Research Report

Sustainable WASH Systems Learning Partnership

SUMMARY REPORT OF BASELINE IFML ANALYSES IN KAMULI DISTRICT, UGANDA

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SUSTAINABLE WASH SYSTEMS
A LEARNING PARTNERSHIP

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Front cover: Whave staff conducting an IFML session in Namwendwa Sub-county, Kamuli District, Uganda. Photo credit: Nicholas Valcourt.

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Executive Summary

This report presents a synopsis of findings from a factor mapping activity conducted by the University of Colorado Boulder (UCB) and Whave, a non-profit social enterprise, with key stakeholders in Kamuli District, Uganda. The analysis is part of the iterative factor mapping and learning (IFML) process, a participatory, stakeholder-driven approach for collecting and analyzing insights into how different local factors impact the success of water, sanitation, and hygiene (WASH) projects and policies. The analysis identified several factors, described by stakeholders, that could be used as leverage points to affect positive and sustainable improvement of reliable water source functionality in Kamuli District.

Methodology

The factor mapping process employs a complementary suite of systems analysis techniques to analyze information collected during group model building sessions with key local stakeholders. The process includes a facilitated workshop in which participants are asked to identify the key factors affecting the sustainability of rural water services and then map the relationships between each of these factors. The exercise evaluates how participants believe factors interact as a system to affect WASH service delivery outcomes. The output of the session is a cross-impact matrix that represents participants' perspectives of the interactions between factors driving WASH service delivery outcomes. Three systems analysis techniques are used to interpret the cross-impact matrix: influence mapping, centrality analysis, and causal loop analysis. Influence mapping and centrality analysis identify potential leverage points in the WASH system. These leverage points represent factors and processes where small changes can produce larger changes that affect the whole system, resulting in improved outcomes. Causal loop analysis adds further depth to understanding how leverage points affect the system by showing how factors form dynamic causal chains known as feedback loops. The combined results from these systems analyses are intended to be used, as appropriate, to inform interventions that strategically target key elements of the WASH system to promote more sustainable service outcomes.

Findings

Combining the outputs of the various systems analyses with a qualitative review of information gathered during the activity, the analysis identified three key findings: (1) each stakeholder group sees the local system from their perspective; (2) the ability of water user committees to collect water user fees is key to functionality and preventive maintenance; and (3) government support, regulation, and politics are under-prioritized. To address these issues, three key recommendations are proposed for Whave and their partners: (1) show each group their role in the system so they can strengthen the system together; (2) strengthen water user committees' ability to collect fees; and (3) strengthen the regulatory enabling environment for rural water service delivery. In line with the systems-based approach of the analysis, any actions taken to address these key findings and proposed recommendations should be evaluated to understand how they can lead to changes in the outcomes of the system (i.e., reliable water source functionality) or how they may change the underlying structure of the system. Overall, the findings point to the need to promote more holistic thinking among local stakeholders to consider the larger enabling environment required for improving the sustainability of water services.

Introduction

This report presents an overview of results from a suite of systems analyses performed on data collected during multiple factor mapping workshops in Kamuli District, Uganda. The activity was part of the IFML process, a stakeholder-driven activity that seeks to increase participants' systems thinking skills by sharing, challenging, and making explicit their assumptions of how local issues arise from a complex interaction of unique factors. During the activity, stakeholders are asked to describe what specific elements, or factors, they believe influence the reliable functionality of rural water services (i.e., sustainability) and the interdependencies of those factors. The resulting cross-impact matrix of factors and connections is then analyzed to investigate different aspects of the complex system and describe how observable outcomes result from the structure of the system. The overall goal of the activity and analysis is two-fold: (1) to increase stakeholders' understanding of how factors operate together as a system and (2) to identify potential leverage points within local systems that can be used to increase the likelihood of sustainability of rural water service delivery. The resulting analysis is a combination of systems-based quantitative methods informed by qualitative observations of the participants' discussions.

Context

The workshops presented in this report were part of an ongoing process of Whave engaging local government under the Sustainable WASH Systems Learning Partnership (SWS). Existing rural water services in the district are delivered through a system of community-based management schemes with varying levels of revenue collection and external financial support. Currently, most maintenance services are provided through the government through Hand Pump Mechanics Associations (HPMAs). This approach exhibits many inefficiencies in consistently providing water services, an issue Whave is actively seeking to address through the introduction of preventive maintenance services coupled with advocacy for an improved regulatory environment for the delivery of these services through private contractors or public-private partnerships.

UCB and Whave conducted the factor mapping workshops on Apr. 16–20, 2018 and Oct. 1, 2018, in Kamuli District, Uganda. Whave conducted a social network analysis 2 weeks prior with many of the same participants. After consulting the Whave managers in Kamuli District, they recommended the phrase "reliable water source functionality" as the "outcome factor," or workshop focus topic. Participants could easily understand this suggestion, and the terms "reliable" and "functionality" emphasize the strong and sustainable delivery of water sources. Some groups used slightly different wording for the outcome factor, including "functional, reliable water" and "water sources functioning." Each group was asked to define the attributes of this outcome factor, as described in the following section.

The workshops engaged a total of 57 participants from district government (15), Sub-county government (12), water user committees (12), Whave staff (9), and the HPMA (9). Each stakeholder group worked together during the workshops. Collectively, these participants represent different perspectives on the factors that influence reliable water source functionality in Kamuli District. On average, the workshops lasted 3 hours. They were predominantly conducted in English, though participants discussed factors and interconnections in the local language of Lusoga for a portion of each session.

Factor Mapping Activity

While each workshop varied in length, all were conducted with the same agenda and set of activities. At the beginning of each workshop, the facilitator introduced the focus on reliable water source functionality to participants and provided a general overview of the process and goals. During this time, participants completed a pre-activity questionnaire. After participants completed the questionnaire, the facilitator asked the group, "What factors or conditions are necessary to make water sources function all the time in Kamuli District?"

After approximately 1 hour of discussion, brainstorming, and reviewing the factors and their definitions, each group identified a list of 9 to 18 factors (average 12). The full list was presented at the front of the room for all to see and discuss, resulting in the combining of some factors and the condensing of some into other factors. After compiling a final list, participants voted on the top eight[1] influential factors for reliable water source functionality by placing sticky notes next to their selections.

The resulting lists of factors from each group (see Table 1), along with the outcome factor of *Reliable Water Source Functionality*,[2] were added to a cross-impact matrix (or table) as column and row headings (see Figure 1). These tables were written on large sheets of paper at the front of the room for all participants to view throughout the activity. Each participant was also given a copy of an empty matrix to keep notes in throughout the activity.

The cross-impact matrix is the primary tool used by the facilitator and participants to map relationships between factors. Arranging the factors in this format allows the group to systematically discuss how each factor they identified has (or does not have) an effect on every other factor. As the group moved through the matrix, the facilitator asked them to consider: "Based on current conditions, how does factor A influence factor B?" If the group determined a connection existed, they assigned a value to that cell representing how strong the influence is from the factor in the row to the factor in the column. The value ranged from 1 to 3, where 1 denoted weak, 2 denoted moderate, and 3 denoted strong. While discussing each relationship, the facilitator also asked the group whether they thought the effect on the factor in the respective column represented a positive (+) correlation (as one factor improves, so does the other), a negative (–) correlation (as one factor improves, the other degrades), or vice versa.

At the session's end, the facilitator asked the group to reflect on the matrix. The group's comments and questions during the process, as well as the rationale given for their determination of strength and correlation of each relationship, were recorded as part of the analysis. Documentation of the participants' conversations and the values in the matrix served as the primary source of data for all subsequent systems analysis.

[1] The decision to map eight factors (plus the outcome factor, total 9) was made by discussion with the facilitator in the interest of time. However, the Sub-county group requested to add one additional factor (total 10), and the water users group only mapped six factors (total 7 including outcome factor).

[2] Throughout this report, factors are identified with proper names in italics (e.g., *Coordination*).

	Preventative Maintenance	Spare Parts	Government Support	Community Attitude	Mechanics	WUCs	Customer Satisfaction	RWSF
Preventative Maintenance		3	3	3	3	3	3	3
Spare Parts	2		2	1	2	2	3	2
Government Support	3	1		3	3	3	3	3
Community Attitude	3	0	2		2	2	0	3
Mechanics	2	2	1	2		2	3	3
WUCs	3	1	3	2	3		3	3
Customer Satisfaction	2	0	3	3	2	3		3
RWSF	-3	1	1	3	2	2	3	

Figure 1 Whave Staff Cross-Impact Matrix

Ranked Factor Lists

The voting process in each workshop resulted in a ranked list of factors by importance for each group (see Table 1). Because many of the factors were similar across the groups, these "common" factors can also be shown by average ranking across all groups (see Table 2). Note that factors italicized in Table 1 are part of the common set, while factors in bold indicate inclusion in that group's cross-impact matrix. In some cases, the wording of the factor may differ slightly when included in the common set (e.g., "water user fees" versus "safe custody of water user fees"). Annex A provides a complete list of factors and definitions for each group, as well as a breakdown of commonalities across each group.

Table 1 Ranked Factor List

Rank	Whave Staff	District Government	Sub-county Government	Water Users	HPMA
1	**Preventive maintenance**	***Spare parts***	***Water user committees***	***Water user committees***	***Water user committee***
2	***Spare parts***	***Water user committees***	***Mechanics***	***Water source bylaws***	***Preventive maintenance***
3	***Government support and regulation (including bylaws)***	***Water source bylaws***	***Water user fees***	***Mechanics***	***Mechanics***
4	***Community attitude***	***Mechanics***	***Political presence and support***	***Water user fees***	**Meetings**
5	***Mechanics***	**Tools for repair**	***Water source bylaws***	***Coordination***	***Coordination***
6	***Water user committees***	**Proper handling of water sources**	***Supervision and monitoring***	***Monitoring and evaluation***	**Mechanic trainings**
7	**Customer satisfaction**	***Water user fees***	***Spare parts***	*Political involvement*	**Record keeping**
8	**Sensitivity of water users**	**Transport for mechanics**	***Water users know their roles***	*Hygiene*	*Water user fees*
9	*Vandalism*	Operation and maintenance plan	***Safe custody of water user fees***	*Spare parts*	*Water source bylaws*
10	Women in key positions	*Efficient health worker*	Land tenure system		Facilitation of mechanics
11	*Water user fees*	*Supervision*	*Attitude of community*		*Spare parts*

12	*Regulations*	*Safe custody of water users' fees*	*Hygiene and sanitation*		
13		*Proper coordination of stakeholders*	A strong public-private partnership approach		
14			*Presence of political parties*		
15			Location of water sources		
16			Tree planting		
17			*Vandalism*		
18			Transparency and accountability		

Table 2 Common Factors Ranked by Importance

Common Factor	Average Rank	# of Groups
Preventive maintenance	1.5	2
Water user committee	2.2	5
Mechanics	3.4	5
Water source bylaws	4.8	4
Spare parts	6.0	5
Coordination	6.8	4
Role of water users	7.3	3
Supervision and monitoring	7.5	4
Water user attitudes	7.5	2
Water user fees	7.7	5
Political involvement or government support	8.0	5
Hygiene and sanitation	11.0	2
Vandalism	13.0	2

Insights

- Of the 63 factors collectively brainstormed by all groups, most of them were part of a group of 13 common factors (41, or 79 percent) (see Table 2). The result of each group's voting produced a collective list of 13 common factors.

- Of all the factors, preventive maintenance, water user committees, mechanics, and water source bylaws were ranked the highest on average.

- However, each group placed these common factors at different levels of importance. For example, while both Whave and the district government ranked *Spare Parts* very high (second and first, respectively), the Sub-county government ranked it seventh, and the water users and HPMA ranked it last. There were similar differences in rankings for *Water User Fees*, *Attitudes of Community Members*, and *Bylaws or Regulations*.
- An interesting outcome of this process is how much of each group's factor list was common to the others. While the Sub-county government identified the most common factors (12), all of the factors the water users brainstormed were common factors (9). Similarly, Whave staff identified eight common factors, the district government identified nine, and the HPMA identified seven.

Systems Analysis

Following the factor mapping activity, the cross-impact matrix for each group is evaluated using three complementary methodologies from system dynamics and network sciences to provide insights into different aspects of the system structure and behavior (outcomes). It is important that outputs from each of the analyses are considered separately and then combined with notes and observations collected during the activity to understand the local system. As a group, these analyses begin to describe a narrative of how each of the factors affects the others and how together they produce a complex and adaptive system. Table 3 presents the three methodologies and resulting outputs utilized in the analysis.

Table 3 Summary of Systems Analyses

Analysis	Outputs
Influence mapping	Relative Influence & Dependence of each factor on all other factors in the system
Centrality analysis	Metrics of how factors connect, and which are most central
Causal loop analysis	Identification of reinforcing or balancing feedback loops that drive system behavior

The remainder of this section presents the results of each analysis followed by a synthesis section describing how the outputs of the analyses can be considered together to describe the overall system. Annex B provides detailed descriptions of each methodology, along with details of the analysis for each group.

Influence Mapping

Influence mapping is used to gain insight into the direct and indirect interaction between factors to better understand how changes in one factor may affect the whole system. This analysis creates two scores, one for influence (how strongly a factor affects other factors) and another for dependence (how strongly a factor is affected by other factors). The sum of the values in each row is the total influence each factor has on the system as a whole, and the sum of the values in the column is the dependence of that factor on all other factors in the system.

The output of the analysis can be shown either as two lists of the same factors ranked by Influence & Dependence or as an influence map, where the plotting of the factors is by influence (y-axis) and dependence (x-axis). This section presents ranked lists of factors by Influence & Dependence for all groups, as well as an example of one group's influence map, to compare the four different groups.

Table 4 Factors Ranked by Influence

	Rank	Whave Staff	District Government	Sub-county Government	Water Users	HPMA
Most Influential	1	Preventive maintenance	**Reliable water source functionality**	Water users know roles	Water user committees	**Reliable water source functionality**
	2	Government support and regulation (including bylaws)	Water user committees	**Reliable water source functionality**	Water user fees	Mechanics
	3	Water user committees	Water source bylaws	Water user committees	**Reliable water source functionality**	Coordination
	4	Customer satisfaction	Mechanics	Water user fees	Water source bylaws	Preventive maintenance
	5	Mechanics	Water user fees	Water source bylaws	Coordination	Mechanic trainings
	6	**Reliable water source functionality**	Spare parts	Spare parts	Mechanics	Water user committees
	7	Spare parts	Proper handling of water sources	Political presence and support	Monitoring and evaluation	Meetings
	8	Community attitude	Tools for repair	Mechanics		
Least Influential	9		Transport for mechanics	Supervision and monitoring		

Insights

- Table 3 shows that while all groups identified a common set of factors, the way they ranked these factors varied considerably. This finding highlights how groups that work with one another in the same contexts can have a different understanding of the same system. It also shows the importance of using a diverse group of stakeholders to map the local system based on their unique perspectives.

- The table shows the outcome factor *Reliable Water Source Functionality* (in bold), was identified by four of the groups as one of the most influential factors in the system. This finding suggests increased (or decreased) water source functionality and reliability will have a significant feedback effect on the other factors. Participants explained that if the sources are working well, then water users will be more likely to pay for services, water user committees may do their job better, and the government may promote bylaws for preventive maintenance based on seeing successful outcomes. Note that, based on the Whave group's cross-impact matrix, this factor was ranked 6 out of 8 in influence.

- Results show that the hardware elements of the system (i.e., spare parts and tools) are consistently ranked the lowest by all groups.

- Sub-county government and water users identified a monitoring factor, but both groups ranked it as the least influential factor.

Table 5 Factors Ranked by Dependence

	Rank	Whave Staff	District Government	Sub-county Government	Water Users	HPMA
Most Dependent	1	**Reliable Water Source Functionality**	**Reliable Water Source Functionality**	**Reliable Water Source Functionality**	Water user committee	**Reliable Water Source Functionality**
	2	Preventive maintenance	Spare parts	Spare parts	**Reliable Water Source Functionality**	Water user committees
	3	Customer satisfaction	Mechanics	Water user fees	Water source bylaws	Preventive maintenance
	4	Water user committees	Water user fees	Water user committees	Mechanics	Mechanics
	5	Mechanics	Water user committees	Water users know roles	Coordination	Coordination
	6	Community attitude	Proper handling of water sources	Mechanics	Water user fees	Meetings
	7	Government support and regulation (including bylaws)	Transport for mechanics	Water source bylaws	Monitoring and evaluation	Mechanic trainings
	8	Spare parts	Water source bylaws	Supervision and monitoring		
Least Dependent	9		Tools for repair	Political presence and support		

Insights

- Table 4 indicates the outcome factor, *Reliable Water Source Functionality* (in bold), in addition to being ranked as a very influential factor, is also the most dependent on other factors. This finding aligns with the idea that water source functionality depends on many of the other factors in the system, such as *Mechanics*, *Spare Parts*, *Water User Fees*, and *Water User Committees*. These connections demonstrate the highly complex and connected nature of the system of factors supporting the functionality and reliability of water sources.

- The table shows significant differences in rankings for factors identified as being very influential in Table 3 — most importantly, *Water User Committees.* Rankings also vary for *Water Source Bylaws*, *Mechanics*, and *Water User Satisfaction or Attitudes*. These variations suggest each group has a different understanding of how much these factors can be influenced (either improve or decrease).

- Both government groups ranked *Spare Parts* as the second-most dependent factor, whereas Whave ranked it as the least-dependent factor. The explanation for Whave's ranking is that because they are a large purchaser of spare parts, they can influence the quality and price from their suppliers. The HPMA group identified *Spare Parts* as a factor in the brainstorming phase of the workshop but chose not to include it in the factor mapping activity.

These insights can also be examined in an influence map, as described above. The axes of this graph move from independent to dependent (x-axis) and ineffective to influential (y-axis). The map has four quadrants, with each representing a different factor type based on its relative scores. Starting in the upper right-hand corner and moving counterclockwise, the quadrants represent factors that are potentially: (I) highly dependent and volatile, (II) effective leverage points, (III) low significance, and (IV) highly sensitive to others. Because all of the factors above the midline are influential, they are generally factors to target. Figure 2 presents the influence map built from the cross-impact matrix completed by Whave staff, and Annex A presents influence maps for all groups.

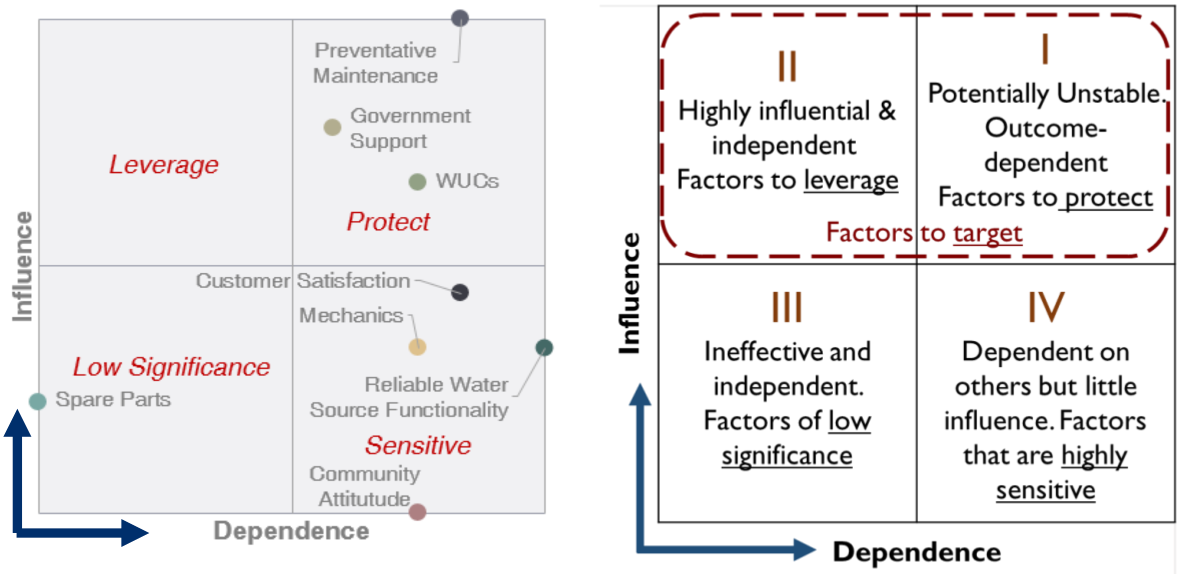


Figure 2 Whave Influence Map and Key

Insights

- The most notable insight from Whave's influence map is that there are no clear factors to leverage (highly influential, but independent from the influence of other factors). This finding reinforces the idea from Tables 1 and 2 of a highly interconnected and dependent system of factors supporting water source functionality. However, it is uncommon for this analysis not to produce at least one clear leverage factor.

- The factors to "protect" in this map generally refer to the management of water sources (*Preventive Maintenance*, *Water User Committees*, *Government Support and Regulation*). This indicates these factors are necessary and central to the reliable operation of water sources and thus need to be strengthened or not allowed to diminish.

- Most of the sensitive factors are outcomes or results of the system, including the outcome factor itself, *Reliable Water Source Functionality.* This indicates perceptions of water users (attitudes and satisfaction) are dependent, logically, on how well the rest of the system functions.

- The location of *Mechanics* in quadrant IV suggests the quality of mechanics and their ability to complete their work well is dependent on other factors besides themselves. Most likely, this includes the influence of *Water User Committees*.

- *Spare Parts*, although initially ranked by all groups as one of the more important factors, is shown to be the only factor that has low significance. This finding indicates that this aspect of hardware for water source functionality is not a driving factor in the system. Note that *Spare Parts* was identified by all groups and was the only hardware-related factor identified by any group.

Centrality Analysis

Centrality analysis utilizes three metrics from network analysis to gain insight into how changes in different factors can move through the system by virtue of their location and connection to other factors. These metrics rank how high a factor's ability is to influence others (degree-in), be influenced by others (degree-out), and bridge connections between factors (betweenness). In general, weighted degree-in and -out serve as a verification check on the Influence & Dependence outcomes of the influence mapping, where the betweenness metric indicates how centrally located or connected a factor is relative to other factors. A high betweenness score would suggest changes in that factor would have more pathways to propagate through the system than a factor with a low betweenness score.

Table 6 Centrality Analysis Rankings (Relative Betweenness Score)

Rank	Whave Staff	District Government	Sub-county Government	Water Users	HPMA
1	Preventive Maintenance (0.6)	Reliable Water Source Functionality (3.7)	Water User Committees (0.3)	Water User Committee (0.8)	Water User Committees (0.2)
2	Government Support + Regulation (0.6)	Spare Parts (3)	Water User Fees (0.3)	Reliable Water Source Functionality (0.8)	Preventive Maintenance (0.2)
3	Mechanics (0.6)	Mechanics (2.8)	Water Source By-laws (0.3)	Water Source Bylaws (0.6)	Mechanics (0.2)
4	Water User Committees (0.6)	Water User Fees (2.6)	Supervision + Monitoring (0.3)	Water User Fees (0.6)	Coordination (0.2)
5	Reliable Water Source Functionality (0.6)	Transport for Mechanics (0.8)	Spare Parts (0.3)	Mechanics (0.4)	Reliable Water Source Functionality (0.2)
6	Spare Parts (0)	Water User Committees (0.6)	Water Users Know Roles (0.3)	Coordination (0.4)	Meetings (0)
7	Community Attitude (0)	Bylaws (0.4)	Reliable Water Source Functionality (0.3)	Monitoring and Evaluation (0.4)	Mechanic Trainings (0)
8	Customer Satisfaction (0)	Proper Handling (0.2)	Mechanics (0)		
9			Political Presence and Support (0)		

Insights

- The centrality analysis highlights the differences of density in how each group mapped the system (note that many scores are similar and tied for rank). Although many of the factors are common across all four groups, the ability of the factors to affect one another based on their connections (per the values assigned in the cross-impact matrix) varies greatly. Table 5 illustrates three levels of complexity:
    - District government: each factor has a different centrality score.
    - Sub-county government: three categories of centrality.
    - Whave staff, sub-county government, and HPMA: only one level of centrality (other factors 0).
- Overall, no single factor emerges as most or least central, although water user committees have the highest centrality score on average. This outcome is substantially different from the Influence & Dependence analysis, especially in Table 4, where *Reliable Water Source Functionality* was (one of) the most-dependent factor(s) across all groups. This demonstrates the degree to which different groups can see differences in the same system, even when evaluating a relatively common set of factors.

Causal Loop Analysis

A causal loop diagram is built by mapping each connection participants identified in the cross-impact matrix (see Figure 3). The resulting diagram is a visual representation of how factors are connected to each other with positive (blue) and inverse (red) relationships, with the outcome factor placed in the middle of the diagram.

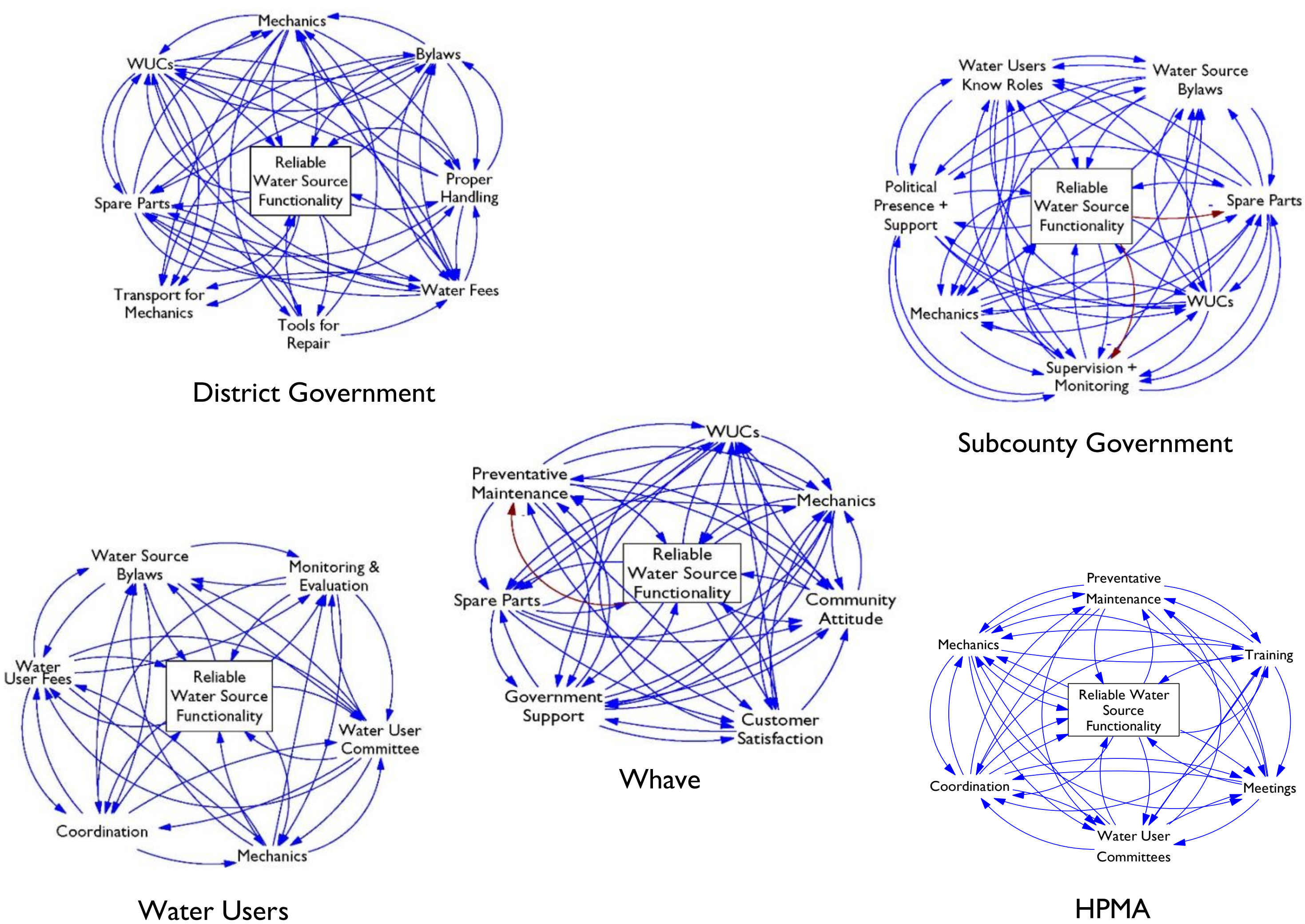


Figure 3 Causal Loop Diagrams by Group

The diagram is analyzed for "feedback loops" that aid in understanding the possible dynamic processes driving the overall outcomes of the system, which builds on the insights developed from the centrality analysis regarding possible pathways of change in the system. The logic behind the analysis is that through unique sequences of cause-and-effect relationships, information and resources are "fed back" through the system, leading to compounding (reinforcing) or stabilizing (balancing) outcomes in the factor at the beginning of the sequence. Each feedback loop tells a story about possible sequences of causality that may either lead to or impede long-term sustainable outcomes of the system.

Feedback loops can be ranked by their relative strength to determine how likely each loop is to drive system behavior. Within this analysis, loop rank is determined by the average absolute value strength of the connections between all the factors within the loop (i.e., *Services* → (3) *Finance* → (2) *Capacity* → (3) *Services*; loop strength = (3+2+3)/3=2.67).

An analysis of the causal loop diagrams in Figure 3 determined the top-ranked unique reinforcing and balancing loops for each group. This analysis revealed 60 unique loops containing the outcome factor *Reliable Water Source Functionality*. Of all these loops, 80 percent were reinforcing (exponential increase or decay), and only 20 percent were balancing (goal seeking, equilibrating).

To simplify the analysis of these 60 unique loops, six loops were present in two or more of the group's causal loop analysis, as illustrated in Table 6. All of these common loops are reinforcing. The common loops in Table 6 were then re-represented in a "prioritized" causal loop diagram (see Figure 4). Annex A provides a list of all of the feedback loops the groups.

Table 7 Common Feedback Loops

Feedback Loop	District	Sub-county	Water Users	Whave	HPMA	Average Rank
Water users' attitudes → reliable water supply functionality		X		X		1.3
Mechanics → reliable water supply functionality	X	X	X		X	2.2
Water user committees → preventive maintenance → reliable water supply functionality				X	X	2.0
Spare parts → reliable water supply functionality	X	X				2.3
Coordination → reliable water supply functionality			X		X	2.5
Preventive maintenance → reliable water supply functionality				X	X	2.7
Preventive maintenance → water user committees → reliable water supply functionality				X	X	3.0
Bylaws → reliable water supply functionality	X	X	X			3.0
Water user committees → reliable water supply functionality	X	X	X		X	3.1
Water user fees → water user committees → reliable water supply functionality	X		X			4.5

A key to understanding feedback loops is to read each sequence as a sentence. For example, the reinforcing feedback loop in the last row suggests as more water user fees are collected, the operation of the water user committees will improve, which in turn will improve the overall reliability of water source functionality. However, the loop can also mean if fewer water user fees are collected, the work of the water user committees will diminish, which would then reduce overall water source functionality.

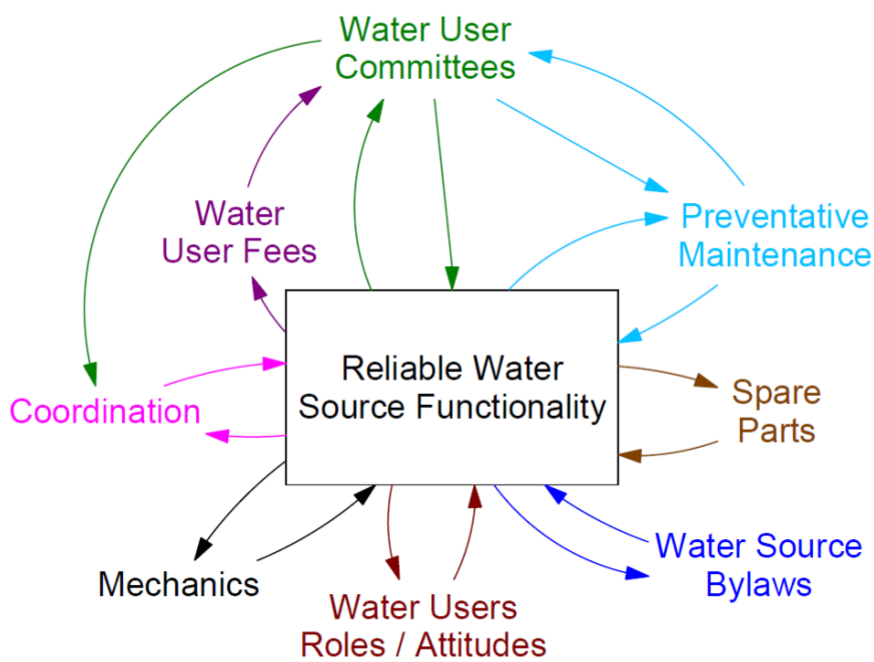


Figure 4 Prioritized Causal Loop Diagram

Insights

- None of the feedback loops are common to all groups. At most, four groups identified the same feedback loop.

- All of the common loops are reinforcing loops. This suggests the local systems around *Reliable Water Source Functionality* tend to drive outcomes in a compounding, instead of balancing, behavior. This finding resulted because only two groups (Whave and sub-county government) identified an inverse relationship (–) that would produce a balancing loop. This suggests local conditions overall tend toward cycles of perpetuating improvement or deterioration. However, it may also be due to the difficulty that participants have properly identifying an inverse relationship.

- Of the 13 common factors identified by all the groups (see Table 2), only five appear in any of the feedback loops from each group (see Annex A). Notably, *Water User Committees* appeared in 12 (20 percent) of the feedback loops. This reinforces the findings from the Influence & Dependence analysis of the key role of the *Water User Committees* in supporting *Reliable Water Source Functionality*.

- The HPMA identified the most common feedback loops (7), whereas Whave identified the least number of common feedback loops (4). However, 3 of the 4 common feedback loops from Whave were the same as those from the HPMA. This finding may suggest that Whave sees the system very differently than the other groups, and their work with the HPMA has potentially aligned their perspectives.

Participant Feedback

As part of the factor mapping activity, UCB researchers administered a post-activity questionnaire to evaluate the utility of the factor mapping workshop to the participants and to solicit feedback on how it can improve. UCB transcribed questionnaires in English, with support from notetakers for translating questionnaires in Lusoga. Whave and UCB completed analysis of the responses. Overall, the participants shared positive feedback about the workshop, with a majority indicating the meeting was valuable and improved their understanding of factors supporting the sustainability of water services. In closed responses, participants indicated the meeting was extremely or very valuable, and 89 percent said their understanding improved a lot (see Table 7).

In follow-up interviews, participants also expressed their enthusiasm for the exercise because it encouraged critical reflection on how something can be directly or indirectly affected by another issue, and how the state of water services themselves can influence the factors that support them. One participant indicated to UCB the intention to repeat the activity with another group of government officials in a local sub-county. In closing remarks at the end of one workshop, a government representative reflected on the results and encouraged participants to engage in systems thinking exercises with community members to help them explore solutions to their issues with water source functionality.

Table 8 Questionnaire Responses

How valuable was the meeting?	
Extremely valuable	78%
Very valuable	17%
Moderately valuable	2%
Slightly valuable	2%
Not at all valuable	0%

How did this session improve understanding?	
Improved a lot	89%
Somewhat improved	9%
Improved very little	2%
Not at all improved	0%

Feedback Workshop

A month after the workshop, Whave brought together representatives from each of the stakeholder groups to participate in a feedback workshop. Whave presented factor lists from each group ranked in order of influence and then asked the participants to reflect on the results. The participants mostly agreed with the findings and provided some explanations of why different groups may have ranked factors higher than others. In a separate debrief feedback workshop conducted immediately after the workshops, Whave staff suggested that different groups prioritized factors which that group had the most ability to influence. For example, the water users ranked *Water User Committees* as the most influential factor whereas the HPMA ranked *Mechanics* as the second most influential factor behind *Reliable Water Source Functionality*.

During the group feedback workshop, participants also discussed additional factors they thought should have been included but were not mentioned by any groups, including response time of mechanics, pricing structure of water user fees, and coordination between Whave, mechanics, and the sub-county government. Presentation of the factors common to all groups provoked a long discussion as well.

During the workshop, participants focused their discussion around the mutually reinforcing interactions between preventive maintenance, water user committees, and mechanics. Participants noted the important and unique roles water user committees and mechanics play in supporting preventive maintenance. Water user committees were highlighted because of their role in the day-to-day operations of the water source; monitoring functionality, collecting fees, and notifying mechanics when breakdowns occur. Highlighting an important positive correlation in the impact matrices, participants indicated the absence of a water user committee would likely lead to longer response times for servicing water sources.

Water user committees were described as being both a key challenge and a solution to improving water source sustainability. The work of the water user committees could likely improve with more sensitization of the water users and better coordination with local government, mechanics, Whave, and the users. Participants agreed that while many of the connections are currently weak, the work Whave is doing to promote preventive maintenance among all stakeholders is strengthening them. In closing the meeting, a local government official encouraged participants to keep working to improve coordination because of the impact it can have on improving water services in Kamuli District.

Findings

The goal of the IFML process is to systematically map, analyze, and assess the key local factors that influence sustained WASH services and their context-dependent relationships. This requires consideration of all the information, both quantitative and qualitative, gathered during the exercise to draw meaning from the suite of analyses used. The findings below are informed by a review of notes of participants' discussion, conversations with key stakeholders, and a debriefing with the session facilitator.

Finding I: Each Stakeholder Group Sees the Local System from Their Perspective

From the factor brainstorming and ranking to mapping the factors and the subsequent analysis, it is clear there are commonalities across the five groups. Of all the possible factors that can influence water services in Kamuli District, the 57 participants identified a total of 63 factors, of which nearly 80 percent (50) were common. When the groups voted to rank the factors to use in the factor mapping activity, they all selected the same group of 13 factors. The definitions for each of these factors were very similar as well (see Annex B). This relative alignment in understanding of critical factors demonstrates the groups are speaking the same language when they refer to those factors.

However, closer inspection of the results of the analysis highlights important differences among the groups. These differences are most clear in the influence mapping analysis, where each group ranked the factor most easily influenced as the one that group is most likely to be able to influence (see Table 4). For example, Whave ranked *Spare Parts* as the easiest to influence, this is something they can affect because they are a major buyer of spare parts.

The district government ranked *Water Source Bylaws* (and *Tools for Repair*) as the least-dependent factor, implying this group believes enacting bylaws could be a relatively easy task. Similarly, the Sub-county government ranked *Political Presence and Support* as their least-dependent factor, presumably because they are the ones, along with their elected colleagues, who can most easily exert influence at the local level. The water users group ranked *Monitoring* and *Water User Fees*, two tasks community members are capable of and responsible for within the system, as their least-dependent factors. Finally, the HPMA group ranked *Meetings*, an activity they can conduct independently of other actor groups, as their least-dependent factor (after *Reliable Water Source Functionality*).

The differences between group perspectives on how each factor affects the others is clearest in the centrality analysis, which shows a striking difference in the ranking of the centrality of different factors. The outcome factor, *Reliable Water Service Functionality, was the* only factor ranking that was similar across all groups.

Finding II: Water User Committees' Ability to Collect Water User Fees Is Key to Functionality and Preventive Maintenance

Throughout the analysis, *Water User Committees* and *Water User Fees* were shown to consistently play an important role in affecting *Reliable Water Source Functionality* and *Preventive Maintenance*. These factors were among the most influential, dependent, and central to the system, and were part of some of the common feedback loops. Workshop participants also ranked *Water User Committees* and *Water User Fees* as the most important factors before the factor mapping activity began.

Participants from all groups described similar qualities desired of the two factors. In order to support sustainable preventive maintenance systems, water user committees should be fully constituted, trained, and capable. In their critical role for preventive maintenance, committees should implement bylaws, oversee the work of mechanics, and be trusted to collect and manage water user fees. Similarly, all the groups noted that water user fees should be agreed upon, known by the users, collected regularly, and kept secure, ideally in a banking facility.

Most telling was the highest centrality scores for *Water User Committees* (on average) of all the factors. This suggests water user committees are an essential part of the local system that, when strengthened, have a higher likelihood of strengthening other parts of the system as well. In practice, this would imply there is a higher likelihood of increasing and maintaining water source functionality through preventive maintenance when water user committees demand higher service quality from mechanics, more effectively implement water source bylaws, and consistently collect water user fees. Combining these insights, especially the feedback loops, indicates that water user committees' abilities to instill confidence in community members and collect water user fees can have a positive, near-term impact on functionality and preventive maintenance.

Finding III: Government Support, Regulation, and Politics Are Under-Prioritized

Whave, the sub-county government, and water users collectively discussed five factors related to government or political involvement in the brainstorming phase. However, only two factors ended up being used in factor mapping activities for Whave (*Government Support and Regulation*) and the sub-county government (*Political Presence and Support*). Thus, of the 63 total factors mapped across all five groups, only two factors focused on government support, regulations, or politics (not including *Water Source Bylaws*, as these are enacted by water user committees). These factors were given relatively low influence ranks, with the exception of Whave's high ranking of *Government Support and Regulation* in influence and centrality. However, it is important to note that in Whave's definition of this factor, they included *Water Source Bylaws*, which all other groups listed as a separate factor. If Whave separated these factors it might lead to slightly different conclusions. However, based on the analysis of all five groups' cross-impact matrices, participants did not appear to rate factors around governance and politics very highly overall.

It is important to note this finding may be the result of participants focusing their discussion around the functionality of water points at the community level. This would explain why all groups identified *Water Source Bylaws* as an important factor in the brainstorming phase of each workshop, as these are the government regulations enacted at each water point. It is also important to highlight the factors of a strong *Public-Private Partnership Approach*, *Presence of Political Parties*, *Regulations*, and *Political Involvement* which were also proposed by workshop participants across all groups but not included in the factor mapping exercise. Thus, even though participants recognized the importance of governance, regulations, and the enabling environment for sustainable services, it was not reflected in the resulting analysis of the cross-impact matrices.

Recommendations

Discussion of the systems analysis presented in this report indicates there are many possible ways to influence the local system. Based on the findings outlined above, the following recommendations have been developed to address the factors, structures, and dynamics of the local system that have the highest potential to promote reliable water source functionality.

Recommendation I: Show Each Group Their Role in the System to Strengthen the System Together

No single group can strengthen all parts of the system alone or without the support of other actors. This analysis has shown how complex and interconnected the elements of the local systems are, but it has also shown where each group sees leverage points in this system. Based on these findings, it is recommended the results be shared with each group, individually or collectively, so they can see where their perspectives do or do not align with other groups. By showing each group their perspective of the system, especially important areas where they do not align (e.g., monitoring, supervision, meetings), stakeholders can begin to identify areas where they can align their priorities and work together on common goals.

Recommendation II: Strengthen Water User Committees' Ability to Collect Fees

The analysis identified water user committees as a key component of the existing community-based management system that supports rural water service delivery. The committees play an important role in communicating between users, mechanics, government officials, and service providers like Whave. The analysis indicates the committees' ability to collect water user fees, in particular, is one of the most critical connections in the entire system.

However, committees' ability to fulfill this important role appears to vary significantly across the different groups. A common theme heard in the workshops was water users would be willing to consistently pay water fees if they trusted water user committee with their fees, saw the value of their contributions, and were satisfied with the service. Committee members also appeared to have issues communicating and interfacing with both water users and government officials in executing their unique role in the system. All of this suggests that in order for water user committees to fulfill their role in the system, they need to be supported by local actors with trust, confidence, skills, and knowledge. Strengthening activities could include capacity training for water user committee members, encouraging them to open bank accounts, and making their activities more transparent to local water users. Without a functional, trustworthy water user committee, the rest of the system, as it exists in its current community-based management form, is susceptible to failure.

Recommendation III: Strengthen the Regulatory Enabling Environment

While new government regulations are needed to create the enabling environment for sustainable water service delivery, these factors did not appear to be at the forefront of participants' minds when they were considering the effect these regulations have on reliable water source functionality. Regulatory factors are most likely known to participants because of their effects on water user committees and the collection of water user fees, both key factors in the analysis. A strong regulatory environment is required to encourage water user committees to exist as a legal entity, with access to proper banking services, and to gain support from local government for adequately adjusting user fees to improve the viability of preventive maintenance services.

Without the proper regulations and support, it is likely efforts to strengthen water user committees (Recommendation II) will be limited in their impact. For this reason, it is essential to continue to promote consideration of the larger enabling environment among local stakeholders. This may include highlighting the role of regulations and their connections to other important factors discussed during the workshops (water user committees, fees, effective public-private partnership structures, etc.). Repeating the factor mapping activity with a wider range of stakeholders to focus more holistically on the enabling environment as opposed to the reliable functionality of water sources can also support this effort.

The development of these findings and recommendations came from a participant-driven process informed by a multi-method approach to illustrate, to the best degree possible, participants' view of the local water service delivery system. The analysis is therefore not intended to represent an all-encompassing investigation of these issues from other observers' perspectives. It is strongly recommended these results be shared with the stakeholders in a consultative workshop to validate and supplement the findings with additional insights from the group. Accordingly, the recommendations section proposes follow-up activities to evaluate the potential impact of actions taken to strengthen the system and/or provide additional insight to the analysis by mapping the factors of a sub-system of the local water service delivery system.

Iteration

Further repetition of the factor mapping activity after some action or intervention has taken place would generate additional insights to understand how those actions affected the local water service delivery system. Ideally, participants in a second factor mapping session would include the same, or mostly the same, group of stakeholders. There are two principal options for the focus of a second session. First, the session could focus on the same outcome factor as the first (*Sustainable Water Services*) to refine and strengthen the analysis and create a more robust model for evaluating possible actions. Second, participants could select a new outcome factor (e.g., *Payments for Services*) to explore a unique sub-system of the model developed from the first session. Information from this second option could also add a module to the original model, expanding the possible analysis of outcomes of the local water service delivery system. Within the Kamuli District context, the relationships between *Water User Committees*, *Water User Fees*, and *Bylaws* are key connections that need to be better understood.

During a meeting to share initial results, Whave staff suggested a future iteration should determine what the most influential factors are overall and then present those to each group as the set of factors to map. All groups would use the same set of factors in the proposed future factor mapping exercise. Meeting with all groups before repeating the IFML to share findings and re-introduce the activity with the agreed-upon factors before meeting with individual groups was another recommendation. The facilitator also said more time for each session would allow participants to engage in a rich discussion about the interactions of the factors.

ANNEX A
Analyses for All Groups

Factors and Definitions

Group	Factor	Definition
Whave Staff	Preventive maintenance	Working without breaking. Repair before it breaks.
	Water user committee	Committee aware of its roles in management of water sources and accountable. Women are involved in key positions. Committee continuously sensitives water users to proper use and regulations.
	Spare parts	Long lasting, durable, available, accessible, affordable
	Mechanics	Experienced, able to handle all forms of break downs
	Government support	Planning and regulations about location of water sources, spare parts, water user committees, service providers, financial support, payments and banking. Enforcement of bylaws. Sensitization of water user committees.
	Attitude of community members	Positive awareness of responsibility. Community members pay water user fees in a timely manner. They are accountable.
	Customer satisfaction	Community is happy with work done and value for money
District Government	Spare parts	Quality parts that are durable, affordable, available, not fake, and have a long-life span
	Presence of water user committees	Fully elected and constituted committee that is functional trained and facilitated
	Bylaws governing the water sources	Approved by the relevant authorities and known to all water users
	Mechanics	Trustworthy, fully trained and authorized by the district
	Tools for repair	Complete, good quality tools available to make the repairs
	Proper handling	Users don't vandalize or bang on the pump and carry out minor repairs
	Water user fees	Money is collected monthly, kept safely with paper records and accountability (including safe custody)
	Transport for mechanics	Availability of mechanics to travel to sites by *boda* or bicycle with transport refunds
Sub-county Government	Water user committee	A fully constituted, trained, and functional committee
	Mechanics	Mechanics are reliable, trained, equipped, accessible, and trustworthy
	Water user fees	An agreed upon amount which is collected periodically (including safe custody)
	Political support and presence	Politicians putting in place enabling policies
	Water source bylaws	Approved by subcounty authorities, enacted by the community
	Supervision and monitoring	Checklist followed by technical and politicians group
	Spare parts	Durable, availability, quality, and affordable
	Water users know their roles	Each water user is being accountable
Water Users	Water user committee	Committee that is trained and elected by water users
	Water source bylaws	Laws put into practice that are agreed upon by the community
	Mechanics	Mechanics are reliable, trained, and accessible
	Water user fees	Money collected periodically, agreed upon by water users
	Coordination between committee and water users	Community and committee follow what has been agreed upon. There is "no dictatorship."
	Monitoring and evaluation	Monitors check to confirm work is done as agreed
HPMA	Presence of water user committee	Fully committed, trustworthy, trained
	Preventive maintenance	Routine monitoring, stand-by mechanic, contract with service provider
	Qualified mechanics	With a toolbox, experienced, trustworthy, registered with HPMA, trained with
	Meetings	Community quarterly meetings, monthly meetings for water service technicians
	Good relationship among stakeholders	Proper definition of roles
	Refresher training for mechanics	Bi-annual trainings

Common Factors

Rank	Whave Staff	District Government	Sub-county Government	Water Users	HPMA	Common Factors	Count
1	Preventive maintenance	Spare parts	Water user committee	Water user committee	Water user committee	Water user committee	5
2	Spare parts	Water user committee	Mechanics	Water source bylaws	Preventive maintenance	Mechanics	5
3	Government support	Water source bylaws	Water user fees	Mechanics	Mechanics	Water user fees	7
4	Attitude of community members	Mechanics	Political presence and support	Water user fees	Meetings	Political involvement or government support	5
5	Mechanics	Tools for repair	Water source bylaws	Coordination	Coordination	Water source bylaws	4
6	Water user committee	Proper handling of water sources	Supervision and monitoring	Monitoring and evaluation	Mechanic trainings	Supervision and monitoring	4
7	Customer satisfaction	Water user fees	Spare parts	Political involvement	Record keeping	Spare parts	5
8	Sensitivity of water users	Transport for mechanics	Water users know their roles	Hygiene	Water user fees	Role of water users	3
9	Vandalism	Operation and maintenance plan	Safe custody of water user fees	Spare parts	Water source bylaws	Water user attitudes	2
10	Women in key positions	Efficient health worker	Land tenure system		Facilitation of mechanics	Hygiene and sanitation	2
11	Water user fees	Supervision	Attitude of community		Spare parts	Coordination	4
12	Regulations	Safe custody of water user fees	Hygiene and sanitation			Preventive maintenance	2
13		Proper coordination of stakeholders	A strong PPP approach			Vandalism	2
14			Presence of political parties				
15			Location of water sources				
16			Tree planting				
17			Vandalism				
18			Transparency and accountability				
Common Factors	9 75%	10 77%	13 72%	9 100%	9 82%		

Cross-Impact Matrices

Whave

	Preventative Maintenance	Spare Parts	Government Support	Community Attitude	Mechanics	WUCs	Customer Satisfaction	RWSF
Preventative Maintenance		3	3	3	3	3	3	3
Spare Parts	2		2	1	2	2	3	2
Government Support	3	1		3	3	3	3	3
Community Attitude	3	0	2		2	2	0	3
Mechanics	2	2	1	2		2	3	3
WUCs	3	1	3	2	3		3	3
Customer Satisfaction	2	0	3	3	2	3		3
RWSF	-3	1	1	3	2	2	3	

District Government

	Spare Parts	WUCs	Bylaws	Mechanics	Tools for Repair	Proper Handling	Water Fees	Transport for Mechanics	RWSF
Spare Parts		3	1	3	3	1	2	0	3
WUCs	2		3	2	0	3	3	2	3
Bylaws	2	3		2	0	3	3	2	3
Mechanics	3	2	0		3	2	2	2	3
Tools for Repair	3	0	0	3		0	1	0	3
Proper Handling	2	2	2	1	0		3	0	3
Water Fees	3	3	1	3	0	2		2	3
Transport for Mechanics	1	0	0	2	1	0	1		3
RWSF	3	3	3	3	3	3	3	3	

Subcounty

	WUCs	Mechanics	Water User Fees	Policical Presence + Support	Water Source By-laws	Supervision + Monitoring	Spare Parts	Water Users Know Roles	RWSF
WUCs		2	3	1	3	1	3	3	3
Mechanics	1		1	0	1	2	3	1	3
Water User Fees	1	3		1	1	2	3	3	3
Policical Presence + Support	3	0	1		3	2	1	2	1
Water Source By-laws	3	1	3	1		1	1	3	3
Supervision + Monitoring	2	3	1	1	1		2	1	1
Spare Parts	1	2	3	1	1	2		1	3
Water Users Know Roles	3	2	3	1	3	3	3		3
RWSF	3	3	3	1	3	-1	-3	3	

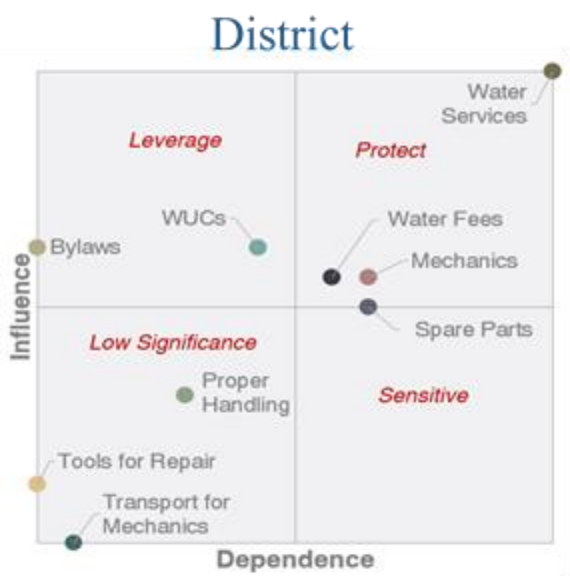
HPMA

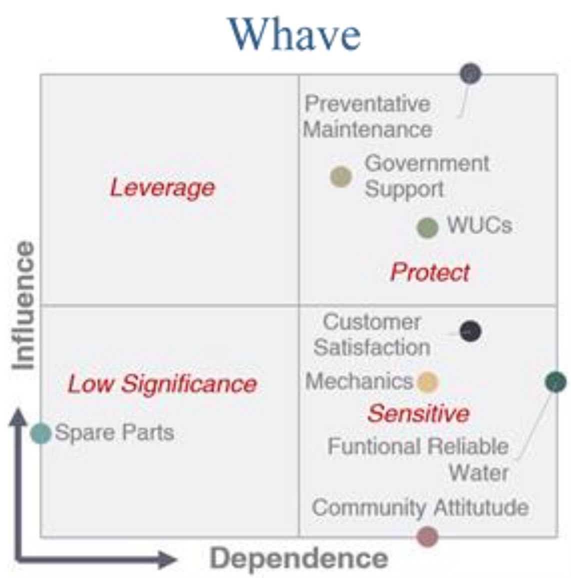
	WUCs	Preventative Maintenance	Mechanics	Meetings	Coordination	Training	RWSF
WUCs		3	2	1	2	2	3
Preventative Maintenance	3		3	1	3	2	3
Mechanics	3	3		2	3	2	3
Meetings	3	3	1		1	0	3
Coordination	3	2	3	2		2	3
Training	2	3	3	2	2		3
RWSF	3	3	3	3	3	3	

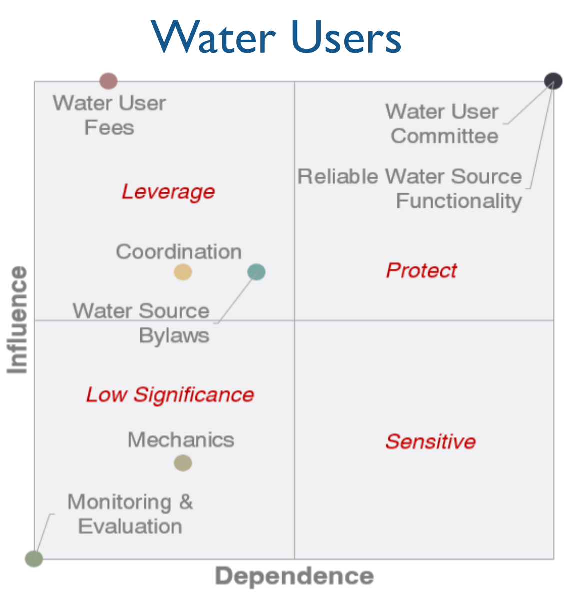
Water Users

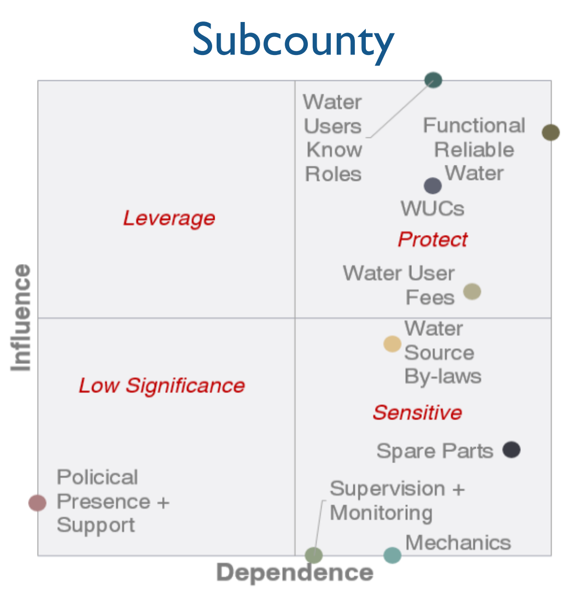
	Water User Committee	Water Source Bylaws	Mechanics	Water User Fees	Coordination	Monitoring & Evaluation	RWSF
Water User Committee		3	2	3	3	2	3
Water Source Bylaws	3		0	3	3	2	3
Mechanics	3	1		3	0	2	3
Water User Fees	3	2	3		3	2	3
Coordination	3	3	3	2		0	3
Monitoring & Evaluation	3	2	2	0	1		3
RWSF	3	3	3	1	3	3	

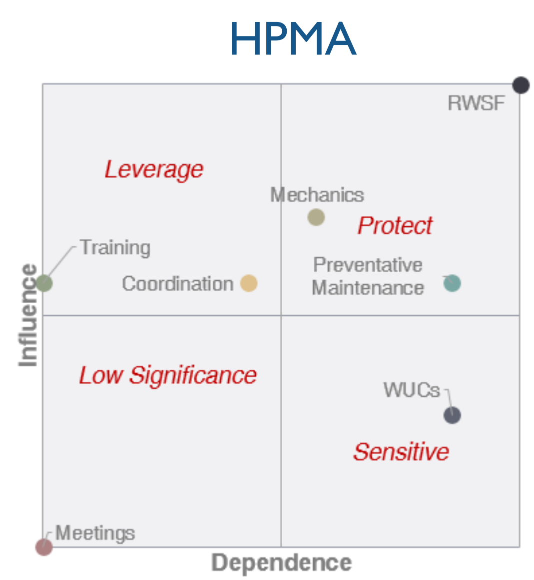
Influence Maps







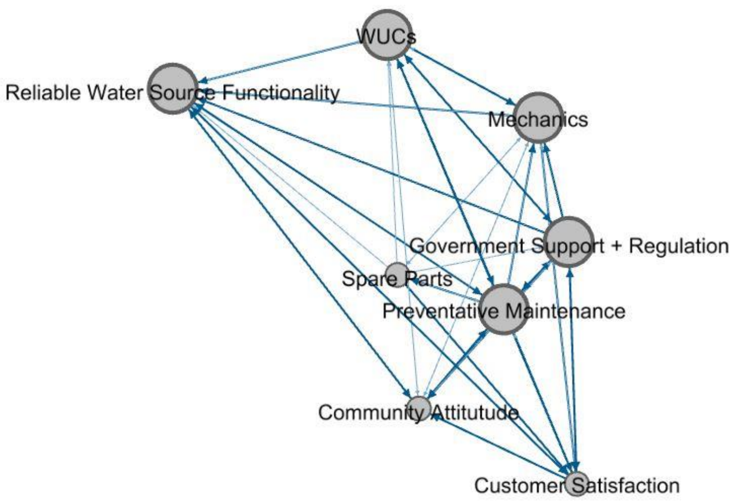




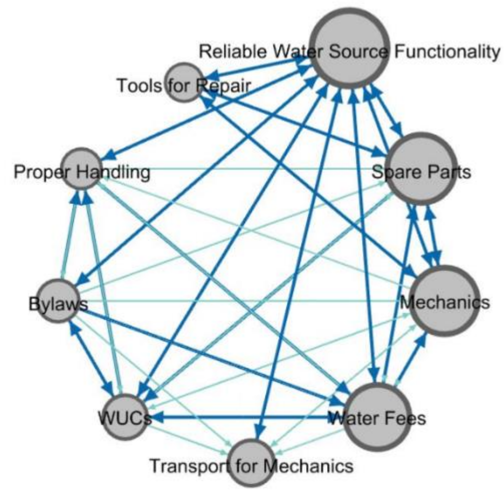
Factor Maps

Factor maps are displayed in a radial axis layout where factors are grouped based on their centrality score and drawn radiating from a center based on their "degree-in" (influence). These graphics display "pathways" through which changes in one factor can "move" through the system and affect another factor.

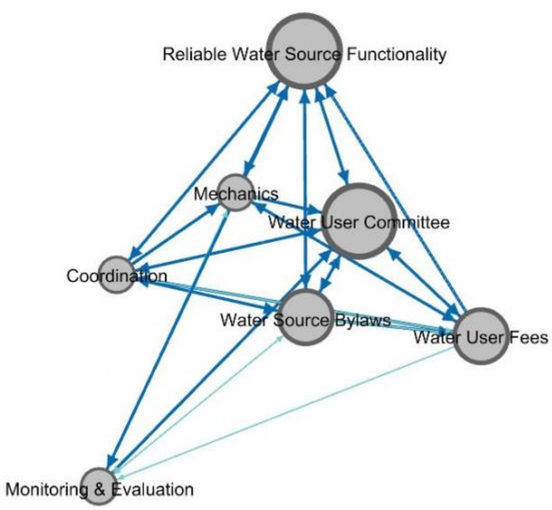
Whave



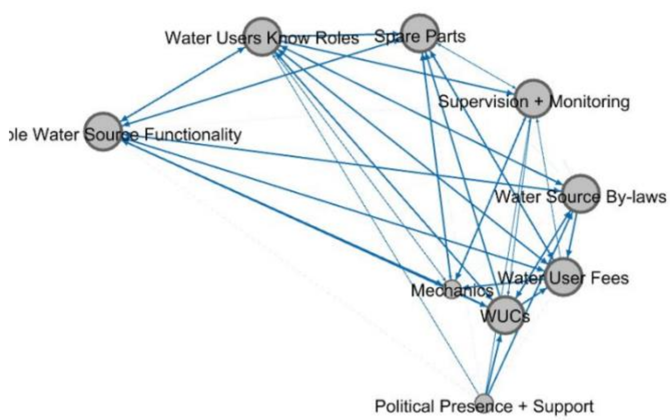
District Government



Water Users



Sub-county Government

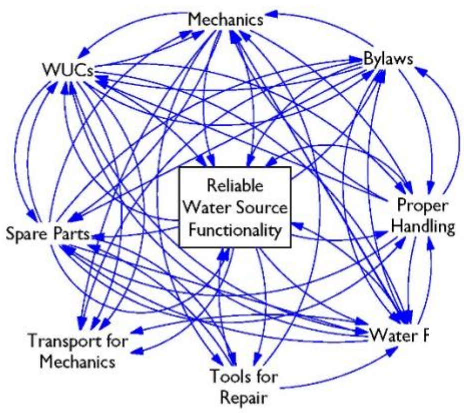


HPMA

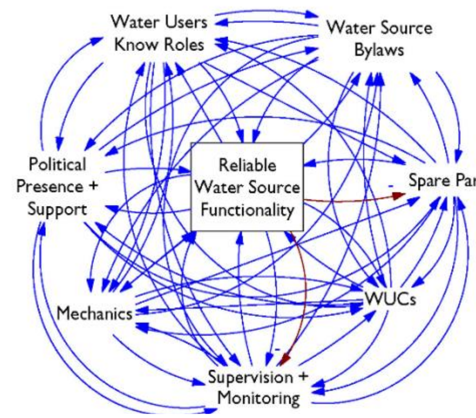

Training
WUCs
Meetings
Preventative Maintenance
Mechanics
RWSF
Coordination

Causal Loop Diagrams

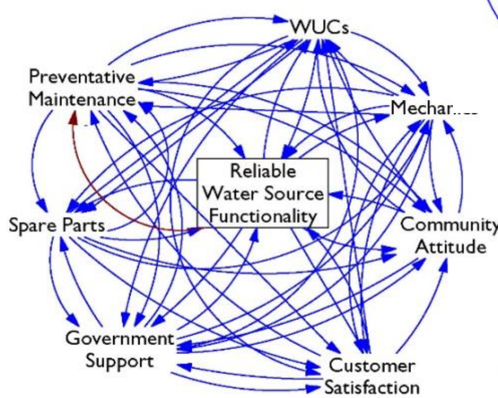
Causal loop diagrams are a direct representation of all the connections identified in the cross-impact matrices. For each non-zero connection in the table, a line is drawn between the two factors. Blue lines represent a relationship that has a positive (+) polarity, and red lines represent negative (–) polarities. These causal loop diagrams are further analyzed to determine which set of connections may drive system behavior in each context.



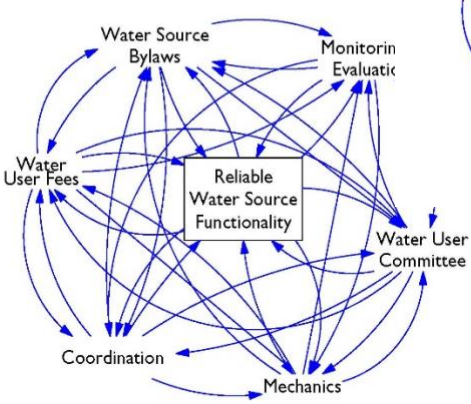
District Government



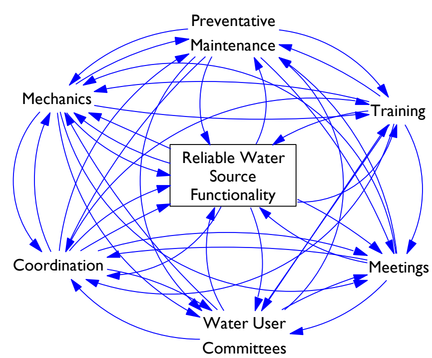
Sub-county Government



Whave



Water Users



HPMA

Causal Loop Analysis

An analysis of the causal loop diagrams produces a list of causal chains of factors that start and end with the outcome factor *Reliable Water Source Functionality*. These causal chains are called feedback loops. Combining the feedback loops with the strength of each relationship identified in the cross-impact matrices creates a ranking of the feedback loops. Within these rankings, the strongest loops are the ones expected to drive overall system behavior and outcomes. By gaining a deeper understanding of the potential actions that drive each system, this analysis evaluates the strength of each loop based on both the values in the cross-impact matrices (direct) and the values from indirect matrices (indirect). See Annex B for more information on indirect matrices.

Whave

DIRECT	Rank	Loops		
Reinforcing Loops	1	Community Attitude	RWSF	
	2	Customer Satisfaction	RWSF	
	3	Customer Satisfaction	Government Support	RWSF
Balancing Loops	1	Preventative Maintenance	RWSF	
	2	Preventative Maintenance	WUCs	RWSF
	3	Preventative Maintenance	Mechanics	RWSF

INDIRECT	Rank	Loops		
Reinforcing Loops	2	WUCs	Preventative Maintenance	RWSF
	4	Government Support	Preventative Maintenance	RWSF
	5	Customer Satisfaction	Preventative Maintenance	RWSF
Balancing Loops	1	Preventative Maintenance	RWSF	
	3	Preventative Maintenance	WUCs	RWSF
	10	Preventative Maintenance	Government Support	RWSF

District Government

DIRECT	Rank	Loops		
Reinforcing Loops	1	Tools for Repair	RWSF	
	2	Bylaws	RWSF	
	3	Mechanics	RWSF	
	4	WUCs	RWSF	
	5	Spare Parts	RWSF	
	6	Water Fees	RWSF	

INDIRECT	Rank	Loops		
Reinforcing Loops	1	Spare Parts	RWSF	
	2	Mechanics	RWSF	
	3	Water Fees	RWSF	
	4	WUCs	RWSF	
	5	Spare Parts	WUCs	RWSF
	6	Water Fees	WUCs	RWSF

Subcounty

DIRECT	Rank	Loops		
Reinforcing Loops	1	Mechanics	RWSF	
	2	Water Users Know Roles	RWSF	
	3	Water Source Bylaws	RWSF	
Balancing Loop	1	Spare Parts	RWSF	
	31	Spare Parts	Mechanics	RWSF
	34	Spare Parts	Water Users Know Roles	WUCs

INDIRECT	Rank	Loops		
Reinforcing Loops	1	Water Users Know Roles	RWSF	
	2	WUCs	RWSF	
	3	Water Users Know Roles	WUCs	RWSF
Balancing Loop	5	Spare Parts	Water Users Know Roles	RWSF
	6	Spare Parts	WUCs	Water Users Know Ro
	10	Spare Parts	Water Users Know Roles	WUCs

Water Users Group

DIRECT	Rank	Loops		
Reinforcing Loops	1	Coordination	RWSF	
	2	Mechanics	RWSF	
	3	Monitoring & Evaluation	RWSF	
	4	Water Source Bylaws	RWSF	
	5	Water User Committee	RWSF	
	6	Water User Committee	Water User Fees	RWSF

INDIRECT	Rank	Loops		
Reinforcing Loops	1	Water User Committee	RWSF	
	2	Water User Committee	Water Source Bylaws	RWSF
	3	Water User Fees	Water User Committee	RWSF
	4	Water Source Bylaws	Water User Committee	RWSF
	5	Water User Committee	Water User Fees	RWSF
	6	Water User Committee	Coordination	RWSF

HPMA

DIRECT	Rank	Loops	
Reinforcing Loops	1	Training	RWSF
	2	Meetings	RWSF
	3	Mechanics	RWSF
	4	Coordination	RWSF
	5	WUCs	RWSF
	6	Preventative Maintenanc	RWSF

INDIRECT	Rank	Loops		
Reinforcing Loops	1	WUCs	RWSF	
	2	WUCs	Preventative Maintenanc	RWSF
	3	Meetings	WUCs	RWSF
	4	Preventative Maintenanc	WUCs	RWSF
	5	WUCs	Meetings	RWSF

ANNEX B
The IFML Process and Systems Analysis

The IFML process is a participatory, stakeholder-driven approach for iteratively building and interpreting factor maps to understand WASH systems and potential areas where systems could be strengthened to increase the likelihood of sustainable services. It was designed based on principles of the value of Group Model Building activities for complex, messy, or "wicked" problems (Andersen, Vennix, Richardson, & Rouwette, 2007; Hovmand, 2014; Vennix, 1996). The process is a direct response to the need to engage key local stakeholders to map and investigate the complexities of their local WASH systems. The insights generated through the process rely on the premise that the collective knowledge of local actors represents a uniquely informed perspective of the interconnections between factors in the WASH system.

IFML was developed at the University of Colorado Boulder and has been implemented and tested in a dozen local contexts to date. Specifically, the process was adapted from "Participatory Systems-based Planning and Evaluation Process," a protocol developed for rural WASH services (Walters, Neely, & Pozo, 2017). As envisioned, the full IFML process consists of a 2-day workshop where results of factor mapping are presented back to the participants on the second day for reflection. The IFML process consists of an iterative set of complementary steps (see Figure 5).

IFML Terminology

While systems terminology varies across the WASH sector, the following definitions for key system elements are used within the IFML process, analysis, and reporting:

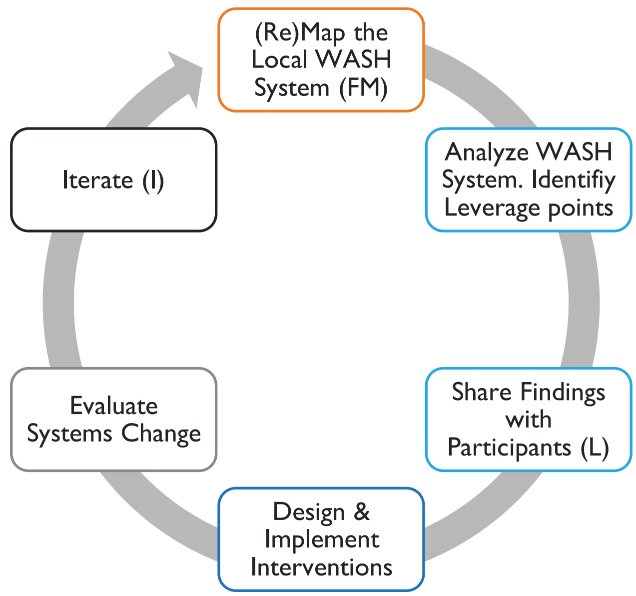


Figure 5 The IFML Process

- **WASH System:**[3] The combination of social, technical, institutional, environmental, and financial factors, actors, motivations, and interactions that influence WASH service delivery within a given context, institutional, or geopolitical boundary.

- **Factors:** Any element, aspect, or component of the WASH service system thought to directly or indirectly influence the WASH system (e.g., finances, water resources, policies, management). Factors by definition are proper, neutral nouns, which can have a range of different states (e.g., collaboration vs. better collaboration between actors). Within the IFML process, this definition allows for consideration of factors in multiple hypothetical states throughout the factor mapping and analysis.

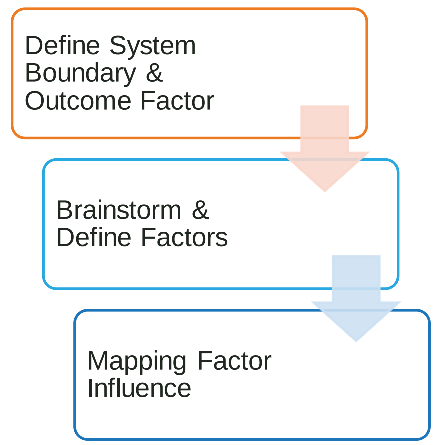
- **Leverage Point:** Factors within a local system which have the greatest potential to affect the whole system. A leverage point can be a unique, singular factor (material or programmatic) or a combination of factors in a

[3] Note SWS terminology refers to WASH hardware systems as "schemes," defined as the combined system of facilities and their operation and maintenance management.

causal chain (underlying process). Targeting these leverage points with strategic adjustments can promote the most favorable result in the system outcomes.

- **Outcome Factor:** The specific factor of inquiry in the WASH system status of which represents the outcome of the system (i.e., sustainable water or sanitation services). The outcome factor is commonly affected by all the factors, directly or indirectly, and can affect other factors itself. The outcome factor is included in the analysis to see how all factors, including the outcome, are interdependent and influence one another.
- **System Behavior:** The observable outcomes of the WASH system that result from the structure of the system (how factors are connected) and the current state of each of the factors. For example, the overall functionality (or downtime) of the scheme would reflect the behavior or outcome of a small town water system.

(Re)Map the WASH System



Mapping WASH systems entails bringing together a thoughtfully selected group of key local WASH participants to conduct a factor mapping workshop. The participants should have a good understanding of WASH issues and represent a diverse set of viewpoints. The group setting of the workshop is deliberate to encourage thoughtful discussion and debate among participants, who may have different perspectives on the local system. This setup results in outputs that synthesize important aspects of these varying perspectives. However, there is no requirement of occupation or educational level to participate in the workshop. This means the activity can include nearly any group from local community members to national-level stakeholders.

During the workshop, participants are asked to brainstorm, define, and prioritize all of the factors that they believe have a direct or indirect influence on local WASH services. The group is then asked collectively to discuss and evaluate the interactions between these factors and the strength of each pair-wise (directional) connection. The workshop can be broken down into three general steps:

1. Determine System Boundary and Outcome Factor

Defining the WASH system entails asking participants to delineate the geographic or political boundary of the WASH service delivery system. While there is no ideal or preferred boundary definition, it should be appropriate to the knowledge of the participants in the workshop. It is important the boundary is explicit as this delineates what factors are internal (e.g., tariffs) and external (e.g., international aid) to the system. Defining the outcome factor determines the focal issue of interest around which to map the system. The outcome factor most frequently represents a service (e.g., rural water services, small town sanitation), but can be a specific sub-system of interest within the larger WASH system (e.g., payment for services, preventive maintenance).

2. Factor Brainstorming

The second step focuses on identifying factors to analyze within the system. The group is first asked to brainstorm the many unique factors that they believe directly or indirectly influence the system. A definition must accompany each proposed factor that the group modifies collectively. It is critical that factor definitions are clear to all participants and that the majority agree on the definition. To make the next step of the workshop manageable for participants, the long list of factors (approximately 20–40 factors), is prioritized to 10–15 factors to include in the mapping exercise. This consolidation process can take different forms, including affinity grouping, expanding definitions, or polling participants on their top choices.

3. Discuss Factor Influence

Once the group has determined the prioritized list of factors, they are asked to systematically evaluate how each factor influences one another, including the outcome factor. Using a Cross Impact matrix (Figure 2), factors are both row and column headings. The facilitator walks the group through evaluating each factor-to-factor influence represented by each box of the matrix. For each box, the group is asked to consider four attributes of each directional relationship: influence, polarity, strength, and delay.

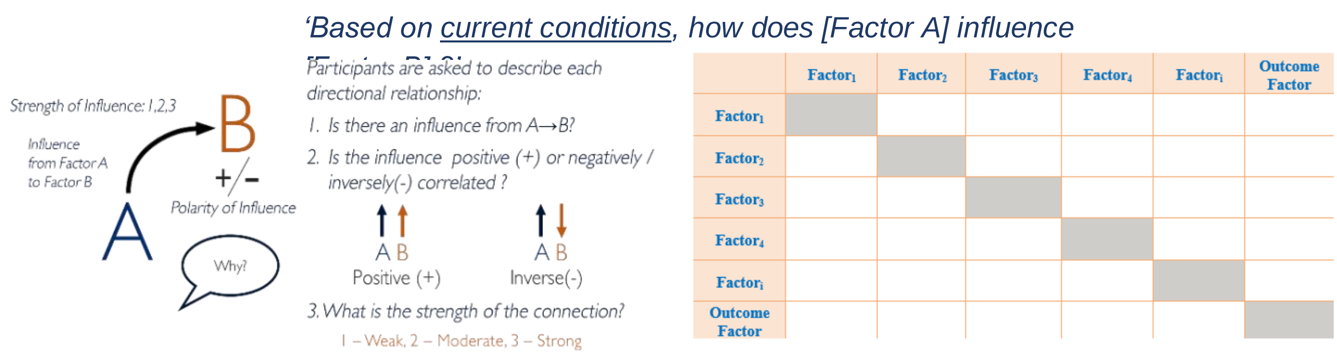


Figure 6 Cross-Impact Matrix

1. **Influence:** Participants are asked to consider the nature of the influence of the "cause factor" on the "effect factor." If the influence represents a direct effect from the cause factor (row) to the effect factor (column), then it is further considered for polarity, strength, and delay. If a direct influence between factors does not exist, it is assigned a value of zero (0), and the remaining influence attributes are not considered.

2. **Polarity of influence:** Participants are then asked to consider the direction of influence. Positive (+) polarity indicates that if the cause factor increases or improves, the effect factor also increases or improves (e.g., as community participation improves, payments for services increases). Negative (-), or inverse, polarity indicates that as the cause factor increases, the effect factor decreases (e.g., as repair services increases, service downtime decreases).

3. **Strength of Influence:** Participants are asked to consider the strength of the influence using a simple scale of 1 to 3 where 1 denotes "weak," 2 denotes "moderate," and 3 denotes "strong." The rating of weights is always relative to each group. In developing the cross-impact matrix, participants commonly return to an influence relationship to revise their rating as their understanding of this relative rating advances.

4. **Delay:**[4] Participants are also asked to consider how fast (F) or slow (S) the influence of the cause factor would manifest in the effect factor. Similar to the strength waiting, conception of fast and slow are relative to the group understanding.

Analyze WASH Systems Map

The purpose of Step 2 is to engage participants with the WASH system map and identify/discuss intervention strategies. The systems map from Step 1 of the IFML can be used to make three distinct, yet complementary, analyses to gain insight into (1) factor influence (influence mapping), (2) centrality and importance of pathways (centrality analysis), and (3) processes and dynamics (causal loop analysis). Each of these three methods presents different insights into the analysis (Table 1), and collectively, they are used to analyze the complex system map created by participants and translate them into actionable insights, based on factor interactions and location within the factor map. Below are short summaries of the analyses with detailed explanations of each.

Table 9: Summary of Systems Analyses

Analysis	Outputs
Influence Mapping	Relative Influence & Dependence of each factor on all other factors in the system
Centrality Analysis	Metrics of how factors are connected, and which are most "central"
Causal Loop Analysis	Identification of reinforcing or balancing "feedback loops" that drive system behavior

Influence Mapping

Influence mapping is used to gain insight into the direct and indirect interaction between factors to better understand how changes in one factor may affect the whole system. The output of the analysis is an influence map (see Figure 3), which is divided into four quadrants and plots factors based on their relative Influence & Dependence on other factors. The axes of this graph can be understood as moving from independent to dependent (x-axis) and ineffective to influential (y-axis). Accordingly, each of the quadrants in the map represents a different factor type based on its relative Influence & Dependence. Starting in the upper right-hand corner and moving counterclockwise, the quadrants represent factors that may be: (I) highly-dependent and influential factors (i.e., volatile, unstable); (II) effective leverage points, if positively influenced; (III) ineffective leverage points due to low significance; and (IV) highly sensitive to others.

The influencing mapping analysis in this report comes from the Matrix of Cross-Impact Multiplications Applied to Classification method (MICMAC), a structural factor analysis technique that entails the creation, manipulation, and analysis of impact matrices to infer factor importance and evolution. Michael Godet developed the MICMAC method in 1971 (Godet, 2000). It is part of Future Methodologies sciences used by the RAND Corporation and others in a large range of scenario planning applications.

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[4] Within the results presented in this report for Concept 1 baseline activities, Delay metrics were not captured for each factor mapping exercise due to time constraints.

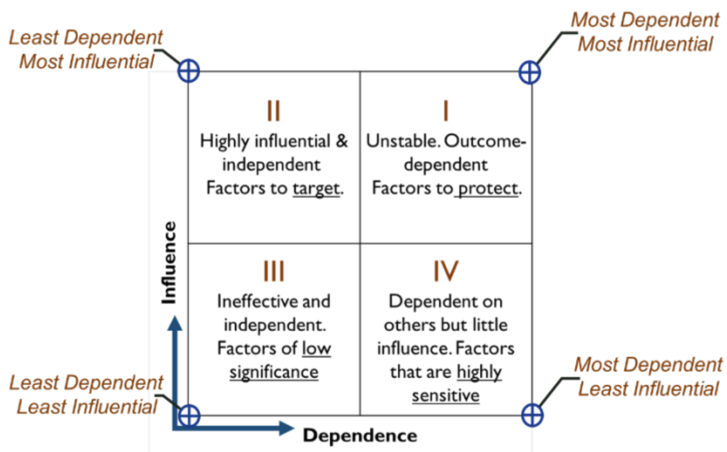

Figure 7 Influence Map

Centrality Analysis

Centrality analysis uses three metrics from network analysis techniques to gain insight into how changes in different factors can move through the system because of their "location" in the system and connection to other factors. In this case, factors are used in place of actors as commonly employed in network analysis. These metrics rank how much a factor is influenced by other factors (degree-in), how influential a factor is on other factors (degree-out), and how central a factor is relative to other factors (betweenness). Betweenness, also described as "centrality," is an indication of how factors connect to other factors in the system. In general, a weighted degree-in and -out serve as a verification check on the Influence & Dependence outcomes of influence mapping, where the betweenness metric indicates how centrally located or connected a factor is relative to other factors. A high betweenness score would suggest that changes in the factor would have more pathways to propagate through the system than a factor with a low betweenness score. UCB usees the open-source software program Gephi for centrality analysis (Bastian, Heymann, & Jacomy, 2009) as based on (Wasserman & Faust, 1994).

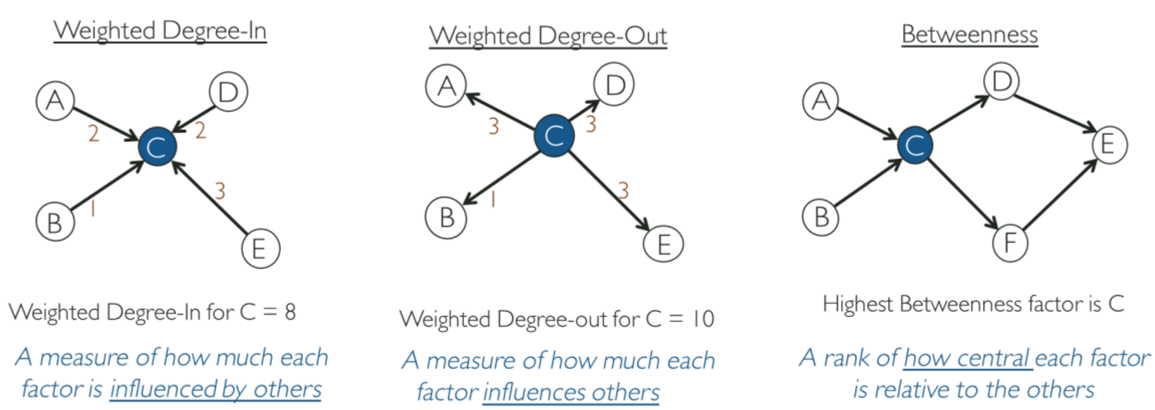

Figure 8 Centrality Metrics

Causal Loop Analysis

Whereas influence mapping and centrality analysis focus on factor influence, dependence, and importance, causal loop analysis (CLA) is employed to directly infer dynamic root causes of the outcome factor (e.g., sustainable water or sanitation services), or other factor in the system (e.g., coordination) (Forrester, 1988; Sterman, 2001). Using the impact matrix created during the factor mapping activity, CLA systematically identifies and prioritizes all possible unique feedback loops — circular sequences of causality — that affect the factor of interest.

Analysis of dominant feedback loops allows the research team to develop complex narratives regarding dynamic pathways that lead to, or may inhibit, the best possible outcome of the system. Often, system behavior can be understood via the comparison to established reference behavior archetypes to support narratives of connections described by the participants during the factor mapping session. Ultimately, combining all of these analyses with the qualitative information collected during the factor mapping exercise can offer insights into potential pathways that may lead to more sustainable WASH systems. UCB conducts CLA using Ventana Systems; Vensim PLE a free, open-source software for qualitative and quantitative system dynamics modeling (Pruyt, 2013; *Vensim*, 2017).

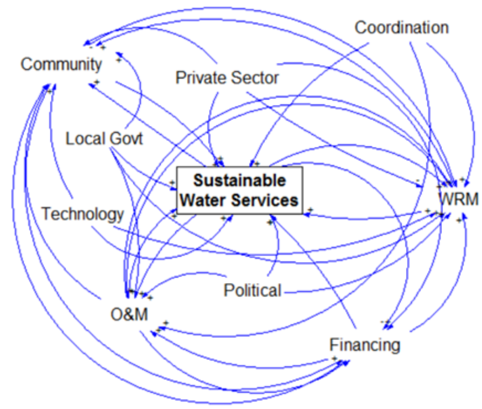

Figure 9 Example Causal Loop Diagram

The diagram is analyzed for feedback loops that aid in understanding the possible dynamic processes that drive the overall outcomes of the system, which builds on the insights developed from the centrality analysis. The analysis is built on the logic that, through unique sequences of cause-and-effect relationships, information and resources are fed back through the system, leading to compounding (reinforcing) or stabilizing (balancing) outcomes in the factor at the beginning of the sequence. In essence, each feedback loop tells a story about possible sequences of causality that may either lead to or impede long-term sustainable outcomes of the system.

Feedback loops can be ranked by their relative strength to one another to determine how likely each loop is to drive system behavior. Within this analysis, loop strength is determined by the average, absolute value strength of the influences between all the factors within the loop (i.e., Services → (3) Finance → (2) Capacity → (3) Services; Loop strength = (3+2+3)/3 influences = average loop strength 2.67).

Design and Implement Interventions

Ideally, upon being presented with the results from the systems analysis, participants will have the chance to discuss intervention strategies based on identified leverage points. It is important that this conversation is properly facilitated to encourage participants to reflect on how the interventions proposed will address the influence, centrality, and dynamics of the leverage point or target factor intended to be affected. Participants should also discuss the changes in the system they expect as a result of the intervention that targets these factors, and how these changes can be measured and evaluated to assess the effectiveness of the intervention. This will help delineate areas within the local WASH system to focus (or refocus) time, effort, resources, and/or material resources.

Multiple activities can aid in this decision-making process, including asking participants to vote on the most important factors based on their interpretation of the model analyses. If it is not possible to directly share the results with those who participated in the activity, it may be possible to engage key stakeholders and those in decision-making positions in consultative sessions where further evaluation of results can occur. It is possible to use outputs from the systems analysis, particularly the causal loop diagram to "test drive" interventions proposed by the stakeholders (i.e., policy analysis).

When deciding what actions, if any, should be taken to address the issues, it is critical to consider how each action will affect other factors in the system, creating unintended, although not necessarily negative, effects. Building off the analysis in this report, there is an opportunity to model proposed interventions to test the assumptions of their impact on the larger system. This would principally include a review of the causal loop diagram with the session facilitator, the implementing partner, and, ideally, the participants of the factor mapping session. Through this activity, there can be modifications and adjustments to the causal loop diagram to better reflect participants' perception of the local system. This would allow it to become a more actionable policy tool through which to evaluate various proposals for action.

The key step of how, when, and where to implement an intervention identified as a result of the IFML is a critical activity, the scope of which is outside of the purview of this report. Within the context of the four analyses presented, the process of designing and implementing activities to strengthen local systems is the product of multiple analyses, in addition to IFML outputs. These analyses are currently being synthesized and planning for future activities is ongoing.

Iterate: Evaluate Changes in WASH System from Intervention

An essential aspect of evaluating the effect of systems-strengthening activities is to have a clear plan for measuring effects within the target outcome factors identified in the factor mapping activity, for example, water point functionality data, records of attendance and reports from coordination events, and payment for services by community members, as appropriate. Depending on the change participants expect to see in the system, a significant amount of time may be required for these outcomes to manifest themselves. It is important to consider when, how, and why a follow-up iteration of the IFML should take place.

Ideally, a second factor mapping session will include the same group of participants. There are two principal options for a second IFML workshop. First, the activity could focus on the same outcome factor as the first (e.g., *Sustainable Water Services*) to refine and strengthen the analysis of and create a more robust model through which to evaluate possible actions. Second, participants could select a new outcome factor (e.g., *Payments for Services*) to explore a unique "sub-system" of the model developed from the first workshop. Information from the second option could also be used to add a module to the original model, further expanding the possible analysis of outcomes of the local WASH system. Through these activities, there can be modifications and adjustments to the causal loop diagram to better reflect the participants' perception of the local system. This would allow it to become a more actionable, policy analysis tool through which to evaluate various proposals for action.

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