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Research Paper

Revealing causal pathways to sustainable water service delivery using fsQCA

Kate E. Gasparro and Jeffrey P. Walters

ABSTRACT

This study aimed to build on theory and practice regarding the combinations of conditions that influence water service sustainability when external partners are involved. The study investigates 26 well projects that have been implemented in developing countries with the assistance of Engineers Without Borders-USA (EWB-USA). Using past literature on sustainable water service delivery in developing communities, emergent coding techniques with project documents, and surveys with EWB-USA team members, this study identifies a set of project conditions to conduct fuzzy-set Qualitative Comparative Analysis (fsQCA). Findings show that the presence of a water committee cannot alone account for project sustainability. Additional conditions, such as technology and construction processes, project governance, and community engagement practices must also be considered for project sustainability. The relationship between construction quality and financial sustainability is also discussed. Overall, the findings from this research contribute to sector theory and reveal distinct pathways towards sustainable water services. These findings informed recommendations for EWB-USA well project implementation and management, and demonstrate the utility of fsQCA as a tool to navigate the complexities of water service delivery by external partners and improve understanding to increase water service sustainability.

Key words | causal pathways, engineers without borders, external partners, fuzzy set qualitative comparative analysis, sustainable service delivery, WASH

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INTRODUCTION

There has been a steadily increasing trend of private investment from external partners in infrastructure delivery in developing countries (Harris 2003). These external partners are not based within the communities they work with, but ‘partner’ with them to help implement and sometimes manage an infrastructure solution. Examples of external partners include internationally and locally based non-governmental organizations (NGOs) or organizations, bilateral and multilateral aid agencies, faith-based organizations, or private businesses. Inherently, external partners lack intimate knowledge about and are often seen as outsiders by the communities with whom they work. Even though external

partners provide resources during water service delivery, inclusion of external partners can lead to unintended consequences, such as an over-prioritization of profits above community needs (Ortiz & Buxbaum 2008), a discordance between implemented infrastructure and community skill and culture (Mansuri & Rao 2004), and undermining the decision-making processes and frameworks used by local government officials (Isham & Kähkönen 1999). Such unintended consequences jeopardize the success of infrastructure projects and service delivery. While these consequences can result in unsustainable water service, there are other conditions that can also lead to negative project

outcomes, such as technical failure and poor design, which do not necessarily depend upon the relationship between the community and external partner (Harvey & Reed 2004). Despite the best intentions of external partners, a field survey conducted in Africa in 2009 found that these unintended consequences led to lack of well maintenance and accounted for thousands of unused wells. This resulted in between \$215 million and \$360 million of failed investment (Skinner 2009). With the introduction of the Sustainable Development Goals in 2015, there continues to be interest in expanding, as well as sustaining, water infrastructure in developing communities. Therefore, it is important that as external partners continue to provide technical, logistical, and financial support for these projects they understand the extent of their involvement and work to mitigate any harmful or negative unintended consequences of working in developing communities.

Past research in water infrastructure has created a strong body of work that supports, as well as refutes, strategies for improving sustainable water service delivery in developing communities. Carter (1999) speaks about the context of water supply projects in developing communities and the history of sustainability among practitioners and academics. Within his study, Carter identifies stakeholder involvement, project maintenance, cost recovery, and continued support from a government or oversight organization as essential for sustainable project outcomes (Carter 1999). Through assessment of past research on water infrastructure, Lockwood *et al.* (2003) identify a list of conditions that are influential in project implementation and management. The most important conditions from their study include maintenance and spare parts availability, financial recovery, community management capacity, motivation and willingness to pay, and external follow-up support and training (Lockwood *et al.* 2003). Another study (Whittington *et al.* 2009) examines the conditions that lead to project outcomes in Bolivia, Peru and Ghana, highlighting the demand-driven community management model in conjunction with spare parts and technical expertise as essential for project sustainability. A similar study by Montgomery *et al.* (2009) evaluated project conditions among water and sanitation infrastructure in rural sub-Saharan Africa. The authors from this study find that effective local demand, local financing and cost recovery, and dynamic operation and maintenance

were the most significant conditions for predicting project sustainability (Montgomery *et al.* 2009). Finally, and most recently, a study by Walters & Javernick-Will (2015) used a system dynamics approach for deriving the most important conditions for water and sanitation infrastructure delivery in developing countries. After conducting a comprehensive literature review of articles referencing sustainable WASH infrastructure, the authors identified factors that impact water service sustainability. The factors were then sent to a panel of experts who systematically identified how the factors influenced long-term functionality of water services. At the end of their analyses, the authors find community engagement, financial recovery, and local management are influential factors for water service sustainability (Walters & Javernick-Will 2015).

There are common conditions that appear within the aforementioned studies as key predictors of WASH service sustainability, specifically: operation and maintenance (O&M) capabilities, local management, financial sustainability, community demand, and supply chain access. This research aims to compare, contrast and contribute to these collective findings by investigating the complex combination of conditions that influence water service and infrastructure sustainability in cases where external partners are embedded within the project planning, implementation and management phases. To accomplish this objective, this study employs fuzzy-set Qualitative Comparative Analysis (fsQCA) to rigorously evaluate the most impactful combinations of conditions that lead to sustainable water service. This research uses well project cases implemented by Engineers Without Borders-USA (EWB-USA) to provide an empirical backdrop. There were several reasons, besides the commonplace practice of well construction, to study well infrastructure. First, well infrastructure planning, design, and construction require specialty equipment and technical skill. Second, because wells are complex infrastructure assets, they require a certain level of monitoring, maintenance and operations. These two considerations for well infrastructure foreshadow potential issues that could deter WASH project sustainability. Given this context, this research sought to answer two overarching research questions:

1. What conditions (project strategies) are important for sustainable water services?

2. When external partners provide resources during infrastructure delivery in developing communities, what combination of conditions lead to sustainable water service outcomes?

METHODS

Past research shows that multiple interlinked project conditions must work together to achieve desired WASH service outcomes (Chatterley *et al.* 2013; Kaminsky & Javernick-Will 2014; Neely & Walters 2016). Qualitative comparative analysis (QCA) uses qualitative and/or quantitative data to identify causal pathways of independent project conditions that lead to a specific dependent outcome (Kaminsky & Jordan 2017). QCA can analyze a medium to large sample size and, in doing so, identify patterns of independent variables (conditions) that lead to a specific dependent variable (outcome). Because QCA identifies patterns (otherwise known as causal pathways), the methodology does not look at individual conditions in relation to the outcome. Rather, as a system, the methodology identifies what conditions, when interacting with other conditions, lead to the specified outcome (Ragin 2008). Therefore, the methodology relies heavily on the researcher's understanding of past theory and the sample set to determine which conditions are relevant to the specified outcome. As such, QCA capitalizes on the nuanced understanding of each case and the researcher's ability to accurately decipher and calibrate each causal condition (Jordan *et al.* 2011). Although QCA is a powerful research methodology, QCA can only handle a small number of causal conditions and each condition is calibrated on the same scale across all case studies (losing some of the case nuances). In summary, QCA's two step approach (condition identification and causal pathway formation) aligns with the two research questions.

There are three types of QCA (crisp-set QCA, multi-value QCA, and fuzzy-set QCA) that can be used depending upon access to case detail and data granularity. Crisp-set QCA (csQCA) only uses 0 (absence of a condition) and 1 (presence of condition) scores and is employed when there is a lack of data granularity and/or each condition is dichotomous. Multi-value QCA (mvQCA) can capture more

categories by allowing the scoring range to reflect discrete options (usually as whole numbers: 0, 1, 2, etc.). Last, fuzzy-set QCA (fsQCA) requires detailed data and does not require a preset scale for all conditions. For example, within the same case one condition could be scored on a non-dichotomous scale while another condition could be scored based on a calibration rubric with five scores (e.g. 0, 0.2, 0.4, 0.7, 1). Because of the data granularity available for this study and the nuanced nature of project conditions and sustainability, fsQCA was selected.

Figure 1 illustrates the four-step process – conjointly with associated activities and outputs – employed to assess the conditions and causal pathways for sustainable water services using fsQCA. A description of each step is provided below.

Step 1: Select sample set

The research sample set was developed based on access to EWB-USA's available and implemented water well projects. Among the community development projects EWB-USA chapters have implemented between 2002 and 2016, 36 projects have been well projects. In selecting the final set of cases for the study, the following criteria were used: (1) the project occurred in a developing country in coordination with a community; (2) EWB-USA was involved with the project design, implementation, and funding; (3) the entirety of the well project was constructed; and (4) there is adequate project documentation. Ten cases were removed from the original sample of 36 cases because they did not meet one or more of these criteria. The remaining 26 cases were continuously checked to ensure variability within project conditions, as well as project outcome, thereby ensuring the logic space was covered. The projects were located in rural communities (of varying population and geographic size) in developing countries. The countries included in this study are Cameroon, Dominican Republic, El Salvador, Ghana, Haiti, Honduras, India, Kenya, Nicaragua, Nigeria, Peru, Philippines, Sierra Leone, Tanzania, Uganda, and Zambia. Most of the well projects were deep wells, requiring drilling expertise and equipment. In some cases, the wells were hand dug and, in one case, the community constructed a horizontal well. A similarity among all well types was the need to select a proper location for the well and to

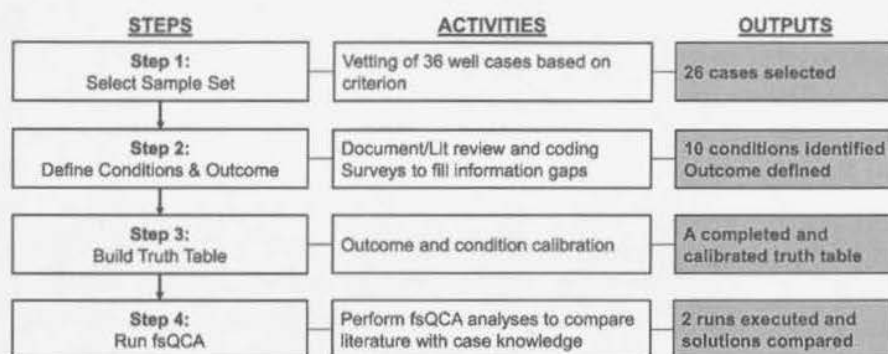


Figure 1 | The four-step research process.

coordinate subsurface and aboveground construction. Additionally, the construction completion dates for the projects within the sample set ranged from 2008 to 2016. As part of meeting the sample selection criteria, each project has a formal or informal monitoring report that occurred in the year following construction completion.

Step 2: Define conditions and outcome

Once the sample set was established, the research team organized the implementation, monitoring and evaluation, and closeout documents for each project. Data collected for this research was primarily based on the availability of project documents from EWB-USA. These project documents, which are written by EWB-USA project participants and then reviewed by a professional engineer at EWB-USA headquarters, offer a firsthand perspective into the cases, including detailed information about project timelines, stakeholders, design and implementation, and community engagement practices. As such, these documents served as the foundation for identifying conditions and understanding the relationship between various conditions and outcomes.

The documents were comprehensively coded using an emergent coding methodology, where the codes were created and defined as the document review occurred. Some codes identified structural elements of the reports, while other codes identified construction and community management practices, such as capital cost contribution, women's involvement, fee structures, and water committee dynamics. Within the first round of document review, a code dictionary including nearly 30 codes was created to reflect the nuances within each case of the sample. Together, the dictionary and coded

documents were verified between authors. During the second round of document review, the data were consolidated into 16 conditions, and the outcomes were identified for each case. Given the sample size of 26 cases, the number of conditions needed to be further reduced (Jordan *et al.* 2011). The 16 conditions were narrowed down to ten conditions. These ten conditions reflect findings from the five aforementioned studies (Carter 1999; Lockwood *et al.* 2003; Whittington *et al.* 2009; Montgomery *et al.* 2009; Walters & Javernick-Will 2015) and are cited as being significant in achieving a sustainable project. Table 1 shows how each of the ten conditions appeared in the five selected studies. The complete list and definition of these conditions can be found in Table S1 (available with the online version of this paper).

To further contextualize these ten conditions and to help bridge gaps within the project documents, a survey was constructed and disseminated to EWB-USA project participants, including program leads, the responsible engineers in charge, and planning, monitoring, evaluation and learning (PMEL) leads from multiple generation of project teams. There was at least one survey response collected for 17 of the 26 projects. For cases that did not have a survey response from a EWB-USA program participant, the research team took the survey on behalf of the EWB-USA chapter. This was considered a satisfactory way to proceed given the researcher's extensive case knowledge from the project reports. The survey, which was approved by the Stanford Institutional Review Board, included qualitative, open-answer survey questions, as well as quantitative questions to elicit project participants' insights on project conditions and outcomes. For example, for the *partner* condition, the following questions were asked: 'Was there a

Table 1 | Appearance of the ten conditions [in italics] in the five selected studies

Study	Conditions
Carter (1999)	Motivation [<i>community initiative, community engagement</i>]; Project maintenance [<i>technology transfer, water committee</i>]; Cost recovery [<i>financial sustainability</i>]; Continued support from a government or oversight organization [<i>partner</i>]
Lockwood <i>et al.</i> (2003)	Maintenance [<i>technology transfer</i>]; Spare parts [<i>local resources</i>]; Adequate tariff [<i>financial sustainability</i>]; Community management capacity [<i>water committee</i>]; User satisfaction, motivation and willingness to pay [<i>community initiative, community engagement</i>]; External follow-up support [<i>partner</i>]; Continued training and support [<i>education</i>]
Whittington <i>et al.</i> (2009)	Demand driven [<i>community engagement</i>]; Community management model in conjunction with spare parts and technical expertise [<i>water committee, local resources</i>]; Financial and managerial post construction support [<i>partner, financial sustainability</i>]; Technical training [<i>technology transfer</i>]; Trust of neighbors [<i>community dynamics</i>]
Montgomery <i>et al.</i> (2009)	Participatory planning [<i>community engagement</i>]; Appropriate technology choice [<i>technology transfer</i>]; Social marketing [<i>education</i>]; Local borrowing and saving schemes, financial planning, community cross-subsidies [<i>financial sustainability</i>]; Clear management responsibilities [<i>water committee</i>]; Accessible spare parts/technical expertise [<i>local resources</i>]; Monitoring/evaluation, ongoing outreach and support [<i>partner</i>]
Walters & Javernick-Will (2015)	Community participation, demand, satisfaction [<i>community engagement</i>]; Finances, cost recovery, financial management, cost of system [<i>financial sustainability</i>]; Management, maintenance, skilled operator [<i>technology transfer</i>]; Technology, construction, materials, spare parts [<i>local resources</i>]; Appropriate technology, construction quality [<i>construction quality</i>]

partner working with the chapter during project implementation?'; 'Explain the relationship with the partner organization?'; 'Is the partner located within or near the community?'; and 'How important was the partner's involvement to project implementation?'

Step 3: Build a truth table

The next step in conducting fsQCA is to create a 'truth table,' with each condition calibrated on a scale between 0 and 1, to import into the fsQCA software for subsequent analyses. The truth table used in this study is shown in Table S3. A truth table is a matrix which houses calibrated condition scores for each case. Intermediate scores between 0 and 1 were determined based on the incremental condition presence and anchor points derived from case knowledge. The calibration rubric can be found in the Supplementary materials section, Table S2. (Tables S2 and S3 are available with the online version of this paper.) The calibration process relied heavily on anchor points informed by the project documents. Anchor points were set for each condition as either 0 (completely outside the set), 0.33 (partially outside the set), 0.67 (partially in the set) or 1 (completely in the set). For example, the presence of the *local resources* condition reflects the ease

or difficulty in obtaining critical system parts. Within the cases, the following anchor points were derived for the location of these critical system parts: near or within the community (1), within the country (0.67), in a nearby country (0.33), and brought by the EWB-USA chapter (0). Each condition was calibrated using a similar schema.

Project sustainability, as the outcome condition, was calculated based on an aggregated score of system functionality as well as water quality, quantity, and reliability (see Table S2). If the project was not functional, the outcome score was 0 regardless of water quality, quantity, and reliability. Water quality failed if recent monitoring reports or survey responses showed that water quality metrics did not meet testing standards. Water quantity was determined based on reports and survey responses where participants indicated that they believed the water supplied by the well met user demand. Reliability reflects the report information and survey responses where participants indicated if there were issues with service continuity. The EWB-USA project participants who took the survey were asked about their current relationships with the community and provided information about the current state of the well system, informed by formal reporting mechanisms and informal communication lines with the community.

Step 4: Run fsQCA

For this research, the open source software 'fs/QCA' was used to perform the analyses (fs/QCA 2009). According to fsQCA best practices, it was necessary to reduce the ten selected conditions down to six or seven conditions (Jordan *et al.* 2011). Because the aim of this research was to build upon sustainability theory from past works, this study opted to run two unique runs – using six and seven of the ten conditions, respectively. To contrast and build upon theory, Run 1 was based on conditions that appeared within three or more of the five selected studies (Table 1), while Run 2 used conditions selected using the authors' case knowledge in conjunction with a super-set analysis (single condition consistency scores) of project conditions.

Each run resulted in three sets of pathways (complex, parsimonious, and intermediate) that made specific assumptions about the run conditions and their relationship to the outcome. Following best practices in fsQCA research, the complex and parsimonious solution sets were not used, as complex solutions (no assumed counterfactuals) can be difficult to interpret, while parsimonious solutions (software inferred counterfactuals) can oversimplify and conceal context-specific nuances (Kaminsky & Jordan 2017). Instead, the intermediate solution set was used, as it is based on the research team's assumptions that the presence of each run's set of conditions would have a positive impact on the case outcome (which correlates to the calibration rubric). The intermediate solution pathways leading to sustainable water service were evaluated for level of significance using consistency and coverage metrics. Akin to statistical significance, consistency measures the degree to which cases sharing the same causal pathway solution have the same outcome, while coverage measures the degree to which the outcomes are covered by the causal pathway solution (Ragin 2006; Kaminsky & Jordan 2017). Values for consistency and coverage range from 0 to 1. For the purposes of this research, the fsQCA analysis was carried out using a significance value of 0.8, which is a best practice for fsQCA analysis (Jordan *et al.* 2011; Wagemann & Schneider 2014).

RESULTS AND DISCUSSION

This section discusses the study findings evaluating 26 EWB-USA well project cases using coding strategies and fsQCA. First, the ten conditions that influence project sustainability are discussed (addressing the first research question). Second, the two runs, one based on literature (Run 1) and the other based on case knowledge and consistency scores (Run 2) are examined. The resulting causal pathway solutions are then assessed for consistency and coverage and contextually expanded upon based on the emergent themes from the document coding and surveys (addressing the second research question). Finally, the salient implications for theory and practice are summarized, highlighting strategies for both EWB project engagement and external partner engagement within the wider WASH sector.

Conditions

To address the first research question, the authors used emergent coding strategies and relevant sector literature to reduce the original 30 codes to ten succinct project conditions. These ten project conditions were organized within three overarching categories: technology and construction, governance, and community engagement. Conditions within the technology and construction category assess the extent to which sustainable technologies and processes were employed during project delivery, as well as the local conditions and technical capacity for O&M (Katsi 2007). The conditions that fit this category included: *construction quality*, *local resources*, and *technology transfer*. The governance category includes conditions that may influence the community's ability to perform O&M. In many cases, and in past research, governance is identified as having proper community-based management of the system which can increase water service reliability (Giné & Pérez-foguet 2008). Therefore, in this study, the conditions that fall under the governance category include *community dynamics*, *partner*, *water committee*, and *financial sustainability*. Finally, the community engagement category measures the extent to which the community was involved with the project implementation process. Not only is community engagement important for providing local

Figure 2 | Intermediate solution pathways for the two IsQCA runs based on the literature (R1) and authors' case knowledge (R2); ~ indicates the absence of a condition; # Cases indicates the number of cases with greater than 0.5 membership in each pathway.

[The partner] helps the community collect taxes for any repairs that the water system may need and is equipped with the contacts for an electrician should any of the electrical components on the system be damaged.'

With the assistance of a strong partner, this community did not have to rely on local resources for maintenance activities; instead the partner was able to provide contacts and logistical support for locating the necessary resources for the project.

Second, while financial sustainability was mentioned within each of the five studies, it did not appear in either solution pathway. Financial sustainability in these studies relates to the community's 'ability to cover recurrent costs' (Lockwood *et al.* 2003, p. 13) and 'financially support the costs associated with operation, maintenance, and eventual replacement of the rural water system' (Walters & Javernick-Will 2015, p. 5037). Within this research, *financial sustainability* was coded based on the community's ability to pay for recurring O&M costs based on user fees and other sources, as voiced in project documentation and survey responses. Checking this within the data set, *financial sustainability* had the lowest consistency score of 0.488, falling well below the 0.9 consistency score that is required for a necessary condition. Given the prevalence of financial sustainability within the literature, Run 2 sought to better understand how financial sustainability, in combination with another condition, could lead to well project sustainability.

Run 2: Case knowledge

In selecting conditions that fit the authors' case knowledge and intuition, attention was redirected towards both the literature and consistency scores within the data set. When running the consistency scores for all ten conditions, *construction quality* had the second highest consistency, 0.852. Referring back to theory and the sample set cases, *construction quality* was highlighted as key for project sustainability. Indeed, a poorly constructed project can result in added maintenance and lead to unexpectedly high maintenance and reconstruction costs, directly impacting *financial sustainability*. In other words, the relationship between *construction quality* and *financial sustainability* conceivably hints at a pathway relationship with these two

conditions. Thus, for Run 2, *construction quality* was selected as a condition to add to the six conditions from the literature used for Run 1.

Run 2 resulted in three pathways with a solution set consistency and coverage that are nearly equivalent to Run 1. These results present two compelling observations. First, with Run 2, *construction quality* and *financial sustainability* appear to have a 'see-saw' effect, where the existence of one omits existence of the other. This interchangeability of *construction quality* and *financial sustainability* is further demonstrated by the closeness in consistency and coverage scores between Run 1 (0.8085 and 0.8078) and Run 2 (0.8089 and 0.8077). Second, the two pathways that share *construction quality* include only three conditions, while the third pathway with *financial sustainability* includes six. It can be inferred from these pathways that high *construction quality* requires a simpler set of accompanying conditions, such as a strong *water committee* and *external partner*, to result in a sustainable well project. This aligns with the literature reference to construction quality and project sustainability: 'water quality or overall satisfaction with system may depend on construction' (Whittington *et al.* 2009, p. 721) and 'if construction quality was poor, systems had a lower chance of sustainability' (Sara & Katz 2004, p. 50). One case that is represented by the second pathway had a high *construction quality* score because construction issues were quickly repaired during the construction phase preventing small errors from becoming operational issues. The project also benefitted from having a strong water committee 'responsible for all aspects of oversight and ownership of the project.' All water committee 'members [received] intensive project training during and after the implementation phase' and facilitate project maintenance and repair without having to spend money to hire an outside technician. The combination of *construction quality*, *water committee*, and *technology transfer* substituted for high *financial sustainability* to result in positive project outcomes.

The third pathway within this run includes a case that shows the interplay between *financial sustainability* and *construction quality*, and the need for many conditions when *construction quality* is absent. This project had a construction issue with the sanitary seal, which threatened the quality of the water source. The project was able to move forward successfully because of the involvement of a strong partner who

provided chlorine dispensers and an involved community that was engaged during the design process and helped to select appropriate technology. Further, the community attended training sessions to become 'promoters' for protecting the water service and raised additional funds to construct a protective fence around the well. The presence of so many conditions was able to override the near fatal construction quality of the project.

Implications for EWB and the water sector

The persistent emergence of the *water committee* condition in intermediate pathway solutions for Run 1 and Run 2, along with its high consistency score (0.873), proves that it is the most important single condition for achieving project sustainability. Therefore, external partners need to ensure a strong water committee is present before construction of the service is completed. Based upon case analyses, there were several best practices that EWB-USA chapters and communities implemented that increased the chances of having a functioning water committee; first is the importance of identifying a water committee from the earliest interaction with the community; and second is the importance of water committee legitimacy within the community to best execute its O&M tasks. Without legitimacy within the community, the water committee will have difficulty when collecting user fees, changing user fees, and changing service provisions. For these reasons, it is important that the external partner allows the water committee to have a voice in public decision-making. Finally, to help maintain good management and governance practices within the water committee, it is important for the external partner to introduce or encourage practices that mitigate potential conflicts within the water committee.

While a strong water committee improves the likelihood of project success, it cannot solely account for project sustainability. Additional conditions from the technology and construction processes, project governance, and community engagement categories must also be considered for project sustainability. For example, the results from all fsQCA runs show *technology transfer* as a recurrent strategy. *Technology transfer* refers to the ability for the community to operate and maintain the water supply service. Another condition that continued to appear was *partner*, showing that

having a strong and consistent partner organization (such as an NGO) within the community has a positive influence on project sustainability.

Another interesting finding was the potential interchangeability between high *construction quality* and *financial sustainability* – where the existence of the former supersedes the latter, and vice versa. Moreover, analysis of the solution pathways (Run 2) showed that if a well technology is well-constructed, there are fewer support strategies that external partners need to implement to achieve project sustainability. In other words, while ensuring construction quality intuitively influences sustained well functionality, perhaps these findings show additional precedence for strong and robust infrastructure to minimize the need for a complex and interdependent set of programming strategies.

In general, these insights on important project condition combinations may be helpful for external partners who provide technology, logistical, and financial resources to developing communities during water service delivery, as well as for different levels of government who provide support to communities during infrastructure delivery, operations, and maintenance. The study findings suggest that higher levels of government (at the state and federal level), as well as multilateral organizations, should conditionally provide funding pending the inclusion of specific conditions, such as a water committee. Regardless of the community context, external partners should also conduct a basic evaluation of the community's resources, strengths, and weaknesses to understand which strategies will be well received by the community during project delivery. It is during this process that the external partner should build rapport with the community and community leaders to facilitate the working partnership. Overall, the more that the external partner can engage with, identify, and rely upon the community's strengths, the easier it will be to remove themselves during the O&M phase and have faith that the community can and will continue to sustainably manage the service.

CONCLUSIONS

To better understand which factors can predict sustainable water infrastructure in light of transitory external

partner engagement, this study investigated EWB-USA well projects to identify the combinations of project conditions that enabled water service sustainability. This objective was accomplished by collection of qualitative and quantitative data that culminated with fsQCA analysis of causal conditions and outcomes for 26 different EWB-USA well project cases. The study findings aligned well with sector literature and revealed several distinct pathways towards sustainable well infrastructure O&M that highlight the importance of strong water committee formation, along with solid technology and construction processes and project governance. The geo-political scope of these projects offers insights for the water sector in general, and EWB-USA in particular, for how external partners should engage with and then withdraw from community well projects. Among these findings was the highlighted importance of construction quality, and the potential for a well-designed and well-constructed well system to lessen the need for complex programming strategies that focus heavily on financial sustainability for service repair.

Several limitations exist with this research, including the relatively small sample size confined to well projects within different stages of O&M. The main limitation of this work is the reliance on project reports and EWB member surveys, which offer subjective perspectives of these projects. Future research has the potential to mitigate these limitations and produce stronger results for creating policy proposals for external partners. First, a larger fsQCA study that includes more community well project cases and reliable data sources, could improve the validity of the results by providing regional and country-specific conditions that change water service delivery outcomes. Second, while this study focuses on EWB-USA specifically, additional research could expand upon the analysis and results by comparing and contrasting the use of different external partners. The methodology could use a sample in which multiple external partners are included, or a parallel study that creates a sample from one external partner. Indeed, the strength of using fsQCA is being able to quantify and organize intimate case knowledge for more generalizable findings. This methodology was able to show the nuances of the relationships between external partners and communities,

while at the same time identifying the range of project conditions, and combinations of these conditions, that influence project sustainability. Consequently, this research was able to confirm the significance of seven project conditions, as identified in the literature, and show how these conditions can be combined in unique ways to achieve well project sustainability.

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