also too much for a community if there is something very technical that they're expected to repair. In those instances, they should also know where the help is so that they can contact. Either is it district assembly or an entrepreneur.”

The employee indicates that government and private sector actors are sources of support for “very technical” repairs that prompt use of this rehabilitation pathway.

In Kenya, a company that supplies and installs pumps and solar panels for the water systems in study communities also plays a role in providing technical support. The company provides product warranties. The company's NGO coordinator stated that their technicians visit broken water systems at no cost during the warranty period and charge a water committee after the warranty has expired. Some committee members were aware of this support, while others only stated that they would contact WV if there were a problem with the pumps or solar panels. WV would sometimes, in turn, contact the company.

In rare cases, community actors do not diagnose the problem themselves; instead, government or WV employees visiting for monitoring trips or to work on other development projects diagnose the problem.

Additional constraints for this pathway are contacting external support and paying for their services. This is especially limiting for complex mechanized water systems (such as those including solar panels) that require high levels of expertise, often in the form of private sector technicians who are far from rural communities and whose services and transportation are costly.

Community support with external technical and financial support actions—

Hardware rehabilitation requiring community support with both external technical and financial support actions occurred for repairs of higher technical complexity for which the water committee is unable to raise funds within the community.

A water committee secretary in Kenya illustrated this pathway, saying:

“We wrote another proposal, and before we wrote a proposal, we enquired skills from water officer to come and see what the problem was. Then he came he advised us. He told us we can buy it from Nairobi but by there we had no money. So we had to write another proposal to the World Vision, then World Vision replaced it.”

In this case, the government water officer acted as the technical support, and WV as financial support.

Often, when external actors supply in-kind support, they also select and acquire materials necessary for repair. Thus, their in-kind support involves technical support. This pathway requires several actors and has the most potential constraints (Table 2).

Management rehabilitation

Water committee members are commonly involved in each step of the hardware rehabilitation pathways. Since several study communities had gone through periods when the water committee was not operating, rehabilitation pathways to address management failures were also identified.

Management failures included committees dissolving and community members demanding changed leadership because of perceived mismanagement of funds.

Management rehabilitation pathways are sorted based on type of support actions taken: community support actions, community actors prompt external support actions, and external actors prompt community actions.

Figure 2 shows the steps for each management rehabilitation pathway as well as the functional roles (Table 1) acting in each step. Unlike hardware rehabilitation pathways, management rehabilitation in study communities always involved some form of community participation or water committee meeting.

Table 3 shows the constraints that slow or halt rehabilitation at each rehabilitation step. These constraints are discussed with each pathway below.

Community support actions—Management rehabilitation using only community support occurs for management failures that established community processes can address.

A local leader in Kenya described management rehabilitation as beginning when either a local leader (a chief or assistant chief) recognizes that the water committee is not effectively managing the water system and calls a meeting; or when the community “shouts” and reports to the chief’s office if the chairperson or the committee are not performing. This local leader went on to state that rehabilitation takes place when *“the community are mobilized, then from there, they can do the election.”*

Constraints that slow or halt management rehabilitation are mostly associated with a local leader’s lack of capacity or willingness to adequately select and prepare new committee members for their tasks.

In two study communities, a local leader dismantled and/or replaced the water committee. In one community, the local leader subsequently managed the water system; in the other, a local leader dissolved a committee and replaced committee members with appointed interim committee members. In both communities, the local leaders had not arranged for training or other preparations for those newly entrusted with managing the water system. While the dissolved committees may not have been operating effectively before actions were taken by local leaders in these communities, not preparing new committee members for their roles prevented full rehabilitation of the committee.

Community actors prompt external support actions—Management rehabilitation in which community actors prompt external support actors occurs for management failures that benefit from outside mitigation. The main difference between this and the above pathway is

that external support actors are contacted instead of local leaders, and are involved in subsequent steps.

External support actors are often government or WV employees. Regional water committee associations sometimes played a role by helping individual water committees resolve conflicts. A water committee member in Zambia described the role of regional water committee associations:

“Zonal committee [regional water committee association] mostly helps the WaSH committees for the borehole that if they don't cooperate, it becomes easy when they go there to help them with what they can do because in other places you can find that a committee has been chosen but it's not working well, they don't cooperate so they go to help with that problem concerning water.”

These regional water committee associations help to rehabilitate management failures that cannot be addressed by the community, such as disputes that benefit from outside arbitration.

Constraints for this management rehabilitation pathway involve confusion about which support actors are relevant and responsive, or challenges in contacting them.

External actors prompt community actions—Management rehabilitation in which external actors prompt community actions occurred for management failures of which the community is unaware or is unable to initiate rehabilitation. In this pathway, external actors diagnose the problem.

Community actors requesting the support of external actors in management rehabilitation was more common than external actors alerting local leaders and community members about management breakdowns, although there are examples of the latter in our data. One government water officer in Kenya described how government employees were responsible for visiting the management committee or auditing committee funds, allowing for them to discover misappropriation that went undetected or unproven by community actors.

Constraints for this pathway relate to infrequent monitoring or lack of presence of external support actors that may diagnose management failure. Even though external actors are responsible for problem diagnosis in this pathway, they alert local leaders, and, ultimately, responsibility for rehabilitation lies within the community.

Discussion

Leveraging community actors effectively

No hardware rehabilitation pathways identified in the data included *only* external support actions – that is, WV or government employees visiting a community without being contacted by community actors, recognizing and diagnosing a hardware problem, and carrying out the technical and financial support actions necessary to rehabilitate the system without any involvement of community actors. This finding confirms the importance of community capacity within the community management paradigm (Lockwood et al., n.d.;

Whittington et al., 2009). Even in pathways involving external support, community actors almost always play roles in problem diagnosis, contacting technical support, and acquiring financial resources. Ensuring that water committee members and local leaders are trained to quickly complete these steps can facilitate rapid rehabilitation.

All hardware rehabilitation pathways begin with problem diagnosis. Failure to complete this step prevents the rehabilitation process from starting and slow diagnosis means rehabilitation is delayed. Women were the primary collectors of water for households in study communities and were cited as more likely to detect hardware breakdowns; training women to identify hardware breakdowns and contact technical support may facilitate more rapid rehabilitation.

The most common barrier that halts problem diagnosis is that the community does not frequently use or rely on the system and thus there is a lack of interest in rehabilitating it. This lack of use and interest in rehabilitating the water system may be related to a lack of community ownership and is associated with water system performance (Marks et al., 2013). This may indicate a problem with initial construction rather than ability to rapidly rehabilitate the system. The existence of more than one water system in a community also contributes to the lack of interest in rehabilitation; where more than one water system in the same vicinity is associated with lower functionality (Fisher et al., 2015).

Frequent water committee meetings are associated with increased functionality of water systems, and improved decision-making for community-managed water systems is associated with the frequency of and attendance at water committee meetings (Foster, 2013; Schweitzer and Mihelcic, 2012). It is possible that meetings to address hardware breakdowns help to more rapidly mobilize relevant community actors to complete rehabilitation steps.

All management rehabilitation pathways identified require the involvement of local leaders and were best executed when action was taken in a participatory manner. Nontransparent dissolving or replacement of committees decreased the capacity of the committee to perform its tasks.

Making sure external support actors are accessible

Poor communication was a constraint to all hardware rehabilitation pathways. Between communities and mechanics or external support actors, poor communication slows rehabilitation (Chowns, 2015). Rehabilitation carried out quickly and effectively often involved a clear understanding of who was responsible for contacting technical support and which technical support actor would be responsive. Having easily accessible, local mechanics was a common reason for rapid rehabilitation identified in the data; previous studies also indicate that presence of local mechanics is associated with functionality of rural water systems (Fisher et al., 2015; Foster, 2013; Nekesa and Kulanyi, 2012). Often, the water system caretaker or the water committee chairperson was primarily responsible for contacting technical support. Effective communication was less common when external technical support actors were necessary for rehabilitation; knowing which external actor to contact and by which means should be emphasized in training for water committees.

In both hardware rehabilitation pathways that do not incorporate external technical support, worse breakdowns sometimes result from improper rehabilitation. Insufficient communication with external support actors indicates reliance on community actors and contributes to water system non-functionality (Bonsor et al., 2015). Our findings suggest that it is necessary for community actors to better understand which repairs they are capable of handling and which require external support. When external support is necessary, community actors must know which external actors should be contacted and how to contact them.

Management rehabilitation pathways that involve external support actors, such as regional water committee associations, are useful where communities do not have excellent internal oversight processes and trusted local leaders that enable management failures to be addressed without external support. Post-construction support programs often focus on both technical and administrative guidance and assistance (Kayser et al., 2014; Whittington et al., 2009). These programs should be improved with better understanding of how to best support water committee operations as well as water system functionality. Pragmatic programming should anticipate management failure and ensure that relevant support is in place to help communities rehabilitate water committees.

Limitations and generalizability

The qualitative data used for this analysis come from six communities each in Ghana, Kenya, and Zambia. While communities were chosen to represent a variety of water system types and ages and water management committee characteristics, they are not representative of communities in each study country or across sub-Saharan Africa. Data were gathered from several actors in each study community (community members, water committee members, and other local leaders) and through both interviews and FGDs for community members and water committee members in order to triangulate information between different activities and improve internal validity.

The rehabilitation pathways are derived from our data; others may exist, and the details of the pathways might vary in other contexts.

Study communities were selected based on the presence of a functional water system at the time of a representative survey of WV systems. Thus, experiences of community actors with water systems that had failed terminally were not our focus, although several study communities had additional water systems that were non-functional and we also collected data on participants' experiences with these systems. It is possible that some of the rehabilitation constraints that lead to long-term or permanent non-functionality are not present in the data because of the focus on functional systems.

We did not collect quantitative data about the cost and duration of rehabilitation of broken water systems in this study.

All but one of the study communities had engaged with World Vision in the implementation and support of at least one of their water systems. World Vision has a distinct community engagement model which is not representative of external support in sub-Saharan Africa or

elsewhere. Rehabilitation pathways could be different for community-managed water systems with other external support actors.

Data were collected between June and August 2015 and thus seasonal trends in water system services and sustainability (Kostyla et al., 2015) are unlikely to have been detected.

Conclusions

This study provides new insight about hardware and management rehabilitation for community-managed water systems and to our knowledge, is one of the first to document these processes. We found that community actors are always involved in hardware and management rehabilitation. When external support is needed, there are often communication challenges with external actors that prevent rapid rehabilitation. There is no strict dichotomy between hardware rehabilitation and management rehabilitation. Steps for both are similar, similar actors sometimes play a role in both hardware and management rehabilitation, and there is overlap in the constraints that prevent rapid rehabilitation. External technical support was frequently used for hardware rehabilitation, which speaks to the importance of post-construction support that is accessible to community water management committees long after a water system is implemented.

This work identifies opportunities to increase functionality, sustainability, and impact of water supply interventions. Governments, NGOs, and private sector actors can better engage with community actors to ensure that capacity building focuses on understanding the role of community and external actors in rehabilitation. Specifically, governments, NGOs, and private sector actors could increase rehabilitation of community-managed water systems by better ensuring that backstopping is available in all cases and that community actors know who to contact when external support is required.

We suggest using the findings of qualitative and participatory studies to inform better monitoring survey questions on rural water system sustainability. We identified the functional roles necessary for water system hardware and management rehabilitation, and we suggest that future surveys investigate whether all necessary rehabilitation functions are fulfilled to identify gaps in supporting rehabilitation. Additionally, future monitoring surveys could include questions on the costs and timeframe of the rehabilitation carried out via the pathways identified in this paper.

Finally, this research used qualitative and participatory methods to explore rehabilitation and success in water system sustainability rather than failure. This approach enables new insights in two ways. First, since success is not necessarily the converse of failure, identifying determinants of system failure is not always an effective way to understand success. By looking at rehabilitation processes, we are able to understand how these processes work and suggest ways to improve them. Second, this shift from focus on failure to rehabilitation requires a shift in methods. The use of qualitative and participatory methods has allowed for insights into *how* the rehabilitation process occurs and could be improved, insights not readily available from analysis of quantitative survey data. We suggest using qualitative and

participatory methods focused on success rather than failure for future research on other WaSH challenges related to processes such as sanitation and hygiene behavior change.

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Highlights

- Four hardware and three management pathways were identified
- Pathways show how resources can be leveraged to restore hardware and management
- Focusing on rehabilitation rather than failure
- Poor communication between communities and external actors is a rehabilitation barrier
- Community capacity building can enhance rehabilitation

Figure 1. Functional roles played in each step of the four pathways for water system hardware rehabilitation. Table and pathways derived from qualitative data on 18 community-managed water systems in Ghana, Kenya, and Zambia.

Figure 2. Functional roles played for each step of the three pathways for water system management rehabilitation. Table and pathways derived from qualitative data on 18 community-managed water systems in Ghana, Kenya, and Zambia.

Table 1

Functional roles for water system hardware and management rehabilitation. Derived from qualitative data on 18 community-managed water systems in Ghana, Kenya, and Zambia.

Functional role	Definition	Examples
Users	Use water from the water system, participate in community meetings, and contribute to rehabilitation costs	Community members, water committee members, local leaders, mechanics
Referrers	Connect system users or service providers to technical or financial resources	Water committee members, local leaders, government employees, WV employees, water committee associations
Fixers	Rehabilitate hardware and management issues	Mechanics, technicians, WV employees
Service providers	Manage the water system	Water committee members, local leaders
External financial support providers	Channel funding for rehabilitation	Government employees, WV employees
Service authority	Support water system management	Government employees, water committee associations

Table 2

Constraints that slow or halt rehabilitation for each step in the four pathways for water system hardware rehabilitation. Table and pathways derived from qualitative data on 18 community-managed water systems in Ghana, Kenya, and Zambia.

Step	Constraints that slow rehabilitation	Constraints that halt rehabilitation
Diagnose problem	Limited knowledge of how water system should operate	Lack of use of system or lack of interest in rehabilitating system
Contact technical support	Lack of clarity about which technical support actor should be contacted Relevant technical support actors are located far from the community Professional technical support is expensive Mechanic has another job, lives in another community or serves multiple communities Communication is challenging	Mechanic moved away or impossible to reach
Acquire financial resources	Committee does not have savings for parts or tools immediately available Poor proposal writing abilities Confusion about which external support actor should be contacted Slow response from external support providers	No knowledge of external support providers Unresponsive external support
Acquire materials	Spare parts or tools only available outside of community Hardware store is far away Poor transportation options to collect materials	No money available for parts or tools
Repair hardware	Unforeseen technical challenges	Lack of knowledge of system and attempted repair leads to a worse breakdown

Table 3

Constraints that slow or halt rehabilitation for each step of the three pathways for water management rehabilitation. Table and pathways derived from qualitative data on 18 community-managed water systems in Ghana, Kenya, and Zambia.

Step	Constraints that slow rehabilitation	Constraints that halt rehabilitation
Diagnose problem	Community members and leaders' lack of awareness of water committee responsibilities and actions Infrequent monitoring/auditing	Lack of use of system or lack of interest in having an effective water committee
Contact local leaders or external support	Confusion or lack of knowledge of relevant support actors Communication challenging	External support unresponsive Individuals that identify problem fear to point it out
Meet with relevant actors	No well-known oversight processes in community	External support actors not seen as agents of change
Rehabilitate management		New committee members not trained or prepared for their role