Research Report

Sustainable WASH Systems Learning Partnership

FACTOR MAPPING FOR RURAL WATER AND SMALL TOWN SANITATION SERVICES

August 2019

University of Colorado Boulder

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SUSTAINABLE WASH SYSTEMS
A LEARNING PARTNERSHIP

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Acknowledgements: The authors would like to acknowledge John Butterworth, Michael Abera, Eyob Defere, Sequar Zekariyas, Tereza Nega, and Betty Hailegiorgis of IRC Ethiopia, as well as Jane Nabunnya, Martin Watsisi, Peter Magara, and David Ndamira of IRC Uganda for their efforts in coordinating, planning, facilitating, and supporting the factor mapping activity, and Angela Houston (IRC) for insights and review. The IRC team was supported by Lucia Henry (Tetra Tech), Matt Guttentag (LINC), Duncan McNicholl (Whave), and Kimmy Pugel and Nicholas Valcourt (UCB).

Many thanks to all the factor mapping participants for sharing their time and insights with the team.

Suggested citation: Valcourt, Nicholas, Jeff Walters, Amy Javernick-Will, and Dan Hollander. Summary Report of Baseline Iterative Factor Mapping and Learning Analyses in Ethiopia and Uganda. Washington, DC: Sustainable WASH Systems Learning Partnership (USAID), 2018.

About the Sustainable WASH Systems Learning Partnership: The Sustainable WASH Systems Learning Partnership is a global United States Agency for International Development (USAID) cooperative agreement to identify locally-driven solutions to the challenge of developing robust local systems capable of sustaining water, sanitation, and hygiene (WASH) service delivery. This report is made possible by the generous support of the American people through USAID under the terms of the Cooperative Agreement AID-OAA-A-16-00075. The contents are the responsibility of the Sustainable WASH Systems Learning Partnership and do not necessarily reflect the views of USAID or the United States Government. For more information, visit www.globalwaters.org/SWS, or contact Elizabeth Jordan (EJordan@usaid.gov).

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Acronyms

CLD	Causal Loop Diagram
CSO	Civil Society Organization
ONA	Organizational Network Analysis
O&M	Operations and Maintenance
SDG	Sustainable Development Goals
SWS	Sustainable WASH Systems Learning Partnership
UCB	University of Colorado Boulder
USAID	United States Agency for International Development
WASH	Water, Sanitation, and Hygiene
WSC	Water and Sanitation Committee, or Water Source Committee
WUA	Water Users Association

Executive Summary

In Ethiopia and Uganda, the Sustainable WASH Systems Learning Partnership (SWS) developed and piloted a novel approach called factor mapping to better understand the complex relationships between factors that influence water, sanitation, and hygiene (WASH) services. The factor mapping process is a stakeholder-driven decision support technique that generates systems-based insights into how factors interact as a complex and dynamic system to affect a particular outcome of interest in WASH programming over time. This report presents findings from factor mapping activities conducted in four local WASH system contexts: the rural and small town water systems of South Ari and Mile *Woredas* (districts) in Ethiopia's South Omo Zone and Afar Region, Kabarole District in Uganda, and the small town urban sanitation system of Woliso in Ethiopia's Oromia Region.

In each context, SWS identified NGOs, public institutions, academic institutions, and private sector organizations at the town, district, zone, and regional level actively providing or contributing to the provision of WASH services. SWS convened stakeholders from these organizations into "learning alliances," a platform to increase collaboration and knowledge sharing for improved efficiency, effectiveness, and sustainability of local WASH services. It is within this context that SWS developed and conducted factor mapping workshops to gain a better understanding of the factors that drive local WASH systems and their underlying interconnections and interdependencies.

Methodology

The factor mapping process employs a complimentary suite of systems analysis techniques to analyze information collected during group model building sessions with key local stakeholders. This includes a facilitated workshop where participants are asked to identify the key factors affecting the sustainability of WASH 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 which represents participants' perspectives of the interactions between factors that drive 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 material, programmatic, and underlining processes that have the greatest potential to affect the system. Targeting these leverage points with strategic adjustments may result in improved system 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

Findings and outcomes are inherently specific to the context in which factor mapping workshops are conducted. Accordingly, an overview of the analysis and findings for each of the four contexts are summarized in the main body of this report and discussed in detail in Appendix B.

Factor mapping identified leverage points that stakeholders perceive influence the sustainability of local WASH services

Across the four contexts, factor mapping identified over a dozen unique, complex, and dynamic factor interactions (processes) that have the potential to promote, or inhibit, the sustainable provision of WASH services. These processes, and the factors which drive them, may represent key leverage points in the system. When strategically addressed, these leverage points have the ability to strengthen local WASH systems, leading to an improved structure to deliver more sustainable services. Leverage points were identified by synthesizing insights from three complementary analyses that looked at relationships between factors, including Influence & Dependence, centrality, and causal relationships. These insights were combined with, and validated by, narratives from participant discussions during the factor mapping process to understand how different factors, and combinations of factors, affect the local system.

For example, in one context the analysis indicated the interdependence of *Community Participation*, *Financing and Ownership*, and *Operations and Maintenance* (*O&M)* was perceived to be the main driver of small town and rural water services.[1] Participants explained that if the community was more actively involved in the management of their water services, this would have a positive impact on their willingness to pay and overall O&M of the water scheme. However, participants also noted where schemes were poorly managed, financing (from the government and NGOs) would be redirected to support those schemes. In other words, there was a disincentive for communities to maintain or pay for maintenance services if they knew the scheme would inevitably be fixed by others. This combination of factors formed a "balancing loop" that the factor mapping analysis suggested would lead to stagnant water scheme functionality levels. This example illustrates how factor mapping outputs can describe complex real world processes that underlie local WASH systems, with the goal of understanding how these processes can be adjusted to promote better outcomes.

Factor mapping helps participants work toward a more holistic understanding of their local WASH system

By sharing multiple perspectives of how key factors affect one another in a group setting, participants begin to understand how other actors in the local context view challenges and opportunities for improving services. This helps build participants' understanding of the local WASH system in three ways: (1) by sharing, formalizing, and aligning individual perspectives on an issue within a group to learn how certain factors contribute to outcomes in the local system, (2) by providing a platform to discuss complex problems using a common terminology, and (3) by better facilitating group consensus on shared strategies and future actions. Participant feedback on the factor mapping process highlighted these aspects, with one participant in South Ari stating, "We were able to think differently, in different directions. We were able to bring evidence to convince another." Another participant in Kabarole noted, "We were aware of these factors, but now the things we took for granted, we appreciate, [such as] some of the interactions between those factors."

[1] Core factors discussed within the workshops are identified with proper names in italics in the report. E.g., Coordination vs. coordination (in general).

Factor mapping can illustrate the complexity of local WASH systems based on stakeholder perspectives

While the sector increasingly describes endemic issues of insufficient and unsustained service provision as "wicked" or complex problems, few practical and replicable tools are available to explicitly investigate the complexity, interactions, and interdependencies between factors in local WASH systems. Of the proposed approaches, few incorporate information regarding factors and interactions directly from local participants. The factor mapping process directly addresses this need by using group model building techniques to work around the limits of "bounded rationality" (the ability to only think of one or two interactions at a time). By facilitating conversations that explore factor-to-factor influences and using the cross-impact matrix, the factor mapping approach grounds the analysis in participants' perspectives, while simultaneously improving the ability of participants to understand the systems they interact with and the perspectives of others.

Outputs of the factor mapping process (e.g., causal loop diagrams) show the approach can produce complex information generated from local participants' perspectives in a digestible format. This allows local partners to investigate the dynamics of common factors necessary for sustaining WASH services and evaluate interventions within a systems context to understand how proposed activities affect local systems. Factor mapping findings indicate WASH programs cannot assume critical factors — such as *Coordination*, *Governance*, or *Finance* — exert the same influence on local systems, or one another, across different contexts. Instead, interventions and programs need to acknowledge, map, and consider the context-specific interactions and dynamics that drive local WASH systems.

Lessons Learned

In addition to the findings identified for each local context, this first iteration of factor mapping under SWS provided a valuable opportunity to reflect on important insights to consider for future iterations of the process in Ethiopia, Uganda, and the WASH sector more broadly.

Findings are bounded to participants' perspectives

A key aspect of participatory group model building is understanding that outcomes represent the perspectives of participants in the activity. Participants must be carefully selected to ensure they have sufficient knowledge of local WASH systems to contribute to group model building. For the factor mapping activities presented in this report, participants were identified and brought together based on their collective knowledge of local systems. The findings presented in this analysis reflect this shared collective knowledge and are limited to participants' perspectives. No additional information was used to develop the findings presented here.

Insights are dependent on quality of documentation and facilitation

The factor mapping process and outcomes of the analysis benefit greatly from high quality facilitation and detailed documentation of participants' conversations about factor influence and relationships. The factor mapping activity may represent a novel meeting format (similar to a focus group) for participants, so their ability to accurately describe factor interactions is enhanced by the facilitators' ability to engage the group in a systems thinking mindset.

Detailed documentation of participant discussions is also highly desirable for extracting meaning from the cross-impact matrix created during the activity. While the matrix represents the participants' direct identification of factors and relationship strengths, the conversation that takes place during the activity provides a narrative that is essential to understanding the local nuances of factor relationships and interactions. Documenting this conversation is especially important when factor mapping is conducted in a local language (three of the four contexts presented in this report). During the analysis phase, UCB relied on facilitator feedback and meeting notes to develop narratives to describe insights from the systems analyses.

Future Work

Results from each factor mapping analysis were presented to participants to elicit their perspectives on the validity, value, and appropriateness of the information. This was a critical step in validating the findings presented in this report. Reflections from the factor mapping sessions were incorporated into each context-specific model to improve its ability to accurately represent the local WASH system. Through this feedback process, factor mapping was also intended to build participants' systems thinking capabilities to understand how local WASH outcomes result from a dynamic web of factors and relationships, as opposed to isolated issues. Insights from these feedback sessions were documented and evaluated to inform how the factor mapping process can be improved and tailored to local contexts.

The results of the factor mapping activities represent a baseline view of the local system from the perspective of learning alliance members. Any future iteration of the factor mapping process can build upon this baseline by exploring local "sub-systems" of factors within each context (i.e., payments for O&M). Mapping these sub-systems would result in a more detailed model of each context which could be used for "test driving" proposed inventions or policies. This task, known as policy analysis, allows stakeholders to explore how selected actions may impact other factors and overall system outcomes. Future iteration could also refocus the workshop on the original outcome factor (e.g., *Sustainable Water Services*) after an intervention has been implemented to understand the extent to which participants believe the structure of the system changed and evaluate how this impacts service delivery outcomes.

Document Structure

This report presents an overview of the factor mapping approach, types of systems analysis employed, and cross-context findings and reflections from the first iteration of factor mapping within SWS. Individual results are then presented for the four local WASH contexts (Woliso, South Ari, Mile, and Kabarole), with background on the specific context in which factor mapping was conducted and a discussion of results. Stakeholder feedback collected during the factor mapping sessions is also briefly discussed for each site. Based on the results of the systems analysis and qualitative notes recorded during each session, key context-specific findings and recommendations for action and iteration are provided. The end of the report presents concluding remarks from facilitators on the process, including lessons learned, interpretation of results, and future work. Appendix B provides detailed analysis and findings for each of the contexts studied.

Introduction

The Sustainable WASH Systems Learning Partnership (SWS) is a global United States Agency for International Development (USAID) cooperative agreement to identify and test locally-driven solutions to the challenge of developing robust local systems capable of sustaining water, sanitation, and hygiene (WASH) service delivery. Led by the University of Colorado Boulder (UCB), SWS emphasizes partnership and learning for catalytic change in the WASH sector. The project includes collaboration with four teams in the priority countries of Ethiopia, Kenya, Uganda, and Cambodia to work toward meeting the rapidly increasing needs of sustainable WASH service delivery.

In Ethiopia, SWS (led by IRC with Tetra Tech and LINC) is working with key stakeholders to develop and test a structured and replicable approach to understanding, engaging with, and strengthening decentralized district- and small town-level systems for WASH service delivery. This report presents findings from factor mapping activities conducted in four local WASH system contexts: the rural and small town water systems of South Ari and Mile *Woredas* (districts) in Ethiopia's South Omo Zone and Afar Region, Kabarole District in Uganda, and the small town urban sanitation system of Woliso in Ethiopia's Oromia Region.

In each of these contexts, IRC identified NGOs, public and academic institutions, and private sector organizations at the town, district, zone, and regional level actively providing or contributing to the provision of WASH services. SWS convened stakeholders from these organizations into "learning alliances," a platform to increase collaboration and knowledge sharing for improved efficiency, effectiveness, and sustainability of local WASH services. It is within this context that SWS developed and conducted factor mapping workshops to gain a better understanding of the factors that drive local WASH systems and their underlying interconnections and interdependencies. Factor mapping was part of a suite of complementary analyses intended to develop a rich understanding of local systems. The analyses focused on different elements of local systems including hardware (asset inventory), finance (life-cycle cost analysis), coordination (organizational network analysis), and institutional capacities and deficiencies (sustainability checks).

SWS conducted factor mapping activities in four active sites in Ethiopia and Uganda. The goal of the factor mapping process is to better understand the underlying structure of local systems. By eliciting local stakeholder perspectives on how system factors interact, factor mapping provides a framework to systematically analyze the root causes of local WASH issues. When paired with the outputs of other SWS analyses, factor mapping helps to promote decision-making that considers the complexity of local issues to determine key intervention areas to strengthen local WASH systems.

The Factor Mapping Process

Factor mapping is a participatory, stakeholder-driven approach for iteratively building and interpreting factor maps to understand WASH systems and identify potential areas where systems could be strengthened to increase the likelihood of sustainable services. Its design is based on group model building activities for "wicked" or complex problems (Andersen, Vennix, and Richardson 1997; Vennix 1996; Hovmand 2014). Factor mapping addresses the need to engage key local stakeholders to map and investigate the complexities of their local WASH system. This process generates insights built on the premise that the collective knowledge of local stakeholders represents a unique, informed perspective on the interconnections between factors in the WASH system.

UCB developed factor mapping and it has been implemented and tested in a dozen local contexts to date. Factor mapping was adapted from "Participatory Systems-based Planning and Evaluation Process," a protocol developed for rural WASH services (Walters, Neely, and Pozo 2017). As envisioned, the full process consists of a 2-day workshop where results of factor mapping activities are presented back to participants on the second day for reflection. It is important to note that results presented in this report correspond to activities conducted in a shorter period (approximately 2.5 hours) than the 1 to 2 day duration outlined in the original factor mapping protocol. The factor mapping process consists of an iterative set of complimentary steps shown in Figure 1.[2]

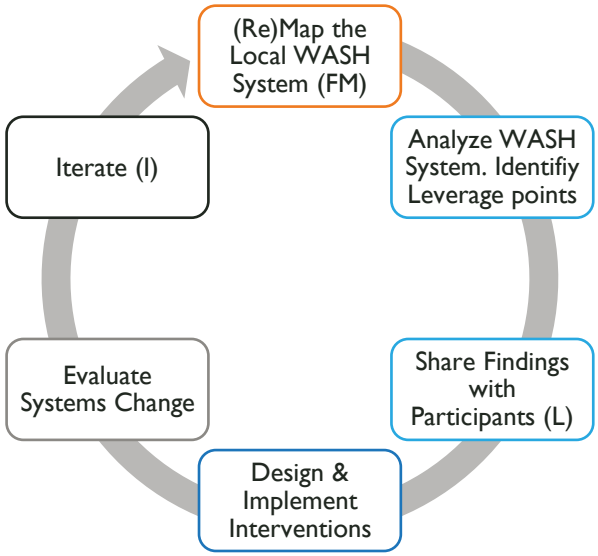


Figure 1 The Factor Mapping Process

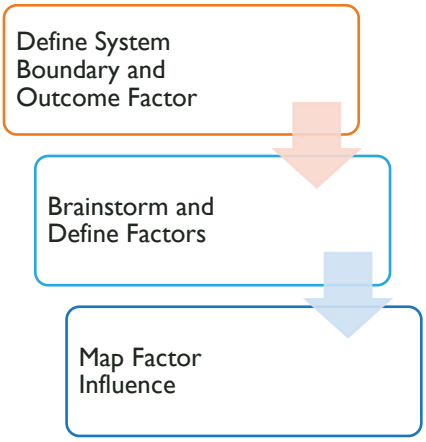
[2] This report presents outcomes through the first two steps of the process: mapping the system and analyzing the results. For SWS activities, the identification of appropriate interventions to address the key factors or leverage points identified is a forthcoming activity.

(Re)Map the WASH System

Mapping WASH systems entails bringing together a thoughtfully selected group of key local stakeholders to conduct a factor mapping workshop. During the workshop, participants are asked to brainstorm, define, and prioritize the factors they believe have a direct or indirect influence on local WASH services. The group is then asked to discuss and evaluate the interactions between those factors and the strength of each pair-wise (directional) connection. The workshop consists of three primary steps:

1. Define System Boundary and Outcome Factor

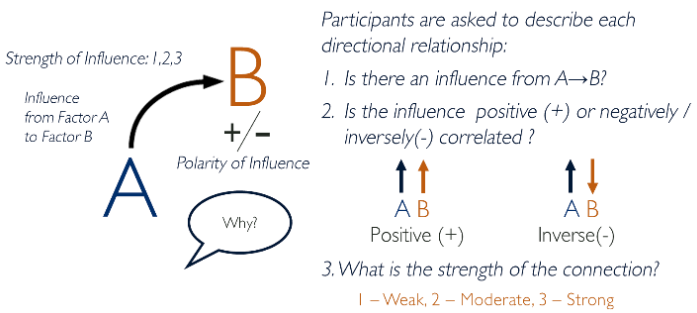
To define the WASH system, participants are asked to delineate the geographic or political boundary of the WASH service delivery system. It is important the boundary is explicit as this delineates the factors that are internal (e.g., tariffs) and those that are external (e.g., international aid) to the system. The outcome factor is the focal issue of interest around which the system will be mapped. It most frequently represents a service (e.g., rural water services, small town sanitation), but can also be directed at a specific sub-system of interest within the larger WASH system (e.g., payment for services, preventive maintenance).



2. Brainstorm and Define Factors

The second step focuses on identifying the factors[3] to be analyzed within the system. Each proposed factor must be accompanied by a definition that the group modifies collectively. It is critical that each factor definition is clear to all participants and the majority of participants agree on it. To make the next step of the workshop manageable for participants, the long list of factors (approximately 20 to 40 factors), is prioritized to 10 to 15 factors that will be included in the mapping exercise. This consolidation process can take different forms including affinity grouping, expanding definitions, or polling participants on their top choices.

'Based on current conditions, how does [Factor A] influence [Factor B]?



	$Factor_1$	$Factor_2$	$Factor_3$	$Factor_4$	$Factor_i$	Outcome Factor
$Factor_1$						
$Factor_2$						
$Factor_3$						
$Factor_4$						
$Factor_i$						
Outcome Factor						

Figure 2 Cross-Impact Matrix

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

3. Map Factor Influence

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

- Influence is the direct affect that one factor has on another separate of other factors,
- Polarity is the direction of the affect, and
- Strength is the relative strength of influence (strong, medium, weak).

Analyze WASH Systems Map

The purpose of Step 2 is to engage participants with the WASH system map and identify and discuss intervention strategies. The cross-impact matrix, from Step 1, can be used in three distinct, yet complementary, analyses to gain insight into factor influence (influence mapping), centrality and importance of pathways (centrality analysis), and processes and dynamics (causal loop analysis). Each of these methods provides different insights for analysis (see Table 1). Collectively, they are used to analyze the system map created by participants and create actionable insights based on factor interactions and location within that map. Table 1 provides short summaries of the analyses, and Appendix B presents more detailed explanations.

Table 1: Summary of Systems Analyses

Analysis	Outputs
Influence Mapping	Rankings of the relative influence — the degree to which a factor affects others – and dependence — the degree to which each factor is affected by others
Centrality Analysis	Ranking of how much factors are connected to one another, directly and through other factors (indirectly), and which factors are most central
Causal Loop Analysis	Prioritized lists of circular cause-and-effect chains of factors that generate either reinforcing (compounding growth or decay) or balancing (pushing towards and equilibrium) 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 which is divided into four quadrants and plots factors based on their relative influence — the degree to which a factor affects others — and dependence, the degree to which each factor is affected by others (see Figure 3). 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 map quadrants represents a different factor type based on its relative Influence & Dependence.

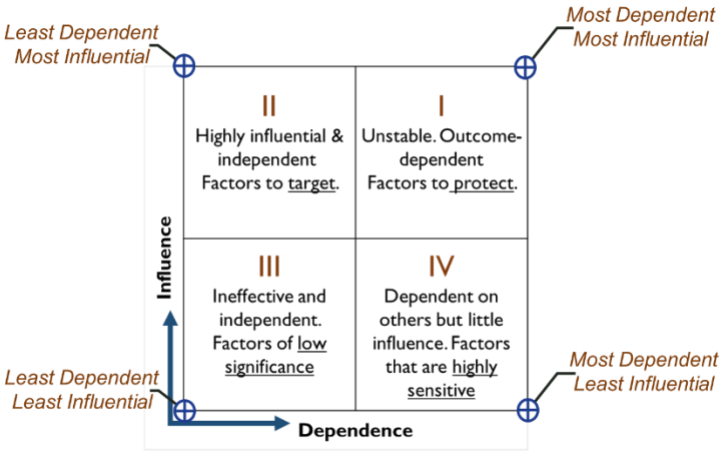


Figure 3 Influence Map

Centrality Analysis

Centrality analysis is used to explore how changes in factors and connections can move through the system through their connections to other factors. This analysis is similar to, and uses the same methods as, identifying central actors in social networks based on how they communicate with others in their network. Using connections identified in the cross-impact matric, the analysis generates a score for how central a factor is relative to other factors. This metric is also commonly referred to as betweenness.

Causal Loop Analysis

Whereas influence mapping and centrality analysis focus on the influence, dependence, and connections of individual factors, causal loop analysis is employed to understand how combinations of factors affect the sustainability of WASH services through their connections to other factors. Using the cross-impact matrix created during the factor mapping activity, a graphic depiction of all the connections identified between each factor is created. This diagram, referred to as a causal loop diagram (CLD), represents all the factors in the system and how they are connected to one another (see Figure 4). It is a holistic visualization of the cross-impact matrix.

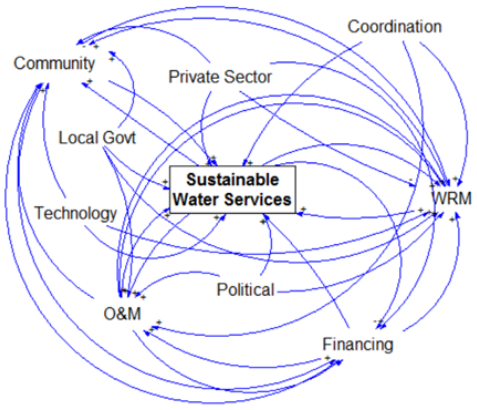


Figure 4 Example Causal Loop Diagram

While the CLD is a useful tool to highlight how factors are more or less connected in the system, computational causal loop analysis is required to understand how these connections may lead to different outcomes in WASH services. Using a system dynamics software program, the CLD is analyzed to systematically identify and prioritize all

of the possible feedback loops — unique chains of cause and effect relationships — that affect the system's outcome. This analysis is built on the logic that through feedback loops information and resources are "fed back" through the system, leading to either compounding (reinforcing) or stabilizing (balancing) behavior in the factor at the beginning of the sequence.

By combining feedback loops with the influence values from the cross-impact matrix, it is possible to infer which feedback loops are most likely to drive the behavior of the system. Using this process, a list of feedback loops ranked by their relative strength is developed for each CLD. Examining each of these dominant feedback loops helps to develop insightful narratives of the possible pathways that either lead to, or inhibit, the sustainability of WASH services.

Design and Implement Interventions

When shown results from the analysis, participants have the opportunity to discuss intervention strategies based on leverage points identified. It is important this conversation is properly facilitated and documented to encourage reflection on how the proposed interventions will address the influence, centrality, and dynamics of the leverage point or target factor they are intended to affect. Participants should also discuss expected changes in the system from proposed interventions and how to measure and evaluate interventions to assess their effectiveness. This will help delineate areas to focus (or refocus) time, effort, and resources. Outputs from the analysis, particularly the CLD, could be used to "test drive" interventions proposed by stakeholders, a process in the field of system dynamics referred to as policy analysis.[4]

Determining how, when, and where to implement an identified intervention is a critical activity outside of the purview of this report. For the four local contexts presented herein, the design and implementation of activities to strengthen local systems is expected to be a product of multiple analyses, in addition to factor mapping outputs. These analyses are currently being synthesized, and planning for future activities is ongoing.

Iterate: Evaluate Changes in WASH System from Intervention

Evaluating the effect of systems-strengthening activities requires a clear plan for measuring the target outcome factors identified in the factor mapping activity. 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. Therefore, it is important to consider when, how, and why a follow-up iteration of factor mapping should take place. Appendix B presents recommendations for context-specific iteration of the factor mapping process.

There are three principal options for a second factor mapping workshop: (1) focus on the same outcome factor (e.g., *Sustainable Water Services*) to refine and strengthen the analysis and create a more robust model through which to evaluate possible actions, (2) update the analysis as the system changes over time, or (3) select a new outcome factor (e.g., *Payments for Services*) to explore a unique sub-

[4] Richardson, G. P. (1991). System dynamics: Simulation for policy analysis from a feedback perspective. In P. A. Fishwick & P. A. Luker (eds.), Qualitative simulation modeling and analysis. New York: Springer-Verlag.

system of the model developed from the first workshop. This information could also be used to add a module to the original model, further expanding the possible analysis of system outcomes and helping create a more actionable policy analysis tool to evaluate various proposals for action.

Data Collection and Analysis

This report outlines the data collection, analysis, and results from four factor mapping workshops conducted in November and December 2017. Planning for these workshops began in summer 2017 with a full protocol for the factor mapping process shared with SWS partners from September to October 2017 (see Table 2). The protocol was revised multiple times to incorporate key insights from local partners. It was also edited into different versions to share with a wide range of actors. UCB completed its analysis between January and February 2018 and shared the results with participants beginning in March 2018.

Table 2 Data Collection Timeline

Time Frame	Activities
September–October 2017	Factor mapping protocol developed, reviewed by SWS partners, and finalized
November–December 2017	Four factor mapping sessions conducted in Ethiopia and Uganda, data and documentation collected, pre/post surveys administered
January–February 2018	Analysis conducted and findings summarized for reporting
March–June 2018	Findings shared with participants, feedback collected and findings revised accordingly, evaluation of value of information to stakeholders

Findings

Insights and findings from the four contexts are presented below with full-length text and figures provided in Appendix B. It is important to note the descriptions of how factors interact with one another in complex WASH systems are bounded to the context in which they were mapped. For example, how factors *Coordination* or *Operations and Maintenance (O&M*) interact in one local context is not directly comparable to how they interact with factors in another context. Additionally, each factor has a unique definition as described by participants in the different factor mapping workshops (see Appendix B).

Kabarole, Uganda: Small Town and Rural Water

IRC conducted a factor mapping activity in Kabarole District, Uganda on Nov. 28, 2017 as part of a standing WASH stakeholder group meeting with civil service, political, and private industry stakeholders involved in rural and small town water service planning and operations the district. The activity engaged 16 participants comprised of technical experts and managers from local government offices, politicians, and a representative of the local Hand Pump Mechanics Association. Participants collectively identified nine factors that influence the sustainability of small town and rural water services across Kabarole District and mapped their influences over a 6-hour workshop. These factors include *O&M*, *Local Government Capacity*, *Community Ownership*, *Technology*, *Private Sector Involvement*, *Political Involvement*, *Coordination*, *Water Resource Management*, *Financing*, and the outcome factor *Sustainable Water Services.*

Analysis of the cross-impact matrix via the influence map identified the factors *Local Government Capacity* and *Coordination* as clear leverage points to improve the *Sustainability of Water Services* due to their high influence on the system and relatively low dependence on other factors. The influence map also showed *O&M*, *Private Sector*, and *Community Ownership* as the most "sensitive" factors in the system, meaning they are heavily influenced by the other factors. The analysis identified *Financing* as a potential "fracture point" in the system, meaning small adjustments or disruptions to financial flows could create unpredictable effects on the *Sustainability of Water Services*.

The centrality analysis reinforced the importance of *Financing* and *Coordination,* indicating these factors are significantly more central than the others. This finding suggests the most efficient pathways for factors to affect one another, and sustainability of services overall, is through *Financing* and *Coordination. Political Involvement* was shown to be the least central, indicating it is a very "disconnected" factor in the system and least likely to affect change based on its connection to other factors.

Of the 44 unique feedback loops analyzed in the CLD (see Figure 5), the causal loop analysis identified three key reinforcing loops (those that can dramatically improve or diminish system outcomes) and balancing loops (those that tend to drive system outcomes to a constant, steady state). For example, the reinforcing loop R3 (*Community → Financing → O&M → Services*) suggests that as the sustainability of water services increase (high functionality, more reliable), the feeling of ownership of the source in the community will improve. This is then expected to increase financial contributions from the community (one component of *Financing*), which will in turn further improve the O&M of the source, resulting in an overall improvement in the sustainability of water services.

One surprising result of the causal loop analysis in the Kabarole context was that balancing loops were ranked higher (i.e., more likely to influence the status of *Sustainable Water Services*) than reinforcing loops. This was a unique outcome in comparison to the other contexts studied in this report and means the combination of factors in these loops will tend to result in a steady state of *Sustainable Water Services*, or unchanging levels of functionality (neither improving nor decreasing). Additionally, participants identified unique inverse polarity relationships between *O&M* and *Financing*, which was explained as "if the O&M of the source is good, financing will be redirected at other sources." This suggests that the relationship between the two factors and *Sustainable Water Services* is key to overall sustainability. Conversely, all the reinforcing loops involved some combination of *Community Ownership*, *Financing*, and *O&M*. Because reinforcing loops have the potential to dramatically increase or decrease the state of *Sustainable Water Services*, this is an indication that *Community Ownership* could be key to increasing *Sustainable Water Services*, because of its direct effects on *Financing* and *O&M*.

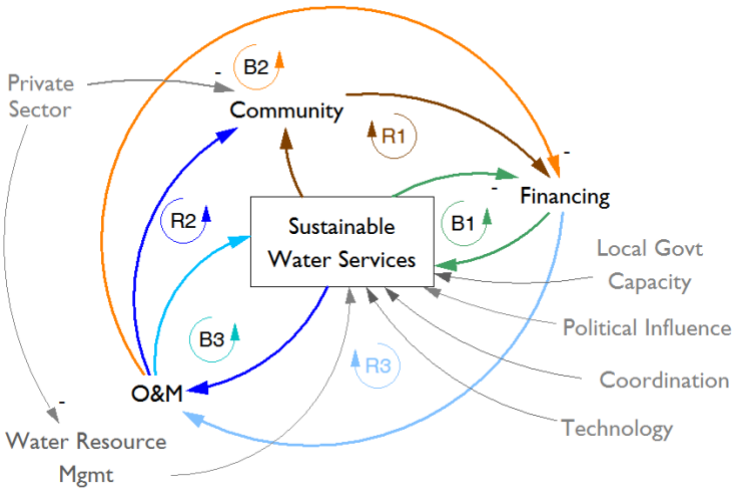


Figure 5: Kabarole Causal Loop Diagram

Findings

Finding I: There is a need to better understand the relationship between *Community Ownership*, *Financing*, and *O&M*

During the factor mapping activity, the relationships between *Community Ownership*, *Financing*, and *O&M* were some of the most heavily discussed and debated of all the influences in the matrix. Participants had multiple perspectives on how *O&M* and *Finance* were connected but agreed there was an inverse effect; if sources are working well, funds will be redirected to low-functionality sources. These factors collectively appear as influential, central, potentially volatile, and driving forces in the system, which reinforces the need to better understand their relationships when working to build a stronger system to deliver sustainable water services.

Finding II: *Local Government Capacity* and *Coordination* are the most likely leverage points to influence the sustainability of water services

It is clear that *Local Government Capacity* and *Coordination* are strong leverage points from the Influence & Dependence graph. The centrality analysis also identified *Coordination* as one of the most central factors, although *Local Government Capacity* was less connected. However, neither of these factors were present in any of the dominant causal loops, which may suggest their effect on the sustainability of water services is independent of their relationships with other factors. The factors *Local Government Capacity* and *Coordination* are intertwined with participants generally agreeing local government should lead local

coordination efforts, making it important to better understand the relationship between these factors and their combined impact on the overall system.

Finding III: Unique interactions of *Political* and *Private Sector Involvement*

Insights from the systems analysis and discussion notes indicate three key findings. First, participants agree both political and private sector actors need to be engaged to support *Sustainable Water Services*. Second, while both can have positive or negative impacts, *Political* aspects have greater potential to create change in the system and are not heavily influenced by other factors. Therefore, the factors that most affect political influence, as it relates to water services, are outside of the local system (as mapped by the participants). Third, despite these known impacts, it is unclear where to engage each set of actors in the system to create positive outcomes.

Recommendations

Recommendation I: Promote clear and balanced policies for community contributions toward O&M

To effectively address the unique interconnectivity of *Community Ownership*, *Financing*, and *O&M*, there is a need to shift polices around how government, NGO, and community contributions are used to promote regular O&M, so as not to incentive breakdown as a means of getting funds. While the policy for addressing both items will likely vary depending on factors in the immediate local context, the type of scheme, and the existing management structure, there are likely some district-wide policies for managing external financial flows and community contributions that could serve as minimum standards or guidelines for clear and balanced policies to support consistent and sufficient O&M of schemes.

Recommendation II: Advocate for additional human resources to improve government capacity at the district level

Because *Local Government Capacity* and *Coordination* were both shown to be key leverage points, these areas should be prioritized for systems strengthening in Kabarole District. While the results of the systems analysis and notes from group discussions point to a need to improve local government capacity, they do not provide detailed insights as to where, within the existing government structure, capacity needs to be increased or how. It is expected members of the WASH stakeholder group are aware of this issue and it has been previously evaluated through context scoping, political economy analysis, or other analyses.

Iteration

The relationship between *Community*, *Financing*, and *O&M* requires further evaluation. A subsequent factor mapping activity could focus on factors that influence a community's willingness to pay for services, with particular attention to contributions to *O&M*. This analysis could also bring in the factors *Civil Society Organization (CSOs)* and *Private Sector*, which appear to be more related to *O&M* and *Community* dynamics than to *Sustainable Water Services*.

South Ari, Ethiopia: Small Town and Rural Water

IRC conducted a factor mapping activity on Nov. 15, 2017 in Jinka, Ethiopia as part of a workshop with key local stakeholders involved in rural and small town water planning and operations in South Ari Woreda. The workshop was part of a series of meetings intended to formalize a learning alliance platform for enhanced coordination and collaboration among stakeholders. The activity engaged 16 participants from the Woreda Offices of Water, Agriculture, and Women and Children; Zonal Offices of Education, Finance, Health, Agriculture, Water, and Mining and Energy; and representatives from two international NGOs working in the region. Participants collectively identified 10 key factors that influence small town and rural water services across South Ari and mapped their influences over a 2-hour workshop. The identified factors were: *Capacity Building*, *Community Participation and Awareness*, *Coordination*, *Environment and Water Resources*, *Finance*, *Monitoring and Information*, *O&M*, *Planning and Construction*, *Policy*, *Proper Use of Water Schemes*, and the outcome factor *Sustainable Water Services.*

Analysis of the cross-impact matrix via the influence map identified *Community Participation* and *Capacity Building* as the most influential and independent factors, indicating they are likely points of leverage within the overall system. *Coordination* also appeared to be a potential leverage point but was more dependent on other factors within the system than *Community* and *Capacity*. The influence map also showed *Policy* as particularly influential while also being highly dependent, indicating small changes to this factor could have wider, unpredictable changes on other factors. The centrality analysis reinforced that *Policy* was the most central factor in the system, meaning it has the closest connections to other factors through which those unpredictable changes could affect the whole system. The centrality analysis also ranked the outcome factor as the second most central, suggesting the current state of services (i.e., levels of functionality) has a close relationship and influence on other factors in the system, and changes in this factor (i.e., increased or decreased functionality) can have near-term influential impacts on other factors, most likely *Community Participation* and *Finances*.

Of the 26 unique feedback loops analyzed in the CLD (see Figure 6), the causal loop analysis identified three key reinforcing loops and balancing loops. The clearest take-away from the causal loop analysis was that *Policy* is present in all the top reinforcing and balancing loops, by itself and in combination with O&M. This finding suggests there is a unique relationship between *Policy* and *O&M* that may be the strongest driver of change in *Sustainable Water Services*. Second to the role of *Policy* in all the balancing loops is *Finance*, due to the special inverse relationship participants identified between *Finance* and *Community Participation*. This finding implies that

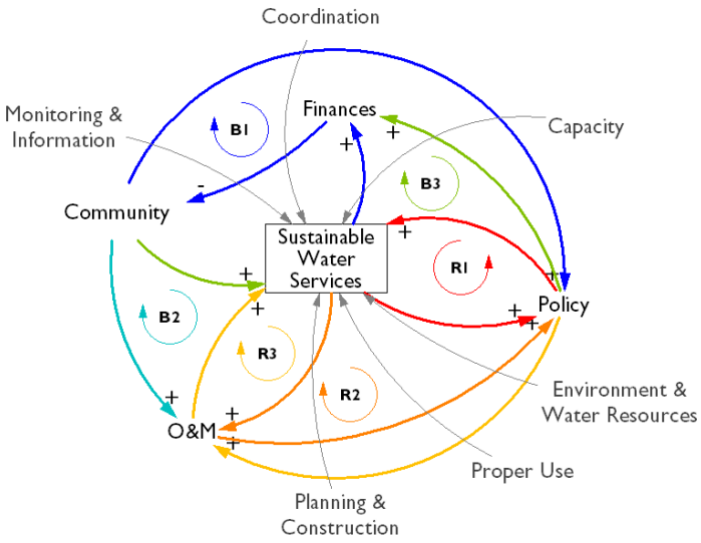


Figure 6 South Ari Causal Loop Diagram

as more financial resources are made available for water scheme operations, communities may be disincentivized to contribute their own financial resources.

Findings

Finding I: The connection between *Policy* and *O&M* defines the state of water services

The high influence of *Policy* coupled with its relatively high dependence on other factors in the system makes it potentially volatile. However, the causal loop analysis illustrated it is not *Policy*, but rather its relationship with *O&M*, that is most likely to drive the overall system, as indicated in two reinforcing loops and one balancing loop. It is important to note that *O&M* is not a part of any other loop where it is not directly connected to *Policy*, either influencing it or being influenced by it. *O&M* was also identified as one of the more dependent or sensitive factors, suggesting the state of water services is driven by the connection between *Policy* and *O&M*.

Finding II: Stable *Finances* are a prerequisite for the local system to support sustainable services

The inverse influence that participants identified of *Financing* on *Community Participation* suggests a tendency for this relationship to balance the system. This would be reflected in persistent issues of low functionality, or if services increased the loop could promote consistently high levels of functionality. During the discussion participants also noted funding issues are multidimensional, where: (1) there are a number of different sources of funding, (2) there is a lack of certainty regarding future financial flows, and (3) there is lack of adequate capacity of woreda offices to handle increased or erratic finances. This was reflected in the cross-impact matrix and influence map, which showed *Finance* as one of the most sensitive factors in the system.

Finding III: *Coordination* platforms need to be strengthened and include *Community Participation*

While *Coordination* was not a top element of either the centrality analysis or CLD, it was one of the target factors in the influence map because it is highly influential and independent. Perhaps more importantly, *Coordination* was mentioned frequently in combination with *Community Participation,* another potential leverage point. During the activity, participants explained that *Coordination* with communities was critical for data collection and responsible management of the schemes (*Proper Use*) as well as sharing best practices for *Monitoring* and *Planning,* two other potential key leverage points.

Finding IV: Increasing *Local Government Capacity* is a fundamental need

Local Government Capacity was deemed to be as influential and as independent as *Community Participation* on the influence map. This was also reflected in its top rank of the Centrality Analysis. However, it was not present in any of the top feedback loops, which limits the ability to estimate its effect on dynamic processes of the system. Still, the influence analysis suggests that *Local Government Capacity* remains a clear leverage point that can lead to positive changes in the factors that appear to drive the system (*O&M*, *Finance*, *Policy*, and *Coordination*).

Recommendations

Recommendation I: Develop policies that incentivize proper O&M and secure finances

Based on the analysis, it is critical new or revised policies also address finances for O&M with special consideration for community contributions. The causal loop analysis showed the relationship between

these factors to have a potential limiting effect on water service sustainability. This is a key focal area because the dynamic relationship between these factors is hypothesized to be the driver that could improve, deteriorate, or hold the system at a status quo of stagnating functionality (either low or high).

Recommendation II: Support a functional coordination and information sharing platform with attention to community participation

Participants identified two issues related to coordination during the exercise: (1) existing communication platforms are not sufficient and need to be improved, and (2) there needs to be a mechanism for the woreda to communicate and effectively coordinate with local communities. Because these actions appear to require different forms of communication, two platforms are needed to fulfill the unique needs of each form of coordination.

Recommendation III: Build woreda capacity to effectively manage Water Office operations

Improvements in woreda capacity are needed because of the connection to all of the factors that collectively promote better services, not because this could have a substantial near-term impact on its own. This will enhance the Woreda Water Office's ability to absorb, manage, and adequately allocate funds and develop and implement better policy around O&M.

Iteration

Within the South Ari context, the relationship between *Policy* and *O&M* is a key connection that needs to be better understood. This is also true with respect to the role *Financing* plays in the system, with the need to break out different financial flows in future iterations. A future factor mapping activity could focus on how *Policy* influences *O&M*, or factors that influence what *Policies* or *Finances* are available for *O&M*. There is also a need to unpack the role *Coordination* plays in the system with regard to different local actors.

Mile, Ethiopia: Small Town and Rural Water

IRC conducted a factor mapping activity on Dec. 19, 2017 as part of a workshop with key local stakeholders involved in small town and rural water services planning and operations in Mile Woreda.[5] The workshop was part of a series of meetings intended to formalize a learning alliance platform for enhanced coordination and collaboration among stakeholders. The activity engaged 28 participants consisting primarily of technical experts from local government offices, including Mile Woreda Office (13), Mile Woreda Administration (9), Afar Regional Office (1), and NGO or other (5). Participants collectively identified nine key factors that influence small town and rural water services across Mile Woreda and mapped their influences on one another. These factors were: *Finance*, *Coordination*, *Water Resources and Infrastructure (WR+I)*, *Proper Use*, *Skilled Water Technicians*, *Spare Part Supply*, *Water Quality*, *Water Demand*, *Woreda Administration*, and the outcome factor *Sustainable Water Services*.

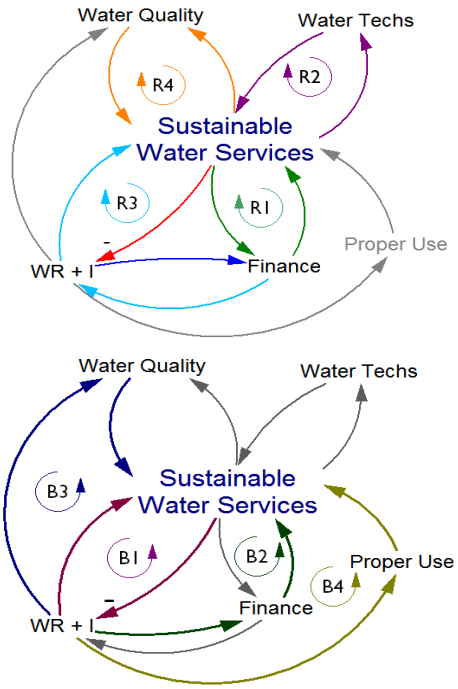


Figure 7: Mile Prioritized Causal Loop Diagram (Reinforcing – Top, Balancing – Bottom)

The influence map for Mile showed the outcome factor *Sustainable Water Services* was highly dependent on other factors, while remaining very influential. This suggests the existing state of *Sustainable Water Services* in the woreda has a feedback effect on the other factors in the system. The influence map also identified *Woreda Capacity* as the only factor that is both highly influential and independent. *Water Technicians* and *Water Demand* appeared to have potential to leverage or influence the system, but these factors were less influential overall than the outcome factor, *Sustainable Water Services*, or the highly influential factor *Finance*. The centrality analysis added more depth to these findings by showing five factors — *Sustainable Water Services*, *Finance*, *Woreda Capacity*, *WR + I*, and *Spare Parts* — were all equally central, suggesting a highly interconnected system where no single factor dominates.

The group was split during the exercise, resulting in two cross-impact matrices. Multiple causal loop analyses were conducted to examine all possible loops from each matrix (see Mile chapter in Appendix B for details). The final CLD (see Figure 7) showed the factor *WR+I* was present in 5 of the top 8 loops (one reinforcing loop and four balancing loops). This indicated water resources and other infrastructure are key to driving the state of *Sustainable Water Services* in Mile Woreda through *Finance*, *Water Quality*, and *Proper Use* of schemes by communities. *Finance* was also shown to be highly influential in the reinforcing loops, which drive or diminish the sustainability of water services. Insights from the causal loop analysis imply any increase in sustainability of water services will require significant investment in

[5] UCB researchers were not present for the factor mapping activity. All data, notes and documentation presented in this report were collected by IRC and provided to UCB for analysis.

infrastructure (*Finances → (+) WR+I*). The limiting factor is likely *WR+I* (see Figure 8). This confirms the reality that Mile Woreda is a dry and arid climate with limited water resources.

Findings

Finding I: Balancing management of existing services and planning for new schemes is key to the overall sustainability of water services

As defined by the participants, *WR+I* included the "planning and construction of schemes, management of existing schemes, and study of potential water sources." While there is a need to unpack elements of this factor into the various sub-components and understand their individual effects on other factors and the system overall, factor mapping showed nearly all the causal behavior in the system relies on the inverse relationship between *Sustainable Water Services* and *WR+I*. This finding implies the balance between managing existing schemes and planning new ones most affects the likelihood of *Sustainable Water Services*. Understanding the sub-components of *WR+I* and their individual connections to *Sustainable Water Services* is essential for developing further insights to target specific aspects of scoping, planning, management, and oversight of new and existing water schemes.

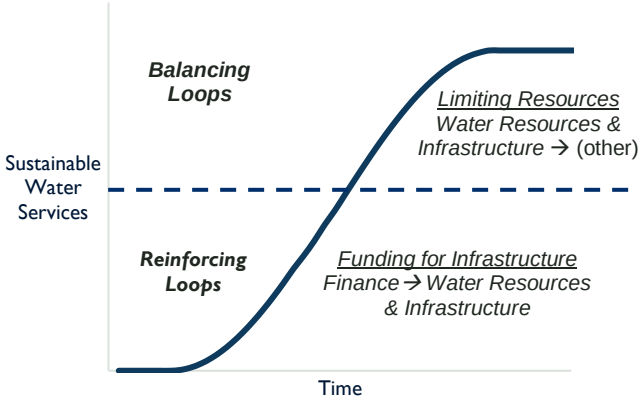


Figure 8 Mile Potential Dynamic Behavior

Finding II: *Woreda Capacity* is a key area to target

Findings suggest better planning and management is needed to increase *Sustainable Water Services* and is mainly within the woreda administration's mandate. It follows that increasing *Woreda Capacity* is essential to improving *Sustainable Water Services*. Further, *Woreda Capacity* was the only clear target factor on the influence map. This implies that while *Woreda Capacity* may not be the most direct driver, it is an essential element in the system and when strengthened could have a positive overall impact on *Sustainable Water Services*.

Finding III: *Coordination* is not a central or influential factor

The influence map indicated *Coordination* was just as likely to be influenced by other factors as it was to influence factors. It was one of the least central factors in the centrality analysis, along with *Water Technicians* and *Proper Use*, and was not present in any of the loops in the final CLD. This finding implies that *Coordination*, on its own, does not have significant potential to lead to larger changes in *Sustainable Water Services*.

Recommendations

Recommendation I: Develop systems for better management of existing schemes and planning for new schemes

Compounding financial, environmental, and technical issues in Mile, and the Afar Region in general, point to the need to address systemic issues, one symptom of which is the imbalance between the planning of new schemes and the management of existing ones. To address this issue, local officials should evaluate what changes can be made within the woreda administration to better manage the operation, maintenance, planning, and financial resources for new and existing schemes.

Recommendation II: Support activities that increase woreda capacity

Developing systems for better management of new and existing schemes will require empowering the woreda to carry out its mandate to provide and manage services. This type of support could include both hardware (motorbikes, petrol) and software (data, skills) assistance. While hardware support may appear to be acute, non-systematic fixes to a larger problem, it is important to consider that some of the existing deficiencies in woreda capacity may stem from a lack of addressing near-term physical needs that cannot be strengthened through software support alone.

Recommendation III: Create an active coordination platform in the woreda

Although coordination did not appear to be either central or influential in the overall system, it was an issue participants discussed throughout the factor mapping workshop. While improved coordination may not lead to a substantial systemic change on its own, the existence of a coordination platform can support other factors identified as influential. For example, increasing data and knowledge sharing by providing the administration with more complete and better-quality data from all relevant actors.

Iteration

Within the Mile context there is a need to unpack the elements of *WR+I* to better understand how different aspects of scoping, planning, and management affect existing and proposed schemes. A logical next step in repeating the factor mapping activity would be to focus on these factors more closely, perhaps within the context of *Planning and Management* as a focal outcome factor. While there are many different types of water schemes in Mile Woreda, it appears the Woreda Water Office's operations drive the overall sustainability of these different schemes. Additionally, any repetition requires narrower definitions for each factor and more detailed documentation of how participants describe factor influences and interactions.

Woliso, Ethiopia: Improved Town Sanitation

IRC conducted a factor mapping activity on Nov. 10, 2017 as part of a workshop with key local stakeholders involved in sanitation planning and operations in the town of Woliso, Oromia. The workshop was part of a series of meetings intended to formalize a learning alliance platform for enhanced coordination and collaboration among stakeholders. The activity engaged 12 participants consisting primarily of technical experts from local town government offices. The participants collectively identified five[6] key factors, from a list of 13 possible factors, that influence sanitation in Woliso and mapped their influences over a 2-hour workshop. The factors were: *Dumping Site*, *Finances*, *Coordination*, *Awareness*, *Turnover of Officials*, and the outcome factor *Improved Town Sanitation.*

The influence map showed *Coordination* and *Awareness* as the most influential factors in the system. This implies they have the greatest potential, individually and together, to affect the rest of the system. The map also indicated *Dumping Site* is highly sensitive (dependent) to all other factors and most likely to be affected by changes to these factors. The centrality analysis confirmed these insights by showing *Dumping Site* with a low betweenness score and *Coordination* and *Awareness* as the most likely to influence other factors. The centrality analysis also indicated *Finance* is as central to the other factors as *Coordination* and *Awareness*, although the influence map did not find it to be very influential. Conversely, low centrality (betweenness) rankings for *Improved Town Sanitation* and *Turnover of Officials* suggests that changes made to other factors will likely have a delayed effect on these factors and will therefore take some time to exhibit positive outcomes (i.e., hiring and training new staff).

Of the 34 unique feedback loops analyzed in the CLD (see Figure 9), the causal loop analysis identified three key reinforcing and balancing loops. Notably, *Dumping Site* was present in all the balancing and reinforcing loops, highlighting its key role in the overall system, especially in connection with *Finance*. This indicates the presence of a proper and full functioning dumping site could generate finances (through dumping fees) which could in turn improve the operation of the dumping site. Another causal chain in both the balancing and reinforcing loops involved the connection between *Coordination* and *Awareness*, directly and through other factors. These factors were also the most likely leverage points in the influence map, which implies they need to be improved at the same time as infrastructure or management investments.

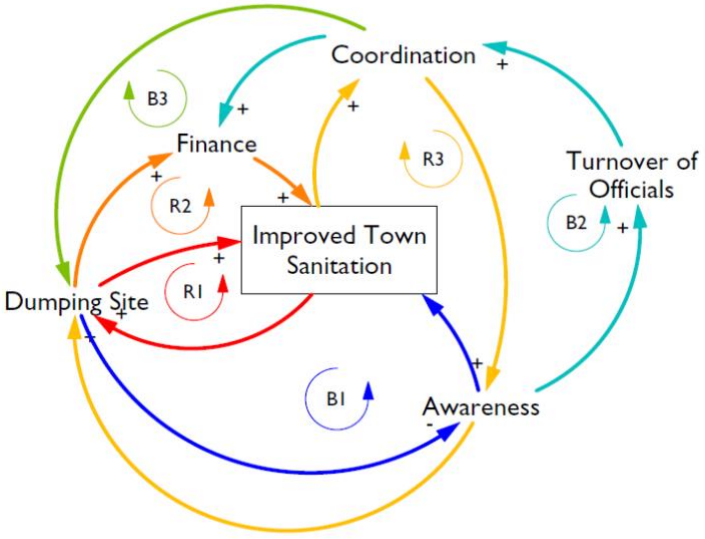


Figure 9 Woliso Causal Loop Diagram

[6] In general, the factor mapping process benefits from the consideration of eight or more factors.

Findings

Finding I: Improved town sanitation requires a *Dumping Site*

Results from all three systems analyses pointed to the critical position of *Dumping Site* in the overall system. The CLD implies a *Dumping Site* is a prerequisite to any change toward *Improving Town Sanitation* through its effect on *Awareness* and *Finance*s. As participants described, no improvement in *Town Sanitation* can occur without a properly constructed and operated *Dumping Site*, and changes made to other factors (e.g. *Coordination*, *Awareness*, *Finance*s) may have limited impact on overall *Improved Town Sanitation* if a physical *Dumping Site* is not part of the solution.

Finding II: *Coordination* and *Awareness* are key leverage points

Coordination and *Awareness* were most directly influential on all the factors (influence map), most central within the system (centrality analysis), and completed one of the strongest causal loops driving an initial change in *Improved Town Sanitation* (causal loop analysis). Enhanced *Coordination* could also help address the issue of *Turnover of Officials* (see Finding IV) by creating a mechanism within the administrative structure to sustain important relationships across agencies that endure changes in staff.

Finding III: *Finance* is central to the system overall, but unlikely to be a driving factor

Finance was not identified as an influential factor in the influence map. However, the centrality analysis showed it as an important link between other factors such as *Coordination* and *Awareness*. When considering the role of *Finance* in the system it is important to note that participants included both tariffs and financial flows from government under the same definition. Any action to address *Finance* will therefore need to parse out these two sources and investigate how they play different roles in the overall system.

Finding IV: *Turnover* of local officials will continue to limit progress in improving town sanitation

Many participants expressed concern over the continuing trend of *Turnover of Officials*, explaining that it was one of the main reasons why the *Dumping Site* had not been completed. This was reflected in the second balancing loop of the CLD where *Turnover of Officials* served as a key piece of a long causal chain which could possibly limit overall *Improved Town Sanitation*. However, *Turnover* was rated as the most independent factor in the influence map and the least central factor in the centrality analysis. This finding suggests the factors that most affect *Turnover* were likely not considered as part of the factor mapping exercise, possibly because the participants thought that these elements were outside the scope of the discussion about *Improved Town Sanitation*.

Recommendations

Recommendation I: Improve coordination and awareness among key stakeholders

The results of the systems analysis suggest primary actions need to focus on simultaneously coordinating key local stakeholders and building awareness among government officials and community members. Such efforts have the potential to positively influence financing (via tariff collection for services), which could lead to a higher probability of establishing and operating a dumping site and improve the overall level of sustainable sanitation services.

Recommendation II: Prioritize the development of a functioning dumping site

For the community to be aware of and utilize town sanitation services, there needs to be an operational dumping site in Woliso. Participants highlighted that while the town had acquired a well-functioning vacuum truck, there was no place to dump the collected waste. In follow-up interviews with local technical staff, it was clear the dumping site was a multi-faceted issue spanning the location of the site in a master plan, enforcement of regulations for improper dumping by environmental authorities, cross-subsidizing fees from water tariffs, and the condition of a road to a proposed dump site.

Iteration

Within the Woliso context, there is a need to better understand the factors that enable the successful establishment and operation of a *Dumping Site*. The factor mapping activity focused on *Improved Town Sanitation* more broadly, of which the *Dumping Site*, *Community Awareness*, and *Infrastructure* could be considered sub-systems. A future iteration could focus on one of these factors as the outcome factor to better understand the factors that are driving the conditions of each sub-system. It is interesting that although local infrastructure (drainage, public and community toilets, etc.) was discussed as an important issue, it was not included as a top factor in the activity. In a future iteration of the workshop, these factors merit a closer review to better understand their role in influencing the larger sanitation system.

Lessons Learned

In addition to the findings identified in each local context, this first iteration of factor mapping under SWS provided a valuable opportunity to reflect on important insights to consider for future implementation of SWS activities in Ethiopia, Uganda, and the WASH sector more broadly. As a participatory research method, the factor mapping process is intended to be flexible, responsive, and adaptive to local conditions. Under SWS, factor mapping will continue to be tested in different formats and contexts, with different groups of stakeholders, and around a range of outcome issues (e.g., water services, sanitation service chains, latrine uptake, preventive maintenance schemes). This will allow for an improved understanding of how and where the process can support other activities focused on strengthening complex WASH systems. SWS will use key lessons learned through the application and analysis of factor mapping to modify the process for future iterations. Additionally, as results are presented back to participants and other local stakeholders, SWS will continue to assess how the information is used (or not) for decision-making and planning interventions.

Scope and Boundary

In the workshop development process, UCB worked with SWS partners to carefully consider the appropriate scope and boundary for each workshop based on the outputs that would be generated from the analysis, and which actors would be most likely to use the information. As local government officials, either in an administration (e.g., sub-county chairperson) or a technical role (e.g., water office staff) were thought to be the most likely actors to take action, bounding the scope of the activity to the geo-political boundaries of a woreda (Ethiopia) and district (Uganda) was thought to be an appropriate selection. This decision was reviewed at the conclusion of each workshop with the facilitators, who agreed the delineation was appropriate for the initial baseline workshops presented in this report but could be expanded in future workshops to include factors that were determined to be out of scope in the first iterations.

Within these boundaries, the focus of each factor mapping session was determined by the outcome factor of interest. Because all of the factor mapping activities presented in this report were conducted as part of a larger baseline analysis under SWS, it was determined that modeling broader local systems of "improved town sanitation" and "sustainable water services" complemented the other analyses (e.g., building block assessments, sustainability checks). For the three factor mapping workshops presented in this report that focused on rural and small town water, mapping the broader system also provided the opportunity for cross-context comparison of factors that influence the provision of water services.

While there are common reflections in systems science of the differences between modeling "problems" or modeling "systems" (Sterman 2000), within this context, having models developed for the overall system in each context provides a future opportunity to build sub-systems into the model to further increase its internal validity. This also allows for future iterations of the same outcome factor to explore how the system has changed over time.

Participants

A key aspect of participatory group model building approaches is understanding that outcomes represent the perspectives of participants in the activity. The participants in these workshops consisted mostly of local government officials with a minority of additional participants from NGOs, the private sector, and Hand Pump Mechanics Associations. Thus, the resulting analyses likely represent the perspective of government officials at the district, zonal, woreda, and sub-county levels. To assess how much the outcomes of the analysis may differ when different and more diverse perspectives are represented in the workshop, the activity would need to be repeated in the same context around the same outcome factor and boundary with different stakeholders. SWS partner Whave is undertaking this approach in Kamuli District, Uganda where five different groups of stakeholders were brought together separately to assess the factors contributing to rural water services. Findings on how these groups were aligned in their perspectives of the local system of factors will be presented in a forthcoming report.

Workshop Format, Documentation, and Facilitation

The overall factor mapping process was originally designed to be conducted over a 2-day period where the first day consisted of brainstorming factors "from scratch" and completing the cross-impact matrix. The matrix would then be analyzed overnight and the results presented back to the group the following day to discuss the outcomes and solicit feedback on the results and overall process. The later part of the second day would represent the learning component of the process. For a number of logistical reasons, the workshops were not executed as originally conceived, mainly due to time constraints, and thus ranged from 1 to 6 hours, with an average of 3.5 hours. In debrief interviews with workshop facilitators, there was a general consensus that there was a limit to how long most participants could maintain a focus in the complex discussion, and that more time was needed for factor brainstorming and reflection on the outputs of the analysis.

Like other participatory community- and stakeholder-focused activities, the execution and outcomes of this process are dependent on the quality of facilitation. The workshops described in this report were conducted in varying contexts and facilitated by different people. UCB trained all local facilitators in consultative pilot sessions to help co-develop a program most appropriate to each context. This included translating the vocabulary and concepts of systems terminology to local languages and heuristics and gauging how to effectively engage participants in an activity which requires a higher level of focus and reflexive thinking. By actively engaging facilitators ahead of each session, the overall factor mapping process benefited from high-quality facilitation.

UCB conducted debrief interviews with facilitators to elicit their feedback on how participants engaged with the activity, and which aspects of the activity they thought could be improved. The facilitators acknowledged the activity was a new concept to most of the participants, which led to some initial confusion or hesitation about how to engage in the discussion.

Quality and Validity of Outcomes

As a new approach within the WASH sector,[7] questions arise regarding the validity of results from a factor mapping analysis. As a participatory, stakeholder-driven group model building activity, the goal of factor mapping is to represent participants' understanding and perception of the local WASH system, which differs between stakeholder groups.

"I think what (the participants) probably have learned from this is not new things about Fecal sludge management but about the importance of thinking systematically"

"Resources are always scarce but tools like this will be helpful to prioritize things…and use resources effectively"

– Factor Mapping Facilitators

The quality of factor mapping results can be evaluated from two perspectives. First, how well do results represent the system being studied (i.e., internal validity)? Second, to what degree can insights be drawn from similar systems in different contexts (i.e., external validity)? Within the fields of complexities science, system dynamics, and community-based modeling activities, there is long-standing recognition that no model of the physical world is truly valid (Sterman 2002). This sentiment is reflected in the commonly-used systems adage, "All models are wrong, but some are useful" (Box and Draper 1987). The validity of factor mapping findings are relative to the purpose for which they were developed. It is therefore critical that outcomes are reviewed with participants, re-evaluated, and adjusted over time as needed to increase how accurately they represent the system, based on participants' perspectives. Ultimately, factor mapping and other community-based systems approaches are decision support tools — not decision-making tools — for those who participate in the activity.

[7] Participatory group model building activities have been applied in many different contexts, industries, and sectors since the 1970s (Hovmand 2014; Vennix 1996).

Next Steps

Appendix B includes recommendations on iteration of the factor mapping process, with possible configurations of future factor mapping activities. How, when, and why each activity is repeated depends on the needs of each context and group of stakeholders. Repetition could include investigating unique sub-systems of a given context (e.g., payments for O&M) to generate more detail and knowledge around a specific issue of interest. This information could then be added to the original results to create a more thorough model of the overall system. Iteration could also include test driving proposed interventions or policies through the models to determine how selected actions impact other factors and overall system outcomes. Finally, iteration could focus on the original outcome factor after some intervention has been implemented to see whether stakeholders believe the structure of the system has changed.

This report presents information from the first implementation of factor mapping under SWS, conducted across four different contexts in Ethiopia and Uganda. Five additional factor mapping workshops were conducted between April and October 2018 in Kamuli District, Uganda with Whave. These workshops explored factors that influence rural water services in Kamuli District and the alignment around these factors between five different groups of local stakeholders: district government, sub-county government, hand pump mechanics, water users, and Whave staff. A factor mapping activity was also conducted with commune councilors in Cambodia focusing on rural sanitation and hygiene.

UCB is working on developing a facilitation guide and software program for use by sector practitioners interested in implementing the factor mapping workshop process. The proposed software would automate the analyses detailed in this report and create instantaneous visual representations of the results to be shared at the conclusion of each factor mapping session. By presenting results directly back to participants, SWS partners could engage in a more robust elicitation of feedback on the various representations of the local system and more accurately gauge the perceived value of the activity.

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Appendix A: The Factor Mapping Process

The Factor Mapping Process

The factor mapping 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. Its design is based on group model building activities for "wicked" or complex problems (Andersen, Vennix, and Richardson 1997; Vennix 1996; Hovmand 2014). The factor mapping process addresses the need to engage key local stakeholders to map and investigate the complexities of their local WASH system. Insights generated through this process are built on the premise that the collective knowledge of local stakeholders represents a unique, informed perspective on the interconnections between factors in the WASH system.

Factor mapping was developed by UCB and has been implemented and tested in a dozen local contexts to date. It was adapted from "Participatory Systems-based Planning and Evaluation Process," a protocol developed for rural WASH services (Walters, Neely, and Pozo 2017). As envisioned, the full factor mapping process consists of a two-day workshop where results of factor mapping activities are presented back to the participants on the second day for reflection. The process consists of an iterative set of complimentary steps as shown in Figure 10.

Factor Mapping Terminology

While definitions of systems terminology have varied across the WASH sector, within the factor mapping process, analysis, and reporting, the following definitions are used for key system elements:

- *WASH System:* 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 geo-political boundary. [8]
- *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 are defined as proper, neutral nouns that can have a range of different states (e.g., better cooperation between actors is *Collaboration*). Defined in this way,

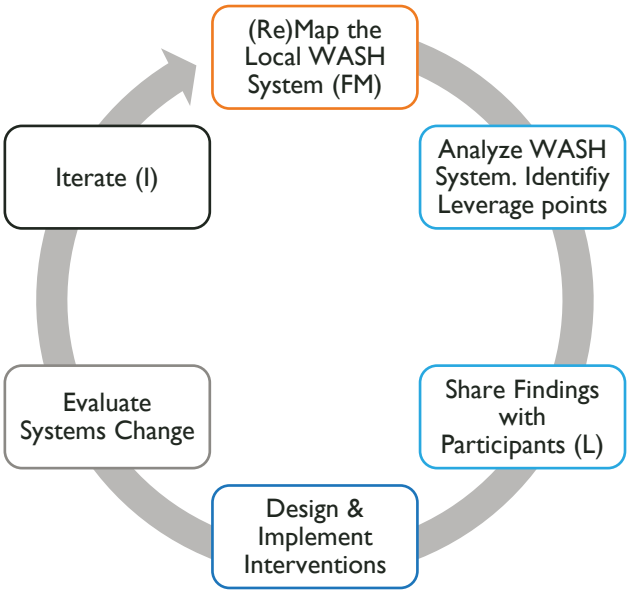


Figure 10 The Factor Mapping Process

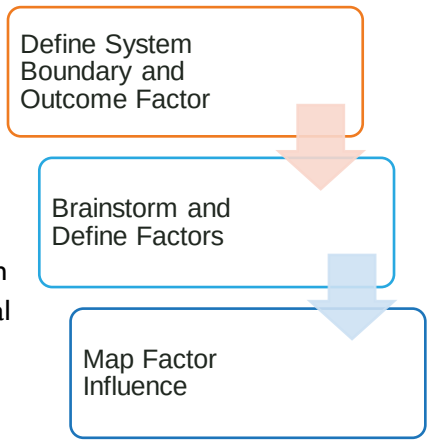
[8] SWS terminology refers to WASH hardware systems as "schemes," the combined system of facilities and their O&M management.[9] Within the results presented in this report, delay metrics were not captured for each factor mapping exercise due to time constraints.

factors can be considered in multiple hypothetical states throughout the factor mapping exercise and analysis.

- *Leverage Point:* Factors within a local system that 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 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 the status of which represents the outcome of the system (i.e., *Sustainable Water Services, Sustainable Sanitation Services*). The outcome factor is commonly affected by all other factors, directly or indirectly, and can affect other factors. The outcome factor is included within 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 resulting from the structure of the system (how factors are connected) and the current state of each of the factors. For example, the behavior or outcome of a small town water system would be reflected in the overall functionality (or downtime) of the scheme.

(Re)Map the WASH System

Mapping WASH systems entails bringing together a thoughtfully selected group of key local stakeholders to conduct a factor mapping workshop. Participants should have a good understanding of WASH issues and represent a diverse set of viewpoints. The group setting of the workshop should encourage thoughtful discussion and debate among the participants, who may have different perspectives on the local system. There is no requirement of occupation or educational level to participate in the workshop, meaning the activity can be conducted with nearly any group, from local community members to national-level stakeholders.



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

1. Determine System Boundary and Outcome Factor

To define the WASH system, participants are asked to delineate the geographic or political boundary of the WASH service delivery system. While there is no ideal or preferred boundary definition, it should align with participants' knowledge. It is important the boundary is explicit as this delineates the factors that are internal (e.g., tariffs) and those that are external (e.g., international aid) to the system. The outcome factor is the focal issue of interest around which the system will be mapped. It most frequently represents a service (e.g., rural water services, small town sanitation), but it can also be directed at 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 the factors to be analyzed within the system. The group is first asked to brainstorm as many unique factors they believe directly or indirectly influence the system. Each proposed factor must be accompanied by a definition the group modifies collectively. It is critical each factor definition is clear to all participants and the majority agree on it. To make the next step of the workshop manageable for participants, the long list of factors (approximately 20 to 40 factors), is prioritized to 10 to 15 factors that will be included 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 another, including the outcome factor. Using a cross-impact matrix (see Figure 11), factors are listed as both row and column headings. The facilitator walks the group through evaluating each factor-to-factor influence represented by boxes of the matrix. For each box, the group is asked to consider four attributes of directional relationship: influence, polarity, strength and delay.

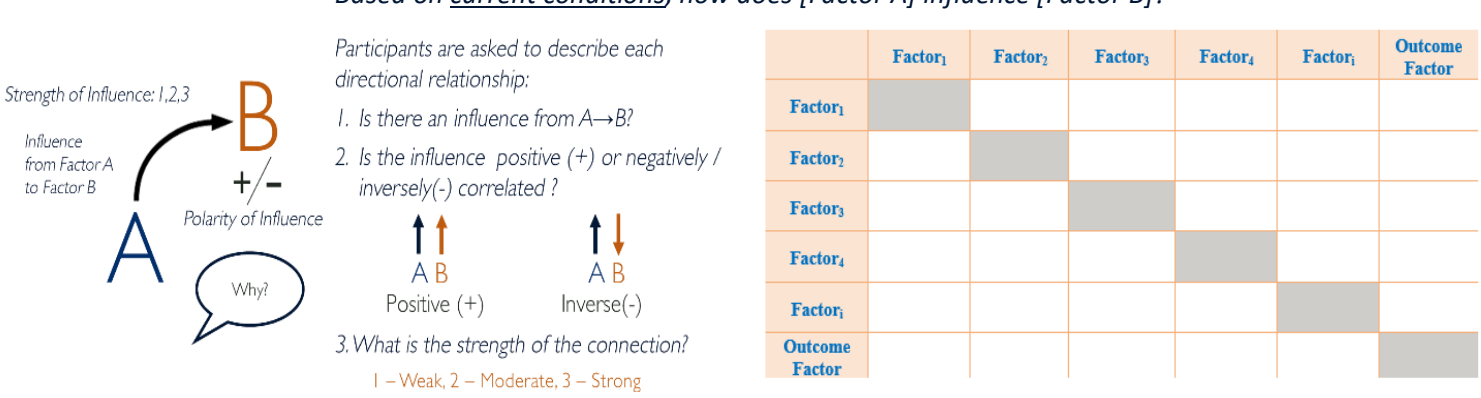


Figure 11 Cross-Impact Matrix

1. *Influence:* Participants are asked to consider the nature of 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 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 down time decreases).

3. *Strength of Influence:* Participants are asked to consider "How strong is the influence?" on 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. As the cross-impact matrix is completed, participants commonly return to an influence relationship to revise their rating as their understanding of this relative rating advances.

4. *Delay:* 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. [9]

Analyze WASH Systems Map

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

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 are connected to one another, and which are most "central"
Causal Loop Analysis	Identification of reinforcing or balancing "feedback loops" that drive system behavior

[9] Within the results presented in this report, delay metrics were not captured for each factor mapping exercise due to time constraints.

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 12) divided into four quadrants that plot 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 quadrant on 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: (1) are highly-dependent and influential (i.e., volatile, unstable); (2) would be effective leverage points if positively influenced; (3) may be ineffective leverage points due to their low significance; and (4) are highly sensitive to others.

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

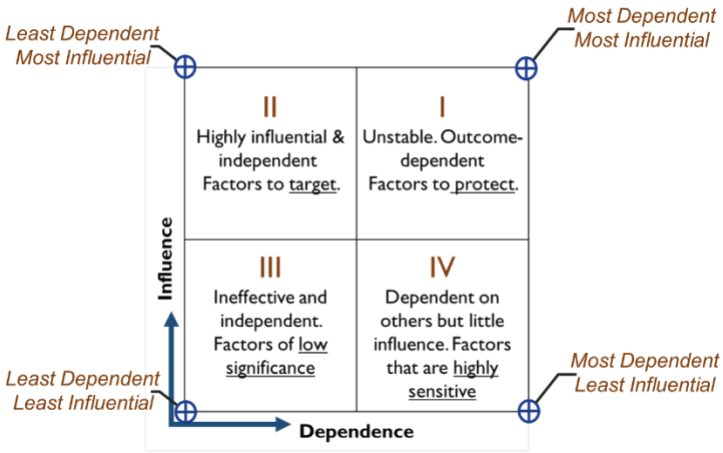


Figure 12 Influence Map Quadrants

Centrality Analysis

Centrality analysis utilizes three metrics from network analysis techniques to gain insight into how changes in different factors can move through the system by virtue of their location 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 in the system. In general, weighted degree in and out serves 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 changes in that factor would have more pathways to propagate through the system than a factor with a low betweenness score. UCB utilizes the open-source software program Gephi for all centrality analysis (Bastian, Heymann, and Jacomy 2009) as based on Wasserman and Faust 1994.

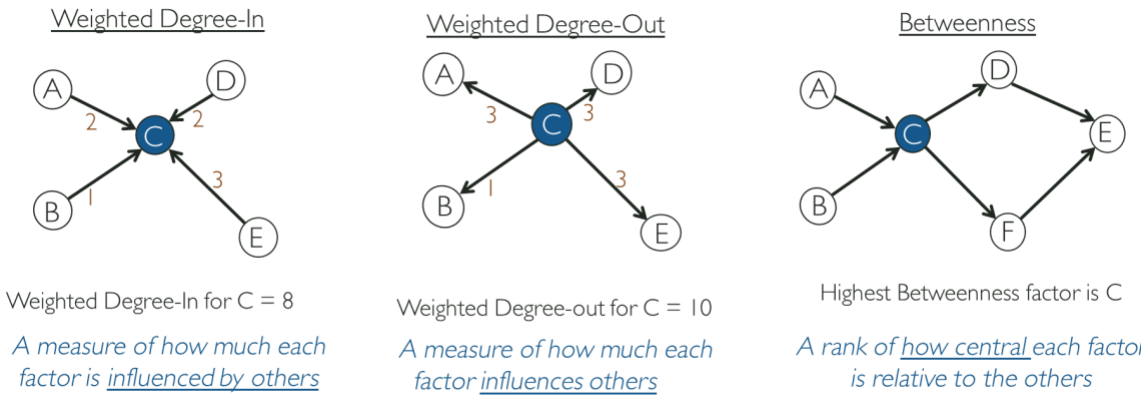


Figure 13 Centrality Metrics

Causal Loop Analysis

Whereas influence mapping and centrality analysis focus on factor influence, dependence, and importance, causal loop analysis is employed to directly infer dynamic root causes of the outcome factor (e.g., *Sustainable Water Services*), or other factors in the system (e.g., *Coordination*) (Sterman 2000; Forrester 1988). Using the impact matrix created during the factor mapping activity, causal loop analysis systematically identifies and prioritizes all possible unique feedback loops, or circular sequences of causality, that affect the factor of interest.

Analysis of dominant feedback loops allows researchers 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 through a comparison to established reference behavior archetypes, supporting narratives of connections described by participants during the factor mapping session. Ultimately, combining all these analyses with qualitative information collected during the factor mapping exercise can offer realistic insights into potential pathways that may lead to more sustainable WASH systems. UCB conducts all Causal Loop Analyses using Ventana Systems' VENSIM PLE, a free, open-source software for qualitative and quantitative system dynamics modeling (Pruyt 2013).

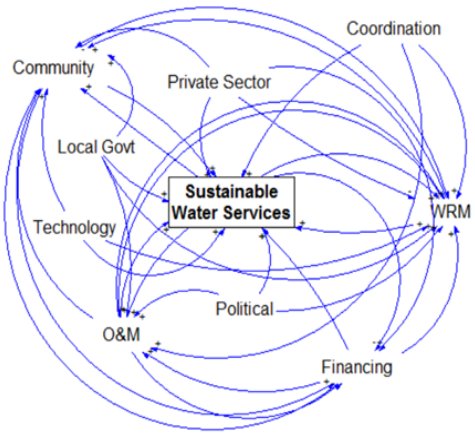


Figure 14 Example Causal Loop Diagram

The causal loop diagram (CLD) is analyzed for feedback loops that aid in understanding the possible dynamic processes that drive the overall outcomes of the system, which builds on 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 in order 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 factors within the loop (e.g., *Services* → (3) *Finance* → (2) *Capacity* → (3) *Services*; loop strength = (3+2+3)/3 influences = average loop strength 2.67).

Design and Implement Interventions

Upon being presented with results from the systems analysis, participants have the opportunity to discuss intervention strategies based on leverage points identified. It is important this conversation is properly facilitated to encourage participants to reflect on how the proposed interventions will address the influence, centrality, and dynamics of the leverage point or target factor they are intended to affect. Participants should also discuss the expected changes in the system from proposed interventions and how to measure and evaluate those interventions to assess their effectiveness. This helps delineate areas within the local WASH system to focus (or refocus) time, effort, and 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 results with activity participants, another option is to engage key stakeholders and those in decision-making positions through consultative sessions where the results are presented and further evaluated. Outputs from the systems analysis, particularly the CLD, could be used 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 factors in the system (e.g., creating unintended, although not necessarily negative, effects). Building off the analysis presented in this report, there is an opportunity to model proposed interventions to test assumptions of their impact on the larger system. This would principally include review of the CLD with the session facilitator, the implementing partner, and ideally, participants of the factor mapping session. Through this activity, the CLD could be further modified and adjusted to better reflect the 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.

Determining how, when, and where to implement an intervention identified through factor mapping is a critical activity outside of the purview of this report. Within the context of the four analyses presented herein, it is expected the process of designing and implementing activities to strengthen local systems will be the product of multiple analyses, in addition to the factor mapping outputs. These analyses are currently being synthesized and planning for future activities is ongoing.

Iterate: Evaluate Changes in WASH System from Intervention

Evaluating the effect of systems-strengthening activities requires a clear plan for measuring the target outcome factors identified in the factor mapping activity. Examples of data sources include water point functionality data, records of attendance and reports from coordination events, and payment for services by community members. Depending on the change the participants expect to see in the system, a significant amount of time may be required for these outcomes to manifest themselves. It is important then to consider when, how, and why a follow-up iteration of factor mapping should take place. Appendix B provides recommendations for context-specific iteration of the factor mapping process.

Ideally, a second factor mapping session would be conducted with the same group of participants. There are two principal options for a second workshop: (1) the activity could focus on the same outcome factor as the first (i.e., *Sustainable Water Services*) to refine and strengthen the analysis and create a more robust model through which to evaluate possible actions; or (2) participants could select a new outcome factor (i.e., *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 an additional module to the original model, further expanding the possible analysis of outcomes of the local WASH system.

Appendix B: Context Chapters

1. KABAROLE, UGANDA

RURAL AND SMALL TOWN WATER SERVICES

IRC conducted the Kabarole factor mapping activity on Nov. 28, 2017 as part of a standing WASH stakeholder group meeting with local civil service, political, and private industry stakeholders involved in planning and operations of water and sanitation systems in the district. The WASH stakeholder group regularly meets to discuss local WASH-related issues and promote coordination and collaboration among stakeholders. The activity engaged 16 participants consisting of technical experts and managers from local government offices, politicians, and a representative of the local Hand Pump Mechanics Association. The full day activity was conducted in English and facilitated by two IRC staff members.

Factor Mapping Activity

At the beginning of the exercise, the facilitator presented a list of 11 factors identified from a qualitative analysis of interview transcripts that asked about challenges to rural water services in Kabarole and possible solutions. Additional factors were added to the proposed list in consultation with IRC Uganda. Because many of the workshop participants were interviewed, there was a significant agreement on the list of factors presented. The facilitator asked the group to determine if the list was valid and if additional factors should be considered. Participants were then split into three groups and asked to brainstorm additional factors for 10 minutes. Each group presented their list of additional factors back to the larger group, along with suggestions for factors they felt should be included or excluded from the list.

Factors Brainstormed by Participants (# of votes)

Community Ownership (3)
Coordination (3)
Financing (3)
Local government capacity (3)
Operation and Maintenance (3)
Technology, quality of materials (3)
Water Resource Management (3)
Private Sector Involvement (2)
Political Involvement (1)
CSO Involvement (0)
Monitoring (0)
Regulation (0)

With this comprehensive list of factors, groups were asked to indicate which factors they wanted to include for the final list. Votes were tallied for each group and participants debated the condensed list. The resulting nine factors (see Table 4), along with the outcome factor *Sustainable Water Services,* were added to a cross-impact matrix as column and row headings (see Figure 15). The matrix was displayed on a large sheet of paper at the front of the room for all participants to view throughout the activity.

Table 4 Kabarole Factors

Factor	Definition	Shorthand
Operation and Maintenance	Repairs, servicing, rehabilitation, correct use, and operation	O&M
Local Government Capacity	Skills and knowledge needed to execute duties of position; human resource capacity	Local Government
Community Ownership	Sense of responsibility, participation, and involvement with community water point	Community
Technology	Physical, functional infrastructure system(s) that are in place to reliably deliver clean water	Technology
Private Sector Involvement	Organizations that supply materials and financing for water point construction, maintenance, and rehabilitation; includes Hand Pump Mechanics Associations, contractors, NGOs, financial institutions, and hardware dealers	Private Sector
Political Involvement	The influence, planning, decision-making and actions of local lawmakers; district and local councilors	Political
Coordination	Mechanisms and platforms that bring stakeholders together to share information, working collaboratively with particular attention to local government and CSOs	Coordination
Water Resource Management	Planning, use allocation, and information sharing around policies for protection of the local watershed and environmental resources	WRM
Financing	Funds available through government transfers and grants (district level), tariffs and taxes, and community capital contributions for water services	Financing
Sustainable Water Services	Services that provide safe, reliable, accessible, equitable, and affordable water in sufficient quality and quantity	-

The resulting matrix of 90 relationships (see Figure 15) was completed in approximately 2.5 hours. The matrix shows a more even distribution of strength weights than similar factor mapping sessions, with nearly a quarter of the potential influences marked as having no connection (0s). The group also identified four key inverse relationships: two from the *Private Sector*, one from *O&M*, and one from *Sustainable Water Services*. The group described each of these inverse relationships as follows:

O&M → (-3) Financing

"If you have good O&M, the other money can be used for other things. When it is bad and poorly managed, they have more allocation."

Private Sector → (-2) Community Ownership

"With the privatization of schemes, the community has no say. Less ownership, just income."

"If the private sector is not working on the supply chain, delivering spare parts, then the community cannot own what is not working."

Private Sector → (-2) Water Resource Management

"The private sector hardly thinks about things like resource management. The effluent from some of their businesses is very negative and discharges directly to the environment."

Sustainable Water Services → (-1) Financing

"If you improve access and reliability and affordability, then it reduces your finance."

	Operation and Maintenance	Local government capacity	Community Ownership	Technology	Private Sector Involvement	Political involvement	Coordination	Water Resource Management	Financing	Sustainable Water Services
Operation and Maintenance		1	3	0	3	0	1	2	-3	3
Local government capacity	3		2	3	3	3	3	3	3	3
Community Ownership	3	0		0	2	1	0	3	2	2
Technology	3	1	2		2	0	0	1	3	3
Private Sector Involvement	3	0	-2	3		0	1	-2	1	2
Political involvement	3	3	3	0	2		3	3	3	3
Coordination	3	3	2	2	3	3		2	2	3
Water Resource Management	0	0	0	3	0	0	2		2	3
Financing	3	3	2	3	3	3	3	3		3
Sustainable Water Services	0	0	3	0	1	0	2	2	-1	

Relative Count #	
0	21%
1	9%
2	20%
3	46%

Figure 15 Kabarole Cross-Impact Matrix

Strength of Connection: 1 – Weak, 2 – Moderate, 3 – Strong; (+) positive (-) inverse correlation

Influence Mapping

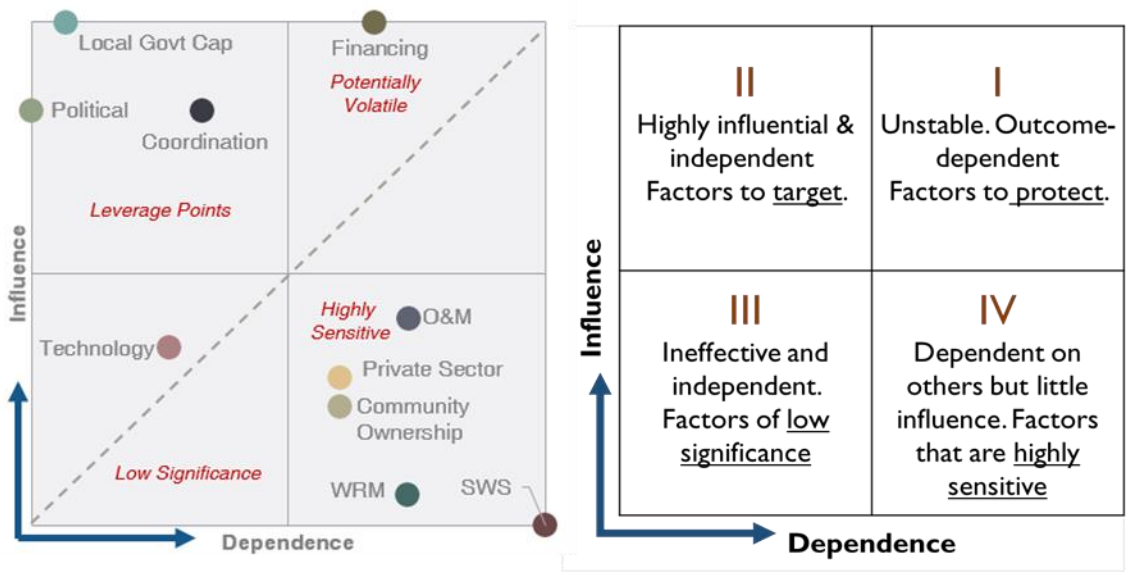


Figure 16 Kabarole Influence Map

Insights

- *Local Government Capacity*, *Coordination*, and *Political Involvement* are clear leverage points. They are significantly higher in influence than the other factors below the midline of the map. *Local Government Capacity* and *Political Involvement* are also the two most independent factors, indicating they are influenced little by the other factors in the system.

- *Financing* may be a particularly tenuous factor. It's position on the map as the only factor in Quadrant I and above the diagonal signals it might be a potential "fracture point" in the system which could "make or break" the *Sustainability of Water Services*. This means small adjustments or disruptions in *Financing* could create unpredictable changes in other factors.

- *O&M*, *Private Sector*, and *Community Ownership* are the most "sensitive" factors in the system, meaning they are heavily influenced by the other factors (Quadrant IV).

- *Water Resources Management* and *Sustainable Water Services* are the most sensitive, or vulnerable, factors in the system. The location of *Water Services* on the bottom right hand corner of the map clearly shows it is the most sensitive and least influential of all the other factors in the system, as the outcome factor.

Centrality Analysis

Table 5 Kabarole Centrality Analysis Rankings

Rank	**Weighted Degree-in** (influenced)	**Weighted Degree-out** (influencing)	**Betweenness** (central, bridging)
1	Sustainable Water Services (25)	Financing (26)	Financing (5.56)
2	Operation and Maintenance (21)	Local Government Capacity (26)	Coordination (4.23)
3	Water Resource Management (21)	Coordination (23)	Private Sector Involvement (1.56)
4	Financing (20)	Political involvement (23)	Community Ownership (1.49)
5	Community Ownership (19)	Operation and Maintenance (16)	Technology (1.41)
6	Private Sector Involvement (19)	Technology (15)	Water Resource Management (1.31)
7	Coordination (15)	Private Sector Involvement (14)	Local Government Capacity (1.15)
8	Technology (14)	Community Ownership (13)	Operation and Maintenance (0.91)
9	Local Government Capacity (11)	Water Resource Management (10)	Sustainable Water Services (0.83)
10	Political Involvement (10)	Sustainable Water Services (9)	Political Involvement (0.5)

Insights

- The important role of *Financing* and *Coordination* in the system is highlighted by their significantly higher values for centrality than the other factors. The centrality measures for these factors are four-times and two-times larger than the average values for factors ranked 3 to 10, respectively. This implies the most efficient pathways for factors to affect one another is through *Financing* and *Coordination*.

- While *Local Government Capacity* is one of the least influenced, and most influencing factors, it is not very central to the system, ranked 7 out of 10 overall and 40 percent below the average ranking (~1.9).

- *Political Involvement* ranks in the middle for degree-in (influenced) and high in degree-out (influencing) but is the least central factor. This indicates it is a very "disconnected" factor in the system and likely not the most efficient factor to affect change.

- *Sustainable Water Services* and *O&M* appear as the two least central factors behind *Political Involvement*. This suggests changes in these factors may not have as many pathways to move through the system as the other factors.

Causal Loop Analysis

Analysis of the CLD (see Figure 17) identified 44 unique loops containing the outcome factor *Sustainable Water Services*. Of these 44 loops, the top three reinforcing (those that can dramatically improve or diminish system outcomes) and top three balancing loops (those that tend to drive the system outcomes to some constant, steady state) were evaluated to gain better insight into the series of cause and effect relationships that may dominate the system (see Table 6). These loops were then re-represented in a prioritized CLD (see Figure 17). Factors not present in any of the top reinforcing or balancing loops are shown in grey, indicating while they are still part of the system, they are not part of key causal chains identified in the causal loop analysis.

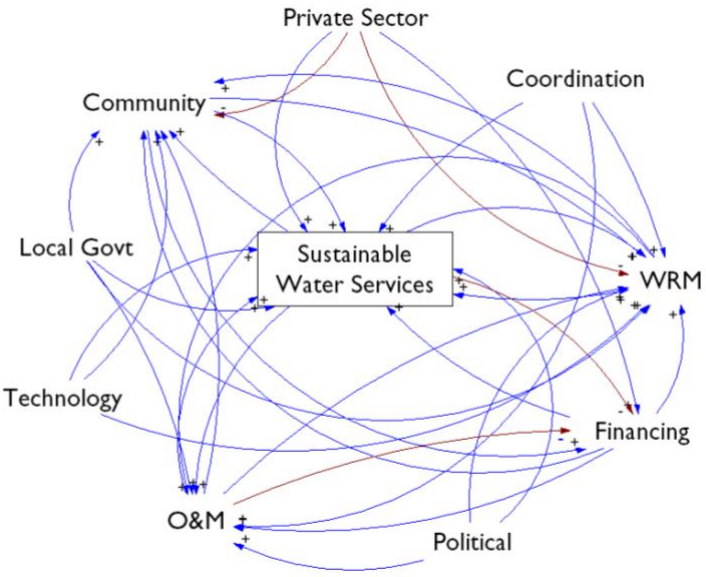


Figure 17 Kabarole Full Causal Loop Diagram

Table 6 Kabarole Top Ranked Reinforcing and Balancing Loops

ID	Rank	Reinforcing Loops
R1	4	*Sustainable Water → Community → Financing → Sustainable Water*
R2	5	*Sustainable Water → O&M → Community → Financing → Sustainable Water*
R3	10	*Sustainable Water → Community → Financing → O&M → Sustainable Water*
		Balancing Loops
B1	1	*Sustainable Water → (-) Financing → Sustainable Water*
B2	2	*Sustainable Water → O&M → (-) Financing → Sustainable Water*
B3	3	*Sustainable Water → (-) Financing → O&M→ Sustainable Water*

A key to understanding feedback loops is reading each sequence as a sentence. For example, feedback loop R1 reads as "If *Community Ownership* improved, then *Financing* would improve (via tariffs), and therefore *Sustainability of Water Services* would improve." Similarly, balancing feedback loop B2 reads "As *O&M* improves, the amount of Financing available may reduce (see cross-impact matrix discussion), which would then reduce the *Sustainability of Water Services*."

Insights

- The most important insight from the causal loop analysis was that the balancing loops (B1 to B3) were the highest ranked loops, indicating they are most likely to drive the *Sustainability of Water Services* (see Table 6). This means the combination of factors in these loops will tend to result in a steady state of *Sustainable Water Services*, most likely as unchanging levels of functionality (not improving or decreasing). Additionally, all the balancing loops involve unique inverse relationships between *Financing* and *O&M* and *Sustainable Water Services*. This indicates the relationship between these two factors and *Sustainable Water Services* is key to overall sustainability.

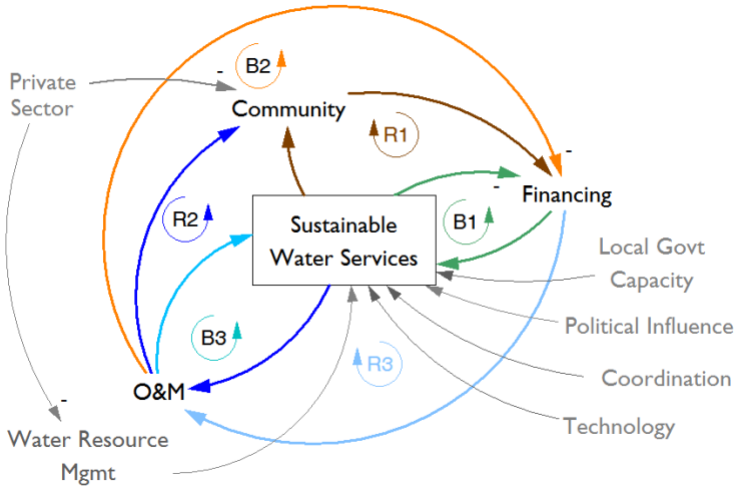


Figure 18 Kabarole Prioritized Causal Loop Diagram

- The causal loop analysis also showed all the reinforcing loops involve *Community* and *Financing*, with R2 and R3 loops adding the *O&M* factor. Because reinforcing loops have the potential to dramatically increase or decrease the state of *Sustainable Water Services*, this is a clear indication that *Community Ownership* is key to increasing *Sustainable Water Services*, because of its direct effects on *Financing* and *O&M*.

The unique scenarios described above can be generally illustrated as a relationship of *Sustainable Water Services* over time as shown in Figure 19.

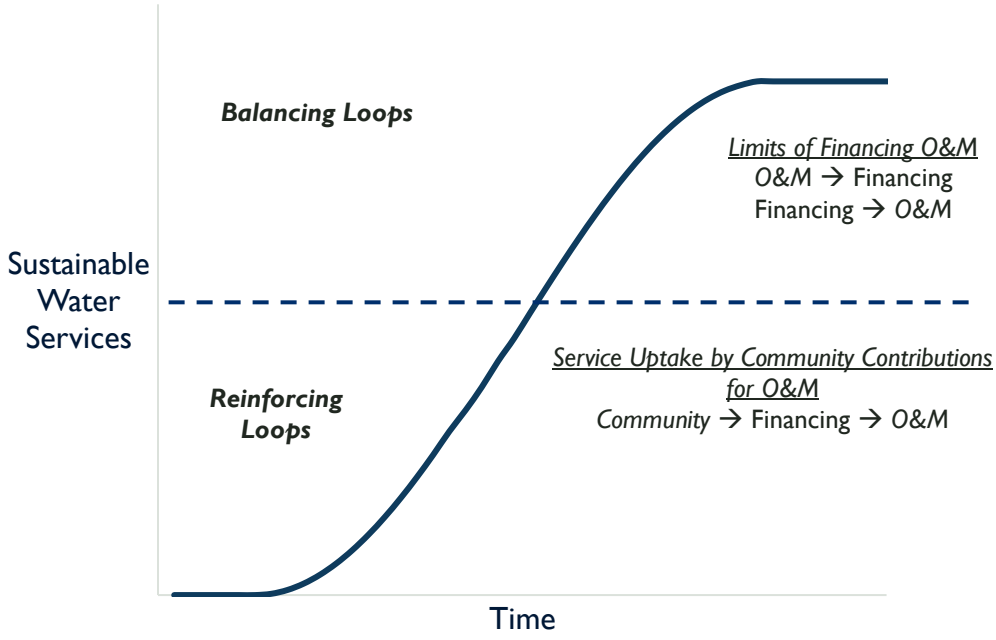


Figure 19 Kabarole Potential Dynamic Behavior

Participant Feedback

As part of the factor mapping activity, UCB administered a pre- and post-activity questionnaire to evaluate the utility of the factor mapping workshop and solicit feedback on how it could have been improved. The questionnaire asked participants to rate the value of the activity and what actions (if any) they or their organizations may take because of learning more about the interconnections of factors within their local system.

"We were aware of these factors, but now the things we took for granted, we appreciate some of the interactions between those factors".

"(the activity was) very valuable. It was interactive. It simplified the complex issues surrounding sustainability of water sources."

- Kabarole Participants

UCB transcribed and analyzed the questionnaires to better understand what participants took away from the workshop and how the outputs could be beneficial to them and their organizations. Of the 15 participants who completed both questionnaires, 11 noted their impression of which factors were most important or influential had changed due to the activity. They rated the activity as valuable (8 rated "Extremely Valuable" and 7 rated "Very Valuable") and indicated it improved their understanding of factors that influence water service sustainability "A lot" (13) or "Somewhat" (2).

Post-activity interviews were also conducted with five participants to understand what, if any, specific aspects of the activity may have influenced a change in their perspectives of the local system. Participants' responses indicated the activity was more in depth than they expected and it would benefit from a longer discussion of the factors over multiple days. Other interviewees repeated the reflection

on the depth of the factor mapping activity comparing it to other analyses they had worked with. As one interviewee reported, "Context analysis helps you understand the context in which you are going to be operating. This one [factor mapping] provides the relationships that exist, which is more influential, needs to be prioritized." The overall positive and detailed responses to the questionnaires illustrated that the factor mapping activity was helpful for building participants' understanding of the complex nature of local issues and encouraged them to develop a systems thinking mindset.

Findings

Finding I: A need to better understand the relationship between *Community Ownership*, *Financing*, and *O&M*

Community Ownership and *O&M* were identified as sensitive factors in the Influence Map, while *Financing* was highlighted as a potentially volatile factor. The centrality analysis also identified *Financing* as the most central factor by a large margin over *Coordination* and all other factors below it. This implies any change in *Financing* would propagate through the rest of the system more quickly than the other factors. In other words, changes in *Financing* may have the most immediate impact on *Sustainable Water Services* than any other factor in the system.

The key inverse relationships between *O&M* and *Financing* and *Sustainable Water Services* and *Financing* is driving the causal balancing loops. Additionally, the relationship between *Community* and *Financing* is present in all the reinforcing balancing loops. While it is somewhat unexpected that the three balancing loops would be the top loops in the system, it is clear functionality levels are balanced or kept in check by financial flows for *O&M*. According to the causal loop analysis, in order for the functionality levels to increase or decrease, some substantial change in a community's contributions to *Finance* for *O&M* will need to occur.

It is important to note *Financing* was defined as both funds from government transfers, taxes, and grants – mainly through the district government – and community capital contributions or tariffs. To better understand the dynamics driving the relationship between *Community*, *O&M*, and *Financing*, the impact of these different forms of financial flows needs to be unpacked more.

During the factor mapping activity, the relationships between *Community Ownership*, *Financing*, and *O&M* were some of the most heavily discussed and debated of all the influences in the matrix. Participants had different perspectives on how *O&M* and *Finance* were connected but agreed there was an inverse effect. The most telling comment was, "If you have good O&M, the other money can be used for other things. When it is bad and poorly managed, they have more allocation." While others noted if "O&M was better there would be no effect on O&M."

Regarding the effect of *Community* on *Financing*, participants were more succinct and straightforward, stating the most the *Community* can do is contribute or not contribute tariffs, but they have limited agency in determining how those funds are used. In terms of the effect of *O&M* on *Community*, participants noted "If we have better *O&M*, the community will be less involved." The group eventually decided, perhaps optimistically, "If O&M improves, then the community will be inspired to be involved." These statements speak to a convoluted relationship between the factors *Community*, *Financing*, and

O&M. These factors collectively appear as influential, central, potentially volatile, and driving forces in the system, which speaks to the need to better understand their relationships to build a stronger system to deliver sustainable water services.

Finding II: *Local Government Capacity* and *Coordination* are the most likely leverage points

It is clear from the Influence & Dependence Graph that *Local Government Capacity*, *Coordination*, and *Political Involvement* are strong leverage points. The centrality analysis also identified *Coordination* as one of the most central factors, although *Local Government Capacity* was less connected. However, neither of these factors were present in any of the dominant causal loops. The factors *Local Government Capacity* and *Coordination* are intertwined as participants generally agreed the local government should be leading local coordination efforts. It is therefore important to better understand the relationship between these factors and their combined effect on the overall system.

During the factor mapping activity, participants discussed the many ways the limiting nature of staffing, skills, knowledge, leadership, and management at local government levels was impeding the ability to absorb more *Financing* and better *Technology*. Some noted the local government's existing resources are strained from responding to community needs, and if communities were more involved in their own water schemes this would perhaps lessen the burden on government and allow for improved capacity to carry out their mandate.

More acutely, participants emphasized the need for improved *Coordination* based on its relationship to *Sustainable Water Services*. Here, key questions revolved around who needs to be more involved in group decision-making activities. Some participants noted CSOs don't coordinate or engage as much as they could because of a fear that discussing *Local Government Capacity* gaps may be seen as disrespectful. The group also discussed the need to involve local communities in coordination platforms to provide them with enhanced skills to locally manage schemes. Participants felt more *Coordination* with local actors would improve *Community Ownership*.

Finding III: Unique interactions of *Political* and *Private Sector Involvement*

In various analyses *Political Involvement* appears to have the potential to induce positive impacts on the system but is also somewhat independent and detached from other factors. *Political Involvement* was ranked as the most independent factor on the Influence Map, but also one of the most influential. Conversely, *Private Sector Involvement* was considered one of the more sensitive factors in the system. The centrality analysis indicated *Political Involvement* is the least central factor by a large margin, while *Private Sector* was third most central. Participants discussed the seemingly important ways in which *Political* and *Private Sector Involvement* impact the provision of *Sustainable Water Services*, but neither factor appeared in any of the top causal loops in the causal loop analysis. This indicates that although political and private sector actors are generally considered to be key partners in the water service sector, their influence is disparate and somewhat confounding.

During discussions, participants noted *Political Involvement* can sometimes be disruptive to programs, especially regarding community contributions of finances (user tariffs). In explaining their high ratings for *Political Involvement* on the Impact Matrix, participants noted politicians have the ability to either

positively or negatively affect *O&M*, *Water Resource Management*, *Financing*, and *Coordination* by deciding which priorities local governments focus their efforts on. At the same time, politicians appear to have the ability to influence the hiring (or firing) of civil servants in local government offices, meaning they have an outsized and independent influence on *Local Government Capacity*.

Private Sector Involvement, on the other hand, can improve water services if there is confidence communities will pay for services. Some participants noted the degree to which the private sector can improve water services is limited by the local government's capacity to facilitate their role in planning, constructing, and maintaining water schemes. If there is low government capacity, it will presumably hinder positive private sector engagement or open the door to unregulated private operations. Some participants countered this point suggesting Public-Private Partnership arrangements are becoming stronger in the district due to *Community Ownership*, even where government capacity is low.

The combination of insights from the systems analysis and discussion notes indicate three key findings for *Political* and *Private Sector Involvement:* (1) participants agree these actors need to be engaged to support *Sustainable Water Services*, (2) while both can have positive or negative impacts, *Political Involvement* has an outsized potential to create change in the system and is not heavily influenced by other factors, and (3) despite these known impacts, it is unclear where to engage each set of actors in the system to create positive outcomes.

In addition to highlighting the main findings from the analysis, it is also important to note which factors were not considered as their exclusion may indicate a possible missing link within the system. During the brainstorming phase of the activity, participants were split into groups and asked to decide which factors they thought were most important and discuss which ideas were brought up by members of their group and then omitted. Three factors discussed at length, but not included, were: *Regulation*, *Monitoring*, and *CSOs/Community-based Organizations/NGOs*. One group noted because it was the local government's role to monitor and regulate, they assumed enhanced monitoring and regulation would likely materialize as *Local Government Capacity* improved. Another group considered monitoring to be more involved in *O&M* activities and felt it was covered under this factor. With regards to NGOs, participants considered these organizations to be most critically involved in *Coordination* efforts and decided their involvement did not warrant a separate factor. It is important to note *Political Involvement* was almost left out of the priority factors included in the mapping activity and was only included after a prolonged discussion on how influential this group of actors could be in local infrastructure services.

Recommendations

Recommendation I: Promote clear and balanced policies for community contributions toward O&M

During the discussion participants agreed the national and district governments needed to contribute more financing to WASH overall. However, it was unclear what portion of government financial flows are directed towards regular O&M versus capital expenditures or major rehabilitations and if this needs to be adjusted. While this may help support better allocation of resources for more expensive aspects of O&M, community members' financial contributions are key to consistent water service functionality.

To effectively address this issue, local stakeholders need to develop a clear strategy for: (1) effectively allocating government and NGO financial flows, and (2) encouraging communities to see the value of cash contributions for regular O&M. Policies will likely vary depending on factors in the immediate local context, the type of scheme, and the existing management structure. However, there are likely some district-wide policies for managing external financial flows and community contributions that could serve as minimum standards or guidelines for clear and balanced policies to support consistent and sufficient O&M of schemes.

Recommendation II: Identify key areas to improve local government capacity

While the results of the systems analysis and notes from group discussion clearly point to a need to improve local government capacity, they do not provide detailed insights about where or how capacity needs to be increased within the existing government structure. It is expected members of the WASH Stakeholder Group are most likely aware of these issues and these items have been previously evaluated through context scoping, political economy, or other analyses. What remains to be understood is how specific improvements in local government capacity would propagate through the system to affect other factors and promote a positive outcome of sustainable water services. For example, it cannot be assumed the recruitment and retention of skilled staff will create this change on its own. There are many local and district government offices involved in the provision of water services (District Water, Environment, Education, etc.). Understanding how to strengthen key positions within this large structure is critical. Additionally, because many CSOs and community-based organizations are intimately involved with water service delivery, strengthening key personnel in these organizations may also have a significant impact on the overall system.

Iteration

Within the Kabarole context, it is clear the relationship between *Community*, *Financing*, and *O&M* requires further evaluation. A subsequent factor mapping activity could focus on factors that influence a community's willingness to pay for services, with particular attention to contributions to *O&M*. This analysis could also bring in the factors of *CSOs* and *Private Sector*, which appear to be more related to *O&M* and community dynamics than they are to *Sustainable Water Services*. It is recommended *Finance* be broken down into community contributions, financial flows to government, and other aspects if participants believe there are additional and separate financial flows that could have direct or indirect influence on communities' willingness to pay.

2. SOUTH ARI, ETHIOPIA

RURAL AND SMALL TOWN WATER SERVICES

IRC conducted a factor mapping activity on Nov. 15, 2017 in Jinka, Ethiopia as part of a workshop with key local stakeholders involved in rural and small town water planning and operations in South Ari Woreda. The workshop was part of a series of meetings intended to formalize a learning alliance platform for enhanced coordination and collaboration among the stakeholders. The activity engaged 16 participants from the Woreda Offices of Water, Agriculture, and Women and Children; Zonal Offices of Education, Finance, Health, Agriculture, Water, and Mining and Energy; and representatives from two international NGOs working in the region. A majority of the participants served their organizations in some technical or managerial capacity and worked directly or indirectly with water services and hygiene promotion in the woreda. IRC staff members facilitated the 2-hour activity in Amharic, which is the local language.

Factor Mapping Activity

At the beginning of the exercise, the facilitator presented a list of nine factors developed from a review of interview transcripts with participants of an Organizational Network Analysis. Participants were asked about challenges to rural water services in South Ari and possible solutions to those issues. Because many in the meeting were also interviewees, there was significant agreement on the list of factors presented. The facilitator asked if the list was valid and if more factors needed to be added.

Factors Brainstormed by Participants

Absence of data
Capacity Building
Community Awareness & Participation
Construction & Planning
Coordination
Culture
Environment
Finance
Monitoring
Operation & Maintenance
Policy

After a 30-minute discussion reviewing the factors and their definitions, two additional factors – *Absence of Data* and *Culture* – were added to the list. The full list of factors was presented at the front of the room on a flip chart and put to a vote, with participants selecting the top 10 factors. The resulting list of factors (see Table 7), along with the outcome factor *Sustainable Water Services*, were added to a cross-impact matrix as column and row headings (see Figure 20). The matrix was written on a large sheet of paper at the front of the room for participants to view throughout the activity.

Table 7 South Ari Factors

Factor	Definition	Shorthand
Capacity Building	Skills and training for existing human resources at community or woreda level	Capacity
Community Participation and Awareness	Participation by the community in maintaining water schemes and communicating with woreda officials	Community
Coordination	Communication of planning, monitoring, financing, technical and physical resources among woreda offices, Zone offices, Kebele administrators, and the community	Coordination
Environment and Water Resources	Climate, drought, desertification, groundwater, reservoirs, rivers, rainwater, wet season, and dry season fluctuations	Environment
Finance	Funds from government budgets, community tariffs, and external sources	Finance
Monitoring and Information	Gathering and sharing of information about location, functionality, and status of schemes; woreda, NGO, and WASH Committee activities	Monitoring
O&M	O&M required for continued functionality of water schemes	O&M
Planning and Construction	Planning and constructing or development or implementation of new or replacement infrastructure	Planning
Policy	Government regulation and policies of procedures, mandates, responsibilities, communication, and reporting	Policy
Proper Use of Water Schemes	The knowledge, information, and use or misuse of water schemes by community members	Proper Use
Sustainable Water Services	Safe, reliable, affordable water available in sufficient quantity and distance	-

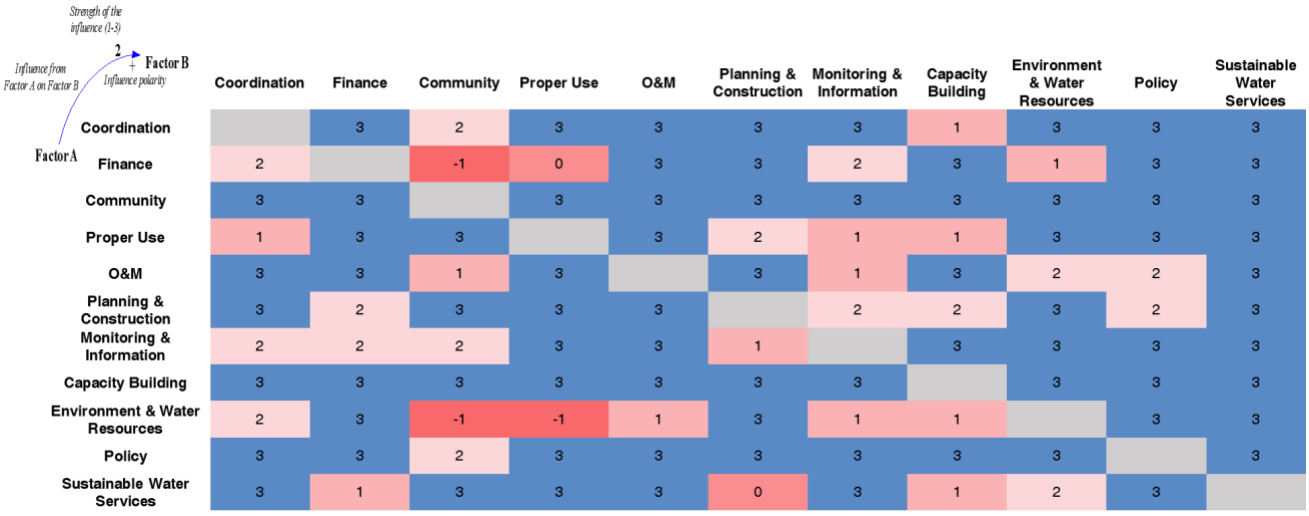


Figure 20 South Ari Cross-Impact Matrix

The resulting matrix of 110 relationships (see Figure 20) was completed in approximately two hours. While the matrix shows a relatively high percentage of strong connections (+3, approximately 70 percent) the group did identify three weak, inverse relationships within the matrix (-1) which indicate the presence of some balancing dynamics (see Appendix A) within the overall system. Interestingly, participants concluded all the factors had some form of influence on one another with the exception of two zero connections (*Finance* > *Proper Use*; *Sustainable Water Services* > *Planning and Construction*). This small number of zero connections shows the highly interconnected nature of all the factors participants deemed important in sustaining rural and small town water services.

Influence Mapping

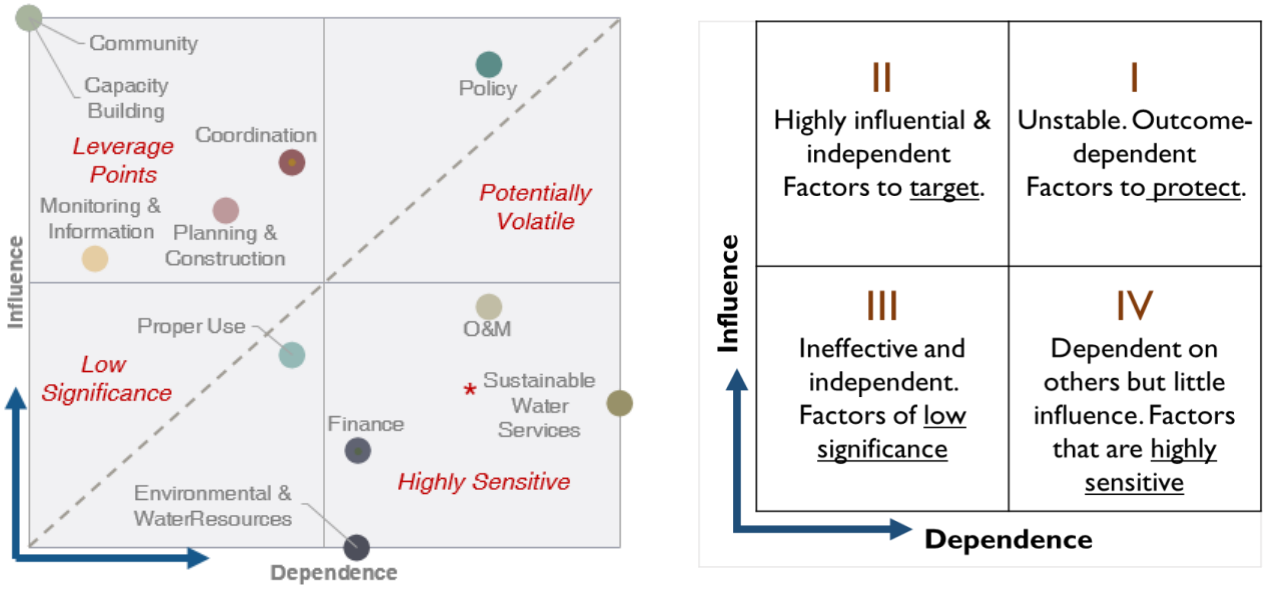


Figure 21 South Ari Influence Map

Insights

- *Community Participation* and *Capacity Building* are the most influential and most independent factors, indicating they are likely points of leverage within the overall system.
- *Coordination* also appears in Quadrant II (target factors) but is considerably more dependent on other factors in the system. This suggests while improved *Coordination* could be used to influence other factors, it is nearly as susceptible to being influenced by other factors.
- The position of *Policy* in Quadrant I as the only "factor to protect" and above the diagonal indicates it may be a potential fracture point (see Appendix A) in the system. This is due to its highly unstable nature – it is both highly influential and highly dependent on other factors.
- *Monitoring and Information* and *Planning and Construction* are also potential target areas, but less influential overall. This means while they are factors that could affect positive change, they have less ability to influence the system as a whole than *Coordination*, *Community Participation*, *Capacity Building*, and *Policy*.
- *Finance* and *O&M* appear to be sensitive to other factors in the system. This indicates the current state of variables may be dictated by the state of other factors within the system such as *Community Participation* (tariffs) and *Monitoring and Information* (functionality data).
- The outcome factor *Sustainable Water Services* is the most sensitive to other factors, as would be expected.

Centrality Analysis

Table 8 South Ari Centrality Analysis Rankings

Rank	**Weighted Degree-in** (influenced)	**Weighted Degree-out** (influencing)	**Betweenness** (central, bridging)
1	Sustainable Water Services (1.09)	Community (1.09)	Policy (2.07)
2	O&M (1.02)	Capacity Building (1.09)	Sustainable Water Services (1.92)
3	Policy (1.02)	Policy (1.05)	O&M (1.90)
4	Finance (0.95)	Coordination (0.97)	Coordination (1.90)
5	Environmental and Water Resources (0.94)	Planning & Construction (0.95)	Community (1.87)
6	Coordination (0.92)	Monitoring and Information (0.92)	Capacity Building (1.87)
7	Proper Use (0.92)	O&M (0.88)	Planning & Construction (1.83)
8	Planning and Construction (0.88)	Proper Use (0.84)	Proper Use (1.76)
9	Monitoring and Information (0.81)	Sustainable Water Services (0.82)	Finance (1.75)
10	Community (0.78)	Finance (0.80)	Monitoring and Information (1.74)
11	Capacity Building (0.78)	Environmental and Water Resources (0.71)	Environmental and Water Resources (1.65)

Insights

- The centrality analysis both validated and added depth to the influence mapping analysis by showing *Sustainable Water Services* is the most influenced factor (degree-in) and *Community Participation* and *Capacity Building* are the most influential (degree-out).
- The high ranking of *Policy* in both degree-in and degree-out and at the top of the betweenness metric indicates it plays a critical role in the overall system. Its central nature suggests *Policy* changes have the potential to propagate through the system more quickly than changes in other factors ranked below it (i.e., *O&M*, *Coordination*, *Capacity Building*, etc.). The difference in ranking between these factors and *Policy* (1.9<>2.07) is equal to nearly 40 percent of the range of all the values for betweenness, highlighting the significantly more connected nature of *Policy* over other factors.
- The high ranking of the outcome factor *Sustainable Water Systems* in the betweenness column suggests there is a close relationship between the current state of services (i.e., levels of functionality) and other influential factors in the system. It also suggests changes in this factor

(i.e., increased or decreased functionality) can have near-term influential impacts on factors, most likely *Community Participation* and *Finance*.

Causal Loop Analysis

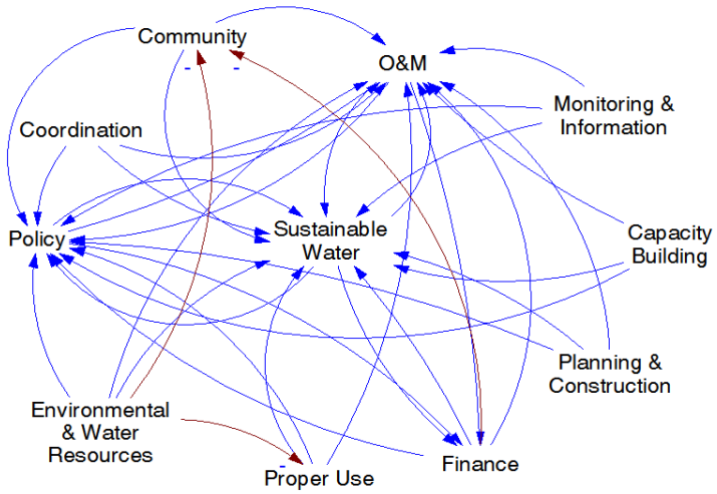


Figure 22 South Ari Full Causal Loop Diagram

Analysis of the CLD (see Figure 22) revealed 26 unique loops containing the outcome factor *Sustainable Water Services*. Of these 26 loops, the top three reinforcing and top three balancing loops were evaluated to gain better insight into the series of cause and effect relationships that may dominate the system (see Table 9). These loops were then re-represented in a prioritized CLD (see Figure 23). Factors not present in any of the top reinforcing or balancing loops are shown in grey in this diagram, indicating while they are still a part of the system, they are not part of the key causal chains identified in the causal loop analysis.

Table 9 South Ari Top Ranked Reinforcing and Balancing Loops

ID	Rank	Reinforcing Loops
R1	1	*Sustainable Water Services → Policy → Sustainable Water Services*
R2	2	*Sustainable Water Services → O&M → Policy → Sustainable Water Services*
R3	3	*Sustainable Water Services → Policy → O&M → Sustainable Water Services*
		Balancing Loops
B1	4	*Sustainable Water Services → Finance → (-) Community Participation → Policy → Sustainable Water Services*
B2	6	*Sustainable Water Services → Finance → (-) Community Participation→ O&M → Policy → Sustainable Water Services*

B3	7	*Sustainable Water Services* → *Policy* → *Finance* → *(-) Community Participation* → *Sustainable Water Services*

A key to understanding feedback loops is to read each sequence as a sentence. For example, reinforcing feedback loop B3 implies "If better *Policies* are put into place, *O&M* will improve leading to an overall improvement in the *Sustainability of Water Services*." Balancing loops are similar with the addition of an inverse relationship. For example, balancing feedback loop B2 reads, "If more *Finance* is available this may disincentive *Community Participation*, particularly in regard to tariffs, which could then cause *O&M* to decline, necessitating or creating a change in *Policy* which would then lower overall *Water Service Sustainability*."

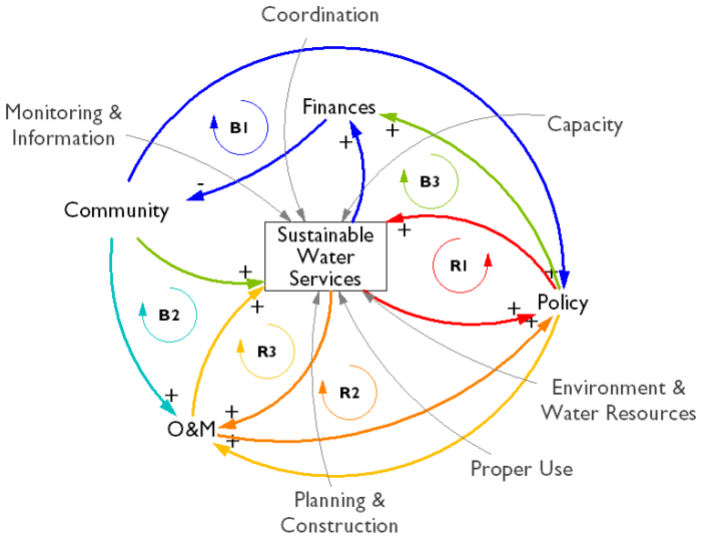


Figure 23 South Ari Prioritized Causal Loop Diagram

Insights

- The clearest take-away from the causal loop analysis is the various roles *Policy* plays in all the top reinforcing and balancing loops. *Policy* is the strongest factor within the reinforcing loops, with only the addition of *O&M* for the second and third loops. This indicates the special connection between the two factors, *Policy* around *O&M*, is likely to be the strongest driver of changes in *Sustainable Water Services* either improving or deteriorating.

- *Finance* is second to the role of *Policy* in all the balancing loops. This is due to the special inverse relationship participants identified between *Finance* and *Community*, implying as more financial resources are made available for water scheme operations, communities may be disincentivized to contribute their own financial resources.

- *Policy* augments the combination of *Finance* and *Community Participation* in all the balancing loops, with the addition of *O&M* in B2. This reinforces the finding that there is a key relationship between *Policy* and *O&M*. The inclusion of these two factors in the balancing loops implies the dynamics between them can be tempered by the limits *Finances* and *Community Participation* place on the ability of schemes to be properly maintained.

The potentially dynamic scenarios described above can be illustrated as a relationship of overall *Sustainability of Water Services* over time as shown in Figure 24.

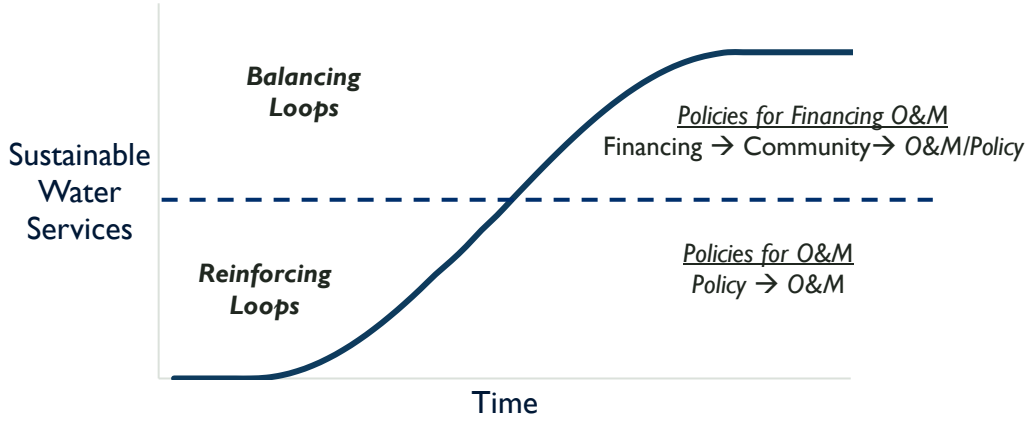


Figure 24 South Ari Potential Dynamic Behavior

Participant Feedback

As part of the factor mapping activity, UCB administered a post-activity questionnaire to evaluate the utility of the workshop to participants and solicit feedback on how it could have been improved. The questionnaires asked participants to rate the value of the activity and what actions (if any) they or their organizations may take as a result of learning more about the interconnections of factors within their local system. The questionnaires were translated and summarized by IRC staff after the workshop and analyzed by the UCB team. Overall, participants shared positive feedback about the workshop, giving an average rating of 4.7 on a scale of 1 to 5 for how valuable they found the activity.

In follow-up interviews, participants also expressed their enthusiasm for the exercise noting it encouraged critical reflection on how factors can be directly or indirectly affected by one another, including the state of water services. One participant asked the research team if the activity could be repeated with another group of stakeholders in the specific region where he worked. At the end of the workshop, one of the participants pointed to the cross-impact matrix, and said, "Resources are scarce, so this will help to prioritize needs." Considering the relatively short duration of the session (2 hours), this shows significant interest in the factor mapping activity and its potential to quickly build participants' understanding of the complex nature of local issues and encourage them to develop a systems thinking mindset.

"The exercise was very nice. We were able to think differently, in different directions. We were able to bring evidence to convince another. I wish we had more time to debate (the matrix)"

"(the activity) is linked to the truth"

"We never had such kind of focused project in areas of system, coordination, monitoring and learning before"

– South Ari Participants

Findings

Finding I: The connection between *Policy* and *O&M* defines the state of water services

Policy was a key factor in all the top balancing and reinforcing feedback loops from the causal loop analysis. This is a relatively unique outcome in a causal loop analysis with 11 factors and 108 interconnections.[10] Reflecting on insights from the influence map, it was clear *Policy* could play a very important role in the system as a potential fracture point in the Quadrant I. *Policy's* high influence, coupled with its relatively high dependence on other factors in the system, makes it potentially volatile. Results of the centrality analysis also indicated *Policy* was the most central factor, by a significant margin. This implies small changes in one or multiple factors could have a substantial, near-term impact on *Policy* because it is the most connected to other factors.

The causal loop analysis also illustrated the unique relationship between *Policy* and *O&M* is most likely to drive the overall system, not *Policy* in and of itself, as indicated by two of the reinforcing loops and one balancing loop. It is important to note *O&M* is not a part of any other loop where it is not directly connected to *Policy*, either influencing or being influenced by *Policy*. *O&M* was also identified as one of the more dependent or sensitive factors, second only to the outcome factor *Sustainable Water Services*.

The overall analysis appears to show *O&M* is most sensitive to the existing state of, or changes in, *Policy*. According to how participants mapped the system, this implies the key to promoting long-term sustainability of water schemes revolves around the policies that dictate how O&M is conducted (including who does it and who pays for it). This insight was reflected in information gathered from a scoping study by IRC and presented to participants during the workshop, which noted mechanisms related to asset management and tariff setting are not clearly defined by the woreda.

Finding II: Stable *Finance*s are a pre-requisite for the local system to support sustainable services

While the influence map and centrality analysis appeared to imply *Finance* played a minor role in the overall system relative to other factors, the causal loop analysis showed the unique connection between *Finance*s and *Community Participation* in all the balancing loops. As described by participants, the balancing nature of this relationship was built on the logic that as a more money was available for the construction of new schemes and the maintenance of existing schemes, this would serve as a disincentive for community engagement and financial contributions. The resulting tendency for this relationship to "balance" the system, or move it to a steady state, would be reflected in persistent issues of low functionality due to *Finance* and *Community Participation*. Alternatively, if services were increased, this would also mean the loop could promote consistently high levels of functionality.

IRC's scoping also identified: (1) one-third of rural water schemes are not managed by a well-established and registered Water Users Association (WUAs), (2) for schemes managed by a WUA, many have not been recently trained in management and almost none have gender-balanced representation, and (3) less than half of the schemes have an established tariff structure. Additionally, many WUAs do not have water safety plans, a critical element of water resources management in drought-prone contexts. This appears to imply *Community Participation* is low due to a lack of adequate organization and management

[10] There were two relationships that participants agreed did not have an influence value.

by WUAs and one consequence of this is a lack of tariff payments (*Finance*) for *O&M*. The same study noted no *Finance*s to major maintenance of water schemes are allocated in the annual woreda budget.

During the discussion participants mentioned issues with funding were multidimensional: there are a number of different sources, a lack of certainty regarding future financial flows, and the woreda offices lack adequate capacity to handle increased or erratic finances. This was reflected in the cross-impact matrix and influence map which showed *Finance* was one of the most sensitive issues in the system, second only to *Environment and Water Resources* for least influence. This may be the result of decisions around financial flows to the woreda made by officials, donors, and NGOs outside of the woreda.

Finding III: *Coordination* platforms need to be strengthened and include *Community Participation*

While *Coordination* was not a top element of either the centrality analysis or CLD, it was one of the target factors in the influence map, and perhaps more importantly, was mentioned frequently in combination with another potential leverage point, *Community Participation*. Participants said coordination with communities was critical for data collection and responsible management of the schemes (*Proper Use*). Participants frequently mentioned the need for community participation in communication platforms with the Woreda Water Office.

While coordination and communication platforms exist between local woredas and the zonal government, these channels are mostly used for emergencies and are not sufficient overall. In one post-activity interview, a representative of the Zonal Water Office explained that in practice not much coordination occurs between different stakeholders except for formal and contractual reasons. The scoping study also found no platforms at the woreda level for sharing, learning, and coordination. This highlights the effect a lack of communication has on sharing best practices for *Monitoring* and *Planning* – two other potential key leverage points.

Finding IV: Increasing *Local Government Capacity* is a fundamental need

Local Government Capacity was deemed to be as influential and as independent as *Community Participation* in the influence map. This was also reflected in the top rank of the degree-in centrality analysis metric. However*, Local Government Capacity* was shown to be equally central and peripheral in the betweenness metric and was not present in any of the top feedback loops. While its absence from the causal loop analysis limits the ability to hypothesize its overall likelihood to drive the overall system, it remains a clear leverage point that can lead to positive changes in the factors that do appear to drive the system (*O&M*, *Finance*, *Policy*, and *Coordination*). This finding is supported by the IRC scoping study, which noted the Woreda Water Resources, Mines, and Energy Offices do not have the required human and financial resources to support WUAs.

In addition to the findings above, it also important to note which factors were not considered as part of the analysis, as their exclusion may indicate a possible missing link within the system. Factors included but deemed to be less significant are also important areas for reflection. In South Ari, there was a substantial discussion of the need for monitoring and evaluation – as opposed to the factor *Monitoring and Information* – but evaluation was not reflected fully in any of the factors. Participants identified issues with data collection and management that result in a lack of knowledge of the maintenance about water

schemes and potential duplication of efforts, especially by NGOs. They also noted turnover of personnel has affected many factors, but most acutely impacts data collection and management.

There was also little discussion on the factor *Environment and Water Resources*, which was included. This factor was originally proposed to the group as *Environment* from the qualitative analysis of pre-activity interviews. It was intended to refer to issues of erratic climate effects on water resources and local livelihoods. As this mostly refers to natural phenomenon, it was surprising it was the least influential factor and was chosen over other factors including *Culture* or *Skilled Technicians*. The inclusion of *Water Resources* as a key factor, but with little discussion and low influence, may indicate while participants believed it was an important influence on water schemes, as the activity progressed, they concluded it was less significant in the overall system supporting sustainable services.

As with many stakeholder-led activities, the results of this analysis are a result of the unique insights of specific individuals who took part in the exercise. The analysis both greatly benefits from these perspectives and is limited by them, specifically with regard to which factors were included by the majority group vote and the exclusion of other factors determined to be most consequential. Including these factors in a future factor mapping activity may substantially change the outcomes of the analysis and recommendations. Because of the context- and stakeholder-specific nature of the activity, it is strongly recommended results be shared with participants in a consultative workshop to validate the findings and supplement them with additional insights from the group.

Recommendations

Recommendation I: Develop policies that incentivize proper O&M and secure finances

Results of the systems analysis strongly suggest primary actions need to focus on strengthening policy around O&M of water schemes. This may involve modifying existing policies, creating new ones, or encouraging more flexible policies for varying contexts. It is critical policies also address finances for O&M with special consideration for community contributions, as the causal loop analysis showed the relationship between these three factors to be a potential limiting factor on water scheme sustainability. This is clearly a key focal area because the dynamic relationship between all these factors is hypothesized to be the key driver that could improve, deteriorate, or hold the system at a status quo of stagnating functionality (either low or high).

During the meeting, some participants noted there were no existing policies for coordination and planning for those involved in developing or managing water schemes. While the need for improved coordination is always a salient issue, this analysis did not indicate that changes in coordination and planning would have a substantial impact on the overall system, at least not initially. However, another participant noted there is no existing database for relevant parties to track what maintenance has been conducted on specific schemes. Others noted the Woreda Water Office maintains a database of water points, but it was unclear if the database tracks O&M activities. Creating a policy that tasks the most relevant office with creating and managing such a database may in turn help improve O&M and overall sustainability of water services.

Recommendation II: Support a functional coordination and information sharing platform with attention to community participation

Two issues appeared clear from undertaking this activity: (1) existing communication platforms are not sufficient and need to be improved, and (2) there needs to be a mechanism for the woreda to communicate and effectively coordinate with local communities. Addressing the first issue may help to address fluctuating financial flows from the Zonal government and the lack of clear policies and guidelines for asset management and tariff setting, while addressing the second would aid in collection of functionality data and improved capacity of communities to properly manage local water schemes. Because these actions appear to require different forms of communication, two coordination platforms are needed.

Recommendation III: Build woreda capacity to effectively manage Water Office operations

Another finding of the analysis pointed to the need for improved woreda capacity, not because it could have a substantial near-term impact on its own but because of its connection to factors that can collectively produce positive outcomes. It is clear more operational capacity is needed for the woreda Water Office to absorb, manage, and adequately allocate funds, support WUAs, and develop and implement better policy around O&M. Initial steps toward this goal may simply involve the hiring and retention of more personnel within the office. However, for this increased human capital to impart a fundamental change in how woreda capacity affects other factors, direct skills building and knowledge transfer to dedicated personnel who can create lasting intuitional knowledge is critical.

Iteration

Within the South Ari context, the relationship between *Policy* and *O&M* is a key connection that needs to be better understood. This is also true with respect to the role *Financing* plays in the system, with the need to breakout different financial flows in future iterations. A future factor mapping activity could focus on how *Policy* influences *O&M* or which factors influence what *Policies* or *Finances* are available for *O&M*. There also appears a need to unpack the role *Coordination* plays in the system with specific regard to different local actors. This could be modeled in conjunction with some form of network analysis that brings in elements on different flows of information and resources to help understand the factors that influence why different partners coordinate (or why they do not). Separately, a follow-up session could focus solely on the issue of what factors limit or could improve organizational capacity of the Woreda Water Office.

3. MILE, ETHIOPIA

RURAL AND SMALL TOWN WATER SERVICES

IRC conducted a factor mapping activity on Dec. 19, 2017 as part of a workshop with key local stakeholders involved in small town and rural water services planning and operations in the Mile Woreda. The workshop was part of a series of meetings intended to formalize a learning alliance platform for enhanced coordination and collaboration among stakeholders. During the meeting, information was presented from baseline assessments conducted by IRC and woreda staff, including: Asset Inventory, Life Cycle Cost Analysis, Sustainability Checks, and Network Analysis. The activity engaged 28 participants consisting primarily of technical experts from local government offices, including Mile Woreda Office (13), Mile Woreda Administration (9), Afar Regional Office (1), and NGOs/other (5). Three IRC staff members facilitated the activity in Amharic, the local language. UCB researchers were not present for the factor mapping activity. All data, notes, and documentation presented in this report were collected by IRC and provided to UCB for analysis.

Factor Mapping Activity

At the beginning of the exercise, the facilitator asked participants to brainstorm responses to the question, "What are the most important factors that influence water and sanitation services in Mile Woreda?" The group was also presented with a list of factors obtained from a qualitative analysis of interview responses completed by UCB. Many of the participants in the factor mapping activity also participated in the interview process, so the list was presumed to be representative of the main factors of interest to the group.

Factors Identified from Stakeholder Interviews

Capacity of Local Government
Community Management
Coordination
Equipment & Spare Parts
Finance
Infrastructure Expansion and Construction
Infrastructure Monitoring and Management
Pastoralist Way of Life
Population Growth and Demand
Power and Electricity
Skilled Water Technicians
Water Quality and Treatment
Water Resources

The group identified nine key influential factors through this process. After defining and agreeing to the factors to be mapped, the large group was split into two smaller groups to complete their own matrix. The resulting nine factors along with the outcome factor *Sustainable Water Services* (see Table 10) were added to a cross-impact matrix as column and row headings (see Figure 25). The matrix was written on a large sheet of paper at the front of the room for all participants to view throughout the activity.

Table 10 Mile Factors

Factor	Definition	Shorthand
Finance	Budget available for use which is allocated from all sources including the government, NGOs, and tariffs	Finance
Coordination	Communication and collaboration between woreda sector offices, between the woreda office and the community, and between the woreda office and NGOs	Coordination
Water Resources and Infrastructure	Available water resources, planning and construction of schemes, management of existing schemes, and the study of potential of water sources	WR+I
Proper Use	A community's sense of ownership, proper use, and management of schemes. Their awareness, participation, responsibility, and capacity	Proper Use
Skilled Water Technicians	The ability of technicians to repair and maintain minor and major problems	Water Techs
Spare Part Supply	Availability of spare parts, equipment, and machinery	Spare Parts
Water Quality	The quality of water during extraction, distribution, and use; this includes proper hygiene	Water Quality
Water Demand	Increase in water demand due to population increases; in addition, the amount of water resources and infrastructure affects the number of people who can be served by the water schemes	Demand
Woreda Administration	Capacity and awareness of woreda administration offices	Woreda Capacity
Sustainable Water Services	Access to all; good water quality; a scheme that can serve for a very long period of time	-

A few key elements of the definitions for selected factors are important to consider when reporting the results of the factor mapping analysis. For example, the factor *Finance* included financial flows from "all sources including the government, NGOs, and tariffs." *WR+I* has a broad definition which, in addition to water resources, considered planning, construction, study of new schemes and resources, and management of existing schemes. Additionally, two of the factors incorporated additional components that are not typically considered: *Proper Use* included "capacity of the community," and *Water Quality* included "proper hygiene."

The two resulting matrices of the same 90 relationships is presented in Figure 25. Considering the large number of factors and relatively short period to review factor strengths, it is not surprising nearly three quarters of each matrix contains +3 values for the factor relationships. Overall, the group identified a

total of 17 inverse relationships (13 for Group 1, and three for Group 2). This led to a robust discussion and understanding of the nature of inverse relationships within the factor mapping activity.

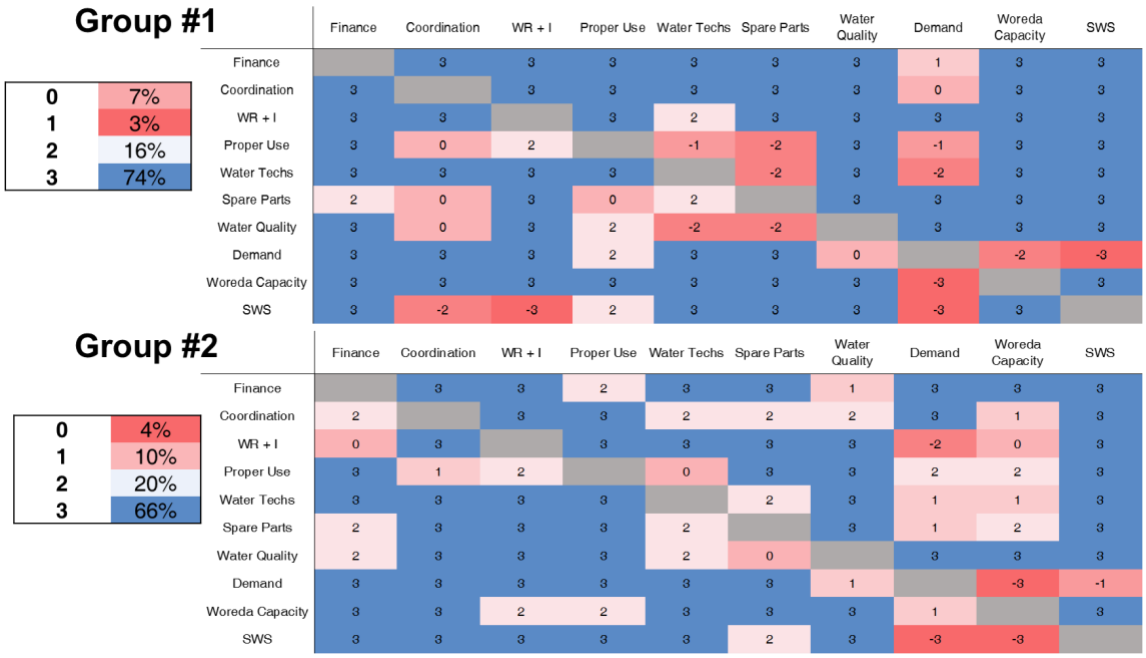


Figure 25 Mile Cross-Impact Matrices

In order to reconcile the two matrices, a comparative analysis of areas of agreement and disagreement (Figure 26, 27) was conducted to gain a better understanding of the differences between how each group rated the same matrix of factors. The matrix of agreement (Figure 26) shows factor influences where the absolute value of the relationship was the same for both groups. In contrast, the matrix of disagreement (Figure 27) shows the scale of disagreement (in absolute value) where the groups identified two different factor influence strengths (i.e., if Group 1 rated a particular influence +3, and Group 2 rated the same influence 0, the matrix of disagreement would show an absolute value of 3 for that interaction). This comparative analysis shows differences in strength, irrespective of whether each group had identified the influence as a positive or inverse relationship. A review of the two matrices shows that overall the groups rated 52 percent of the influences as the same strength, with 90 percent agreement on strong influences (i.e., a value of 3). For the 48 percent of factors where the group disagreed, the overall difference was relatively small, with 63 percent of the relationships separated by just one value and 21 percent separated by two values.

Considering the relatively consistent overall agreement between the two matrices, it was determined the most representative combined matrix (Figure 28) would include an average value of each

corresponding influence from the two groups, rounded down (e.g., 2.5→2).[11] The value of 3 indicates areas where both groups gave the relationship the same value. This process allowed for a higher level of resolution in the data, while maintaining the patterns of agreement and disagreement between the two matrices. The resulting matrix was used primarily for the centrality analysis and causal loop analysis, with the inverse relationships re-introduced and accounted for in the latter. The influence map analysis was performed by averaging the Influence & Dependence values from each matrix.

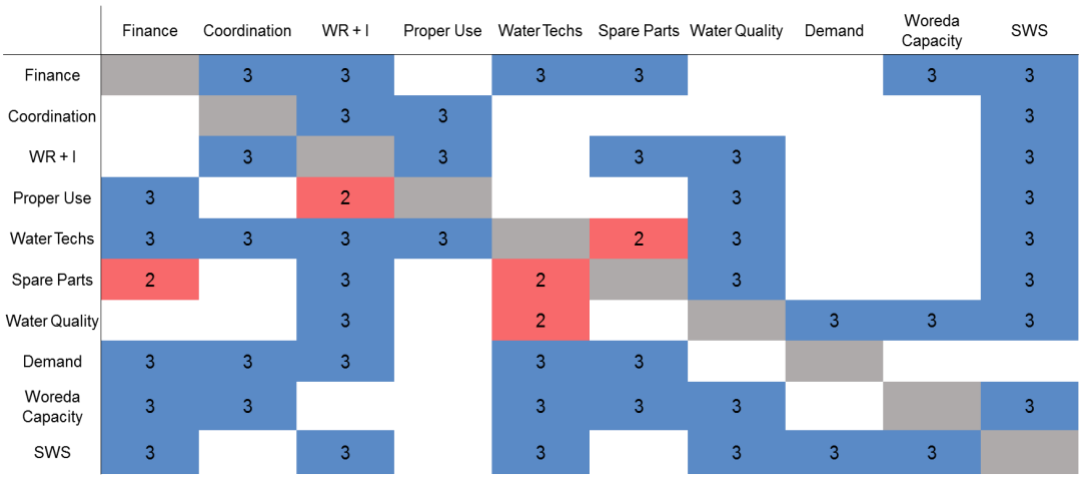


Figure 26 Mile Matrix of Agreement

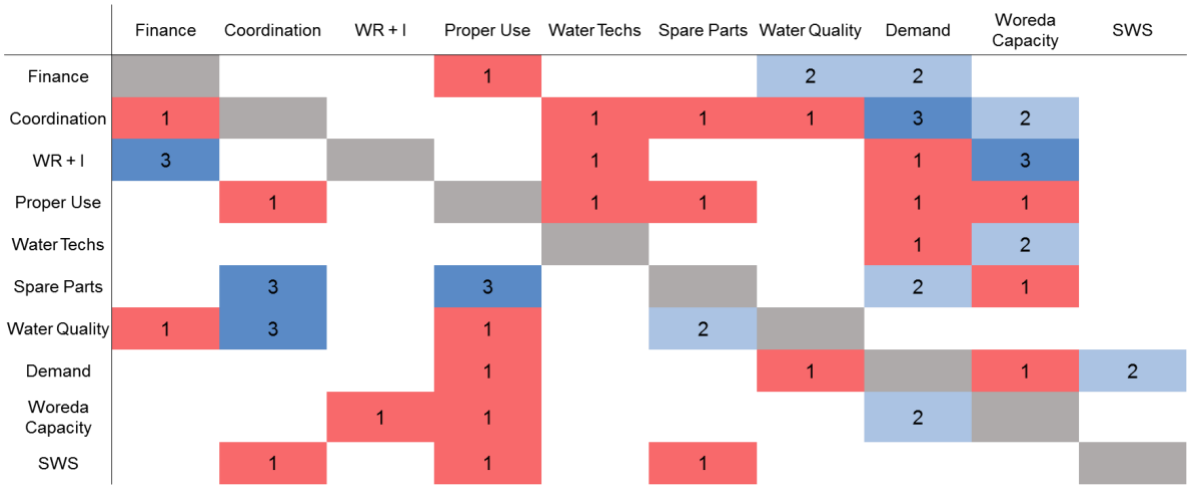


Figure 27 Mile Matrix of Disagreement

[11] This decision was made based on a review of both direct and indirect matrices, including the range of differences in values and implications on factor Influence & Dependence (influence map). The indirect matrices for each group were developed as specified in Appendix A.

0	3%
1	10%
2	34%
3	52%

	Finance	Coordination	WR + I	Proper Use	Water Techs	Spare Parts	Water Quality	Demand	Woreda Capacity	SWS
Finance		3	3	2	3	3	2	2	3	3
Coordination	2		3	3	2	2	2	1	2	3
WR + I	1	3		3	2	3	3	2	1	3
Proper Use	3	0	2		0	2	3	1	2	3
Water Techs	3	3	3	3		2	3	1	2	3
Spare Parts	2	1	3	1	2		3	2	2	3
Water Quality	2	1	3	2	2	1		3	3	3
Demand	3	3	3	2	3	3	0		2	2
Woreda Capacity	3	3	2	2	3	3	3	2		3
SWS	3	2	3	2	3	2	3	3	3	

Figure 28 Mile Combined Average Matrix

Influence Mapping

The influence map analysis was created by averaging the relative Influence & Dependence values from each matrix.[12] A comparison of the influence maps developed from each matrix, a combined average matrix, and the relative Influence & Dependence values indicated the latter was the most representative of the values assigned to each matrix by the two groups.

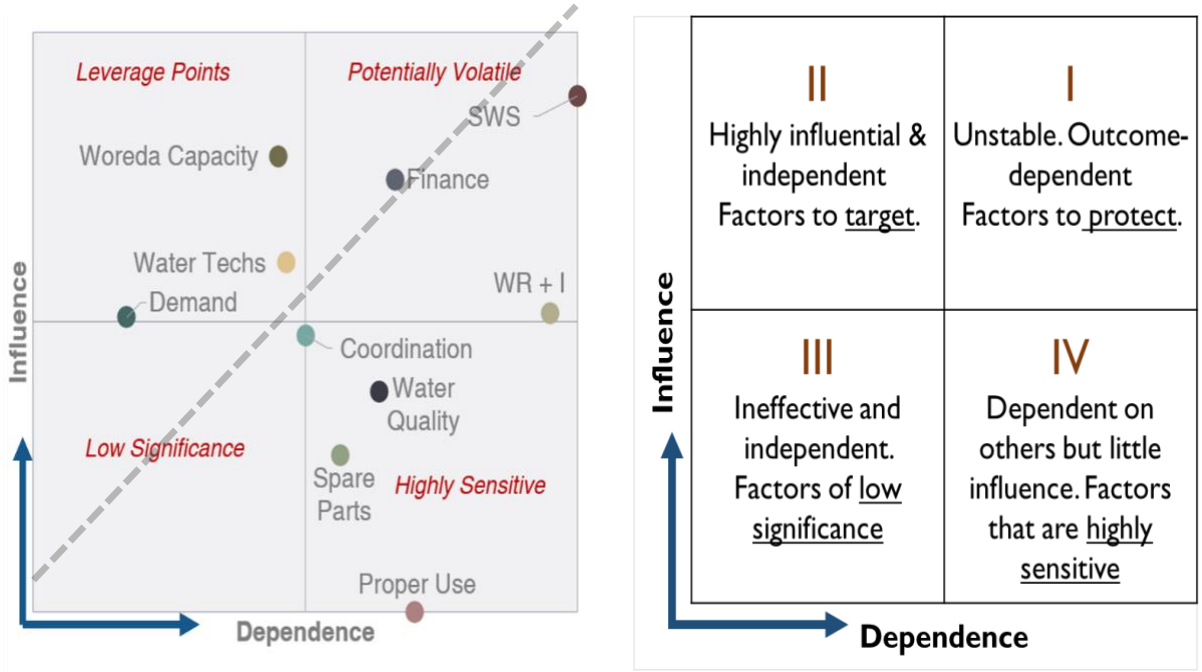


Figure 29 Mile Influence Map

[12] Because the Influence & Dependence values were calculated by averaging the respective values from each matrix, no factor appears full independent (left axis of graph) or completely influential (top axis of graph) in the system.

Insights

- The influence map shows *Woreda Capacity* emerged as the only clear leverage point in the system, although it is close to the midline and not independent of influence from other factors.
- *Water Technicians* and *Demand* also appear to have high potential to influence the system, but are less influential overall than *Sustainable Water Services* or *Finance* in Quadrant I. Because neither factor is very independent, suggesting they cannot experience significant change on their own without changes to other factors in the system.
- *Sustainable Water Services* has high dependence and influence, indicating small changes to this factor could have major effects on the system as a whole. This suggests some factors, in particular *WR+I*, are dictated by the level of functionality of existing schemes and the existing state of services has a feedback effect on the system overall.
- The position of *Finance* in Quadrant I, slightly above the diagonal, indicates its tenuous position in the system. *Finance* is both highly influential and highly dependent on other factors, due to its unstable nature.
- The position of *Coordination* in the middle of the graph appears to indicate it has equal potential to affect the system and be affected by the system.

Centrality Analysis

Table 11 Mile Centrality Analysis Rankings

Rank	**Weighted Degree-in** (influenced by)	**Weighted Degree-out** (influencing)	**Betweenness** (bridging, and indirect)
1	Water Services (26)	Water Services (24)	Water Services (0.41)
2	WR+I (25)	Finance (24)	Finance (0.41)
3	Finance (22)	Woreda Capacity (24)	Woreda Capacity (0.41)
4	Water Quality (22)	Water Techs (23)	WR+I (0.41)
5	Spare Parts (21)	WR+I (21)	Spare Parts (0.41)
6	Proper Use (20)	Demand (21)	Demand (0.28)
7	Water Techs (20)	Water Quality (20)	Water Quality (0.28)
8	Woreda Capacity (20)	Coordination (20)	Water Techs (0.12)
9	Coordination (19)	Spare Parts (19)	Coordination (0.12)
10	Demand (17)	Proper Use (16)	Proper Use (0.12)

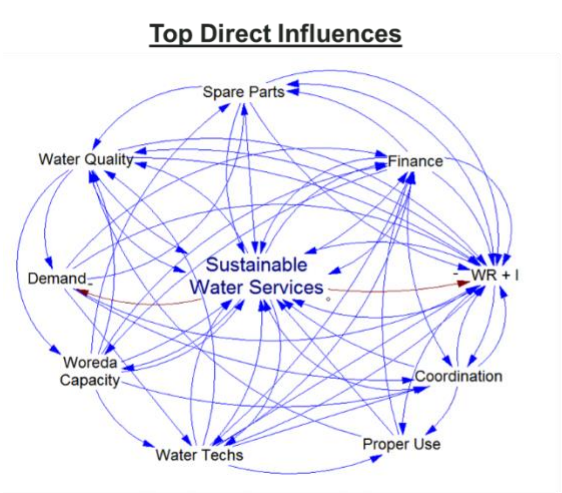
Insights

- Degree-in and degree-out and the influence map confirm *Sustainable Water Services* is the most influential and most influenced factor. However, there does not appear to be a large gradient in the range of degree-out values, with *Woreda Capacity* having the same ranking as *Sustainable Water Services*.

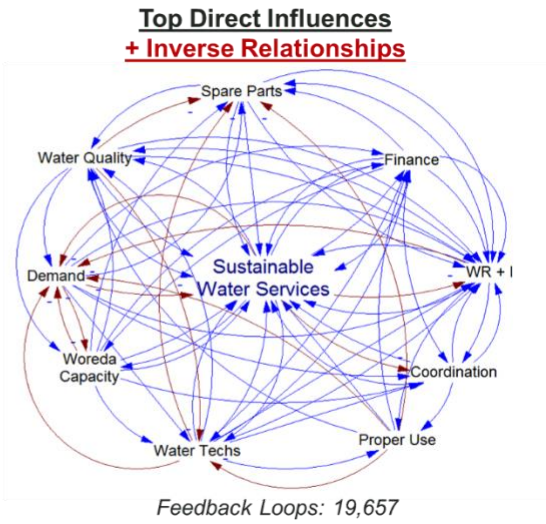
- The betweenness metric indicates *Sustainable Water Services*, *Finance*, *Woreda Capacity*, *WR + I*, and *Spare Parts* are all equally central to the system. This suggests a very dense, highly-connected system of factors, in which changes have more pathways to propagate throughout the rest of the system. This is not surprising for the first three factors but is interesting for the factor *Spare Parts* which appeared as one of the more sensitive factors on the influence map.

Causal Loop Analysis

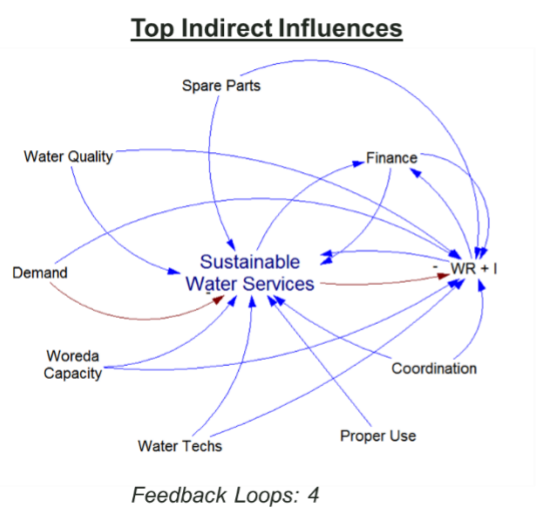
Using connections in the combined average impact matrix, a CLD can be built by mapping each connection identified in the cross-impact matrix. Due to the complexity of combining these two matrices, it was determined the causal loop analysis should consider a range of possible causal chains to confidently identify the most dominant feedback loops. This was accomplished by combining the top influences (three values) from each matrix and considering causal loops from four scenarios: (1) top direct influences, (2) top direct influences + all inverse relationships, (3) top indirect influences, and (4) top indirect influences + all inverse relationships (see Figure 30). The resulting diagrams are a 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 each diagram.



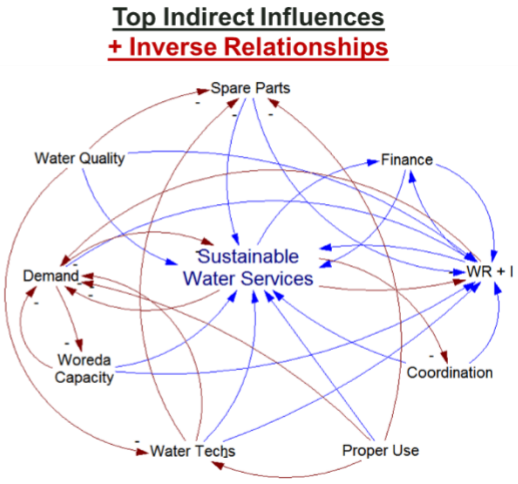
Feedback Loops: 3,326



Feedback Loops: 19,657



Feedback Loops: 4



Feedback Loops: 19

Figure 30 Mile Full Causal Loop Diagrams

These scenarios produced over 23,000 unique loops. The indirect causal diagrams had significantly fewer top loops because there was a larger range of values and more resolution to the indirect matrices than the direct matrices. These loops were then ranked by the absolute value of their average strength to determine which loops were most likely to drive system behavior (i.e., Services → (3) *Finance* → (2) Capacity → (3) Services; Loop strength = (3+2+3)/3 = 2.67). Of all the possible loops, the top three reinforcing and top three balancing loops were evaluated to gain better insight into the series of cause and effect relationships that may dominate the system. Top feedback loops common to all scenarios were combined to identify the top four reinforcing and balancing loops overall (see Table 12). These loops were then re-represented in a prioritized CLD (see Figure 31). Factors not present in any of the top reinforcing or balancing loops are shown in grey in this diagram, indicating while they are still part of the system, they are not part of the key causal chains identified in the causal loop analysis.

Table 12 Mile Top Ranked Reinforcing and Balancing Loops

ID	Reinforcing Loops
R1	*Water Services → Finance → Water Services*
R2	*Water Services → Water Techs → Water Services*
R3	*Water Services → Finance → WR + I → Water Services*
R4	*Water Services → Water Quality → Water Services*
	Balancing Loops
B1	*Water Services → (-) WR + I → Water Services*
B2	*Water Services → (-) WR + I → Finance → Water Services*
B3	*Water Services → (-) WR + I → Water Quality → Water Services*
B4	*Water Services → (-) WR + I → Proper Use → Water Services*

A key to understanding feedback loops is to read each sequence as a sentence. For example, feedback loop R3 reads as, "If *Water Services* improve, *Finance* will increase which will in turn improve *WR+I* which will then lead to overall improvements in *Sustainable Water Services*." Similarly, balancing loop B2 reads, "If *Water Services* improve, this will improve *WR+I* which will improve *Finance* and hence improve *Sustainable Water Services*." However, in the case of all the balancing loops, the inverse relationship between the outcome factor *Sustainable Water Services* and *WR+I* will inevitably lead to a balancing or goal-seeking behavior, driving the system toward an overall steady state.

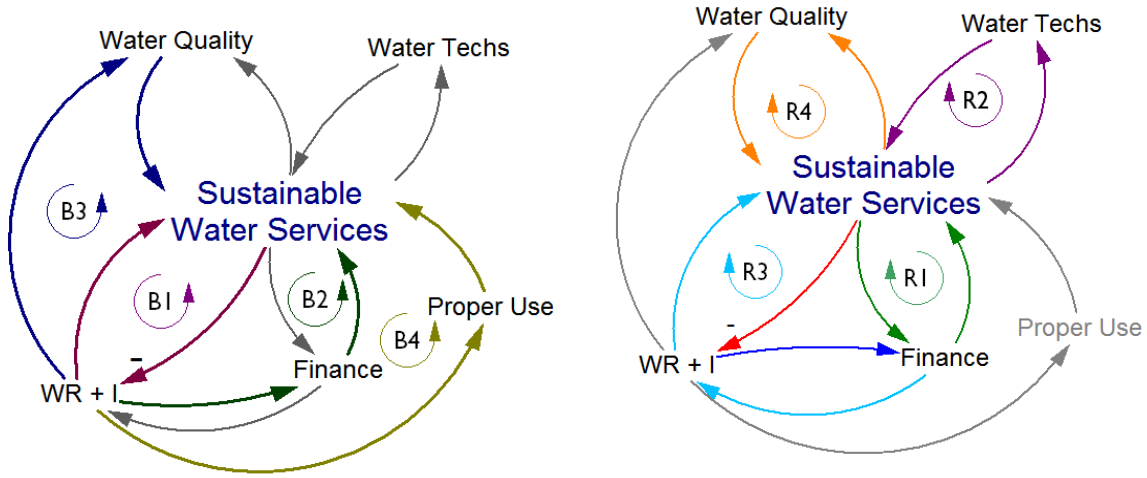


Figure 31 Mile Prioritized Causal Loop Diagram (Balancing – Left, Reinforcing – Right)

Insights

Reinforcing Loops

- R1 implies better services could lead to an increase in *Finance*s (via tariffs). Or conversely, a decrease in services would lead to a decrease in *Finance*s. Reinforcing loop R3 adds *WR+I* to this relationship, suggesting that there are two pathways for *Finance* to have a significant impact on *Water Services* – directly and indirectly through management of existing schemes and planning for new ones.

- Reinforcing loop R2 suggests better *Water Services* could lead to, most likely indirectly, the hiring of more and higher capacity technicians, which would improve services.

- R4 suggests better *Water Services* would result in better *Water Quality*, which would lead to better services. Alternatively, if *Water Services* decreased, so too would *Water Quality* and overall *Water Services*.

Balancing Loops

- The most important insight is that all the balancing loops rely on the inverse relationship of *Sustainable Water Services* on *WR+I*, with additions of *Finance*, *Water Quality*, and *Proper Use*. This indicates extracting meaning from these loops relies on an enhanced understanding of how participants described the inverse relationship between these two factors.

- Overall, the balancing loops imply gains in improving sustainability of existing services could hinder effective future planning, management, and development of new schemes. Alternatively, a decrease in *Water Service Sustainability* could lead to a need for better planning and management of infrastructure.

- The consequence of this unique relationship between *Sustainable Water Services* and *WR+I* is *Finance*, *Water Quality*, and *Proper Use* (*Community Ownership*) will most likely follow whatever trends occur (positive or negative) in water resources planning, construction, and management.
- Balancing loop B4 also appears to indicate the factor *Proper Use* may not be as insignificant or sensitive as indicated in the influence map.

These potential dynamic scenarios can be generally illustrated as a relationship of overall *Sustainable Water Services* over time as shown in Figure 32. It appears increasing *Finance* is the likeliest way to initiate improvements in the sustainability of services by providing the woreda government with a stronger ability to manage and plan water services. However, increases in services will be indirectly limited through *WR+I*. This could happen in one of two ways: (1) through a change in physical water resources and quality, or (2) through a change in woreda capacity.

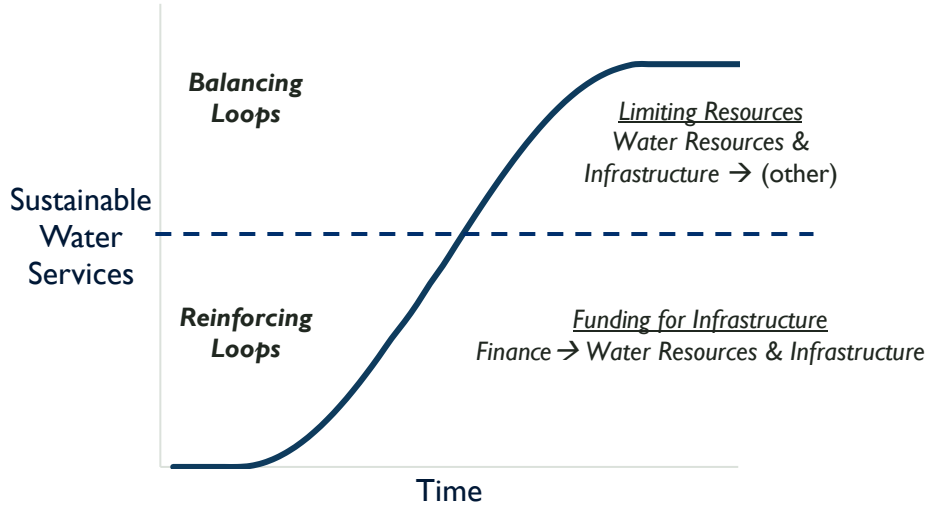


Figure 32 Mile Potential Dynamic Behavior

Participant Feedback

As part of the factor mapping activity, IRC staff administered a post-activity questionnaire to evaluate the utility of the workshop to participants and solicit feedback on how it could be improved. The questionnaires asked participants to identify the factors they thought were most important overall to *Sustainable Water Services*. Unfortunately, responses were only collected from 7 of the 28 participants. Of the responses provided, the most common factor prioritized for action was *Coordination*. Participants also mentioned the need to build more infrastructure and coordinate management of existing water schemes.

Findings

Due to the decision to split the participants into two groups to complete two matrices, along with the relatively small number of notes detailing how participants described factor interactions and rationale for rating each influence, the following findings represent a conservative reading of the overall results of the systems analysis. In order for these findings to be refined into more actionable conclusions, they require more unpacking with the session facilitators and feedback from the participants. At the time of this report, that process has yet to be undertaken.

Finding I: The balance of managing existing services and planning for new schemes is key to the overall sustainability of *Water Services*

From the influence map, the factors *Sustainable Water Services* and *WR+I* were shown to be highly influential and dependent. The centrality analysis also identified them to be the most central factors. Additionally, *WR+I* was present in five of the top eight feedback loops and all the balancing loops. This indicates it is a key factor in driving dynamic system behavior, either toward increasing, decreasing, or balancing outcomes. While *Sustainable Water Services* cannot be targeted as the outcome factor, management and planning of existing and new infrastructure is clearly an area where small changes could have a larger impact on the whole system.

Because this dynamic behavior results from the inverse relationship between *Sustainable Water Services* and *WR+I*, understanding this connection is essential for targeting specific aspects of scoping, planning, management, and oversight of existing and new water schemes. The relationship is somewhat convoluted because of the broad definition of *WR+I*. There is a need to unpack this factor into its various sub-components and understand their individual effects on other factors and the system overall.

Finding II: *Woreda Capacity* is the key area to target

Following the outcomes of Finding I, if better planning and management are needed to increase *Sustainable Water Services* and it is the woreda administration's mandate to perform those services, it follows that increasing *Woreda Capacity* in these areas is essential to improving *Sustainable Water Services*. *Woreda Capacity* was the only clear target factor in the influence map. While it was present in two of the top feedback loops (see Table 12), it was not considered in the final CLD. This implies while *Woreda Capacity* may not be the most direct driver of outcomes in water services, it is an essential element in the system which, when strengthened, could have a substantially positive overall impact.

Finding III: *Coordination* was not shown to be central or influential factor to target

The influence map indicated *Coordination* was just as likely to be influenced by other factors as it was to influence factors. Its position in the middle of the graph was unique among the factors, but this does not imply it was significant. It was one of the least central factors in the centrality analysis (along with *Water Technicians* and *Proper Use*), was in only one of the top feedback loops and was not present in any of the loops in the final CLD. This suggests *Coordination* on its own does not have significant potential to lead to larger changes in the *Sustainability of Water Services*.

In meeting notes collected by IRC, participants referenced the need for better information sharing throughout and across the woreda administration, especially with NGOs and community members. While *Coordination* was not identified as an influential factor, participants clearly believe it needs to be improved. Improving *Coordination* may also lead to changes in the structure of the system, particularly around resource management and planning, and help support a stronger system to provide *Sustainable Water Services*.

It is also important to note the factors that were not considered as part of the analysis as their exclusion may indicate a possible missing link within the system. As mentioned, a preliminary list of factors was generated from a qualitative analysis of stakeholder interviews. Twelve of the 14 factors

proposed were incorporated into the final list. The remaining two factors were Pastoralist Way of Life and Power and Electricity. While these factors represent two widely different issues in the delivery of rural water services, they also appear to be critical parts of the larger system. In order to understand the effects these factors would have had on the outcome of the systems mapping activity, they should be included in a future iteration of the factor mapping process.

As with many stakeholder-led activities, the results of this analysis are a result of the unique insights of specific individuals who took part in the exercise. The analysis both greatly benefits from these perspectives and is limited by them, specifically with regard to which factors were included in the analysis by the majority group vote and the exclusion of other factors determined not to be the most consequential. Including these factors in a future factor mapping activity may substantially change the outcomes of the analysis and the recommendations. Because of the context- and stakeholder-specific nature of the activity, it is strongly recommended results be shared with participants in a consultative workshop to validate the findings and supplement them with additional insights from the group.

Recommendations

Recommendation I: Develop systems for better management of existing schemes and planning for new schemes

The systems analysis shows an imbalance between the woreda administration's need to both manage existing schemes and plan for new ones as a result of limited funds, capacity, changing pastoralist ways of life, and population growth. This would be a difficult task even for a very capable local Water Office, but the compounding financial, environmental, and technical issues in Mile and the Afar region in general, speak to the need to address systemic issues that go beyond the management and administration of water services. To address this issue, local officials should evaluate changes that can be made within the woreda administration to better manage existing schemes and plan for new ones.

Recommendation II: Support activities that increase woreda capacity

Developing systems for better management of new and existing schemes will require helping the woreda to carry out its mandate to provide and manage services. This type of support could include both hardware (petrol) and software (data and skills) assistance. While hardware support may appear to be acute, non-systematic fixes to a larger problem, it is important to consider that some of the existing deficiencies in woreda capacity may stem from not addressing near-term physical needs that cannot be addressed through software support alone.

Recommendation III: Create an active coordination platform in the woreda

Although *Coordination* did not appear to be either central or influential in the overall system, it was an issue participants clearly identified as needing to be addressed. While coordination on its own may not lead to a functional systemic change, the existence of a coordination platform can support other factors identified to be influential. This includes increasing data and knowledge sharing by providing the administration with access to more complete and better-quality data from all relevant actors who collect data. This would help balance resources in the management of existing schemes and development of new ones by leveraging other partners in the local WASH system to alleviate data collection needs and provide a platform for discussing factors that affect the planning of new schemes.

Iteration

Within the Mile context there is a need to unpack the elements of *WR+I* to better understand how the different aspects of scoping, planning, and management effect existing and proposed schemes. A logical next step in repeating the factor mapping activity would be to focus on these factors more closely, perhaps within the context of a focal outcome factor of *Planning and Management*. While there are many different types of water schemes in Mile Woreda, it appears the Woreda Water Office's operations drive the overall outcomes (functionality) of these different schemes. Additionally, any repetition requires narrower definitions for each factor and more detailed documentation of how participants described factor influences and interactions.

4. WOLISO, ETHIOPIA

IMPROVED TOWN SANITATION

IRC conducted a factor mapping activity on Nov. 10, 2017 as part of a workshop with key local stakeholders involved in sanitation planning and operations in the town of Woliso. The workshop was part of a series of meetings intended to formalize a learning alliance platform for enhanced coordination and collaboration among stakeholders. The activity engaged 12 participants consisting primarily of technical experts from local town government offices. An IRC staff member facilitated the 2-hour activity in Amharic, the local language.

Factor Mapping Activity

At the beginning of the exercise, the facilitator asked participants to write down responses to the question, "What are the most important factors that influence sanitation services in Woliso?" After five minutes of brainstorming, each participant presented their ideas back to the group and responded to questions and comments from other participants. This activity lasted approximately 45 minutes.

Factors Brainstormed by Participants (# of votes)

Dumping site (13)
Coordination (12)
Finance (11)
Awareness (8)
Turnover (5)
Building & Latrine Standards (4)
Bureaucracy (3)
Infrastructure (2)
Livelihoods (1)
Drainage (0)
Appropriate Technology and Services (0)
Private Service Providers (0)
Choices of and technology (0)

Next, all the factors participants suggested were combined into a single list on a flip chart at the front of the room (Side Box). The group was then asked to vote by a show of hands for the top five factors they thought were most important from the list. The resulting five factors (see Table 13) along with outcome factor *Improved Town Sanitation* were added to a cross-impact matrix as column and row headings (see Figure 33). The matrix was written on a large sheet of paper at the front of the room for all participants to view throughout the activity.

Table 13 Woliso Factors

Factor	Definition
Dumping Site	The construction and safe operation of a waste disposal site
Finances	Budget for sanitation facilities as allocated by the national government and tariffs collected from town water and sanitation services
Coordination	Municipal and community stakeholders working together on sanitation issues
Awareness	Community awareness of town sanitation series and proper use of latrines, and waste disposal
Turnover of Officials	Frequency in the change in personnel within various town and regional administrative positions

Improved Town Sanitation	Community members have access to improved sanitation services that are safe, affordable, and sustainable

The resulting matrix of 30 relationships (see Figure 33) was completed in approximately one hour. While there are a relatively small number of factors[13] the distribution of influence values (1 to 3) for factors where participants agreed a connection did exist were relatively balanced. The group also identified one inverse relationship from *Dumping Site* to *Awareness*. The group explained this connection as a scenario where a *Dumping Site* existed and was properly operated, which could lead to an eventual decrease in *Awareness* of Town Officials and community members because the problem of waste disposal had been addressed.

Figure 33 Woliso Cross-Impact Matrix

[13] In general, the factor mapping process benefits from the consideration of eight or more factors.

Influence Mapping

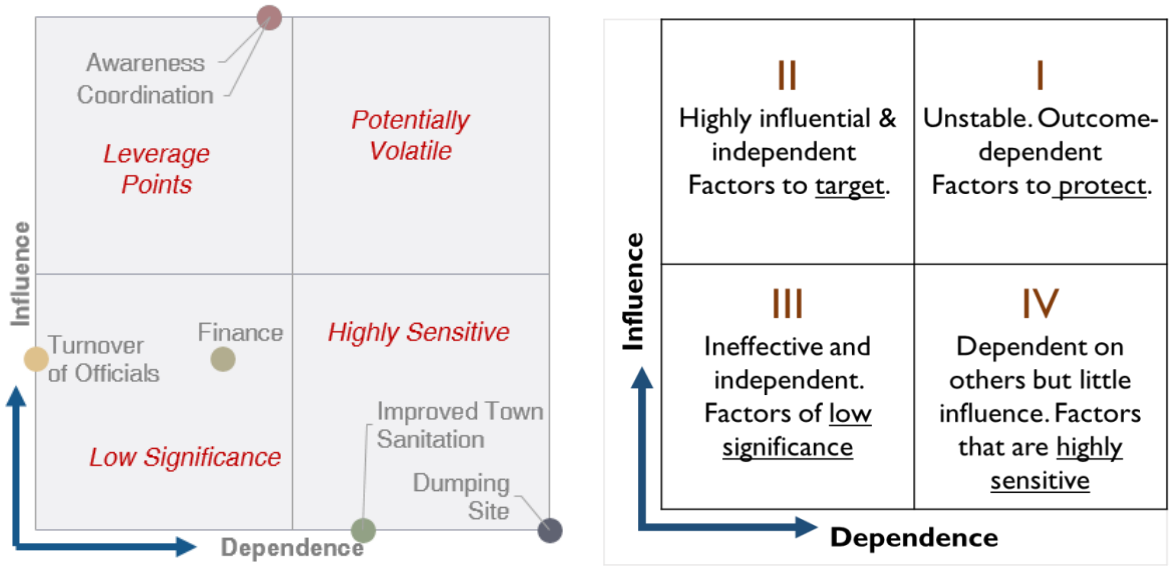


Figure 34 Woliso Influence Map

Insights

- *Coordination* and *Awareness* appear to be the most influential factors in the system by far (and the only factors above the midpoint of Influence). This implies they have the greatest potential to affect the rest of the system.
- The *Dumping Site* is highly sensitive (dependent) to all other factors, indicating it is most likely to be affected by changes in other factors.
- The factors *Turnover of Officials* and *Finance* have relatively little influence overall but appear to be more influential than the *Dumping Site*.
- The outcome factor *Improved Town Sanitation* is in the lower right-hand quadrant, indicating it is sensitive to all other factors.

While it is somewhat unusual for none of the factors to be placed in Quadrant I, this is due to the relatively low number of six factors.

Centrality Analysis

Table 14 Woliso Centrality Metrics

Rank	**Weighted Degree-in** (influenced)	**Weighted Degree-out** (influencing)	**Betweenness** (central, bridging)
1	Dumping Site (15)	Awareness (11)	Awareness (0.92)
2	Improved Town San (11)	Coordination (11)	Finances (0.92)
3	Coordination (9)	Finances (9)	Coordination (0.92)
4	Awareness (9)	Staff Turnover (9)	Dumping Site (0.25)
5	Finances (8)	Dumping Site (8)	Improved Town San (0)
6	Staff Turnover (8)	Improved Town San (8)	Staff Turnover (0)

Insights

- The centrality analysis both validated and added depth to the influence mapping analysis, by showing the *Dumping Site* was the most likely to be influenced (degree-in) whereas *Coordination* and *Awareness* were the most likely to influence (degree-out).
- *Finance*s emerged with a betweenness score equal to *Coordination* and *Awareness* indicating it is just as likely to spur quick changes in the rest of the system. This suggests it may have greater influence on the overall system than the influence map suggests.
- Zero scores for *Improved Town Sanitation* and Staff *Turnover* confirm they are less likely to be affected by changes in other factors, or if they are affected there may be a significant lag time before there is an observable change (improvement or deterioration) in those factors.

Causal Loop Analysis

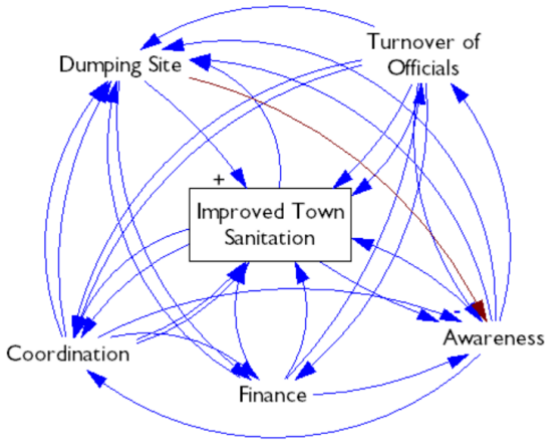


Figure 35 Woliso Full Causal Loop Diagram

Analysis of the CLD (see Figure 35) revealed 34 unique loops containing the outcome factor *Improved Town Sanitation*. Of these 34 loops, the top three reinforcing loops and top three balancing loops were evaluated to gain better insight into the series of cause and effect relationships that may dominate the system (see Table 15). These loops were then re-represented in a prioritized CLD (see Figure 36). Factors not present in any of the top reinforcing or balancing loops are shown in grey in this diagram, indicating while they are still part of the system, they are not part of key causal chains identified in the causal loop analysis.

Table 15 Woliso Top-Ranked Reinforcing and Balancing Loops

ID	Rank	Reinforcing Loops
R1	1	*Improved Town Sanitation → Dumping Site → Improved Town Sanitation*
R2	2	*Improved Town Sanitation → Dumping Site → Finance → Improved Town Sanitation*
R3	3	*Improved Town Sanitation → Coordination → Awareness → Dumping Site → Finance → Improved Town Sanitation*
		Balancing Loops
B1	23	*Improved Town Sanitation → Dumping Site (-) → Awareness → Improved Town Sanitation*
B2	24	*Improved Town Sanitation → Dumping Site (-) → Awareness → Turnover of Officials → Coordination → Finance → Improved Town Sanitation*
B3	27	*Improved Town Sanitation → Coordination → Dumping Site (-) → Awareness → Improved Town Sanitation*

A key to understanding feedback loops is to read each sequence as a sentence. For example, feedback loop R2 implies "as the operation of the *Dumping Site* improves it will generate more *Finances* for operations, leading to more improvement in overall *Town Sanitation*, which in turn would lead to an improvement in the *Dumping Site*."

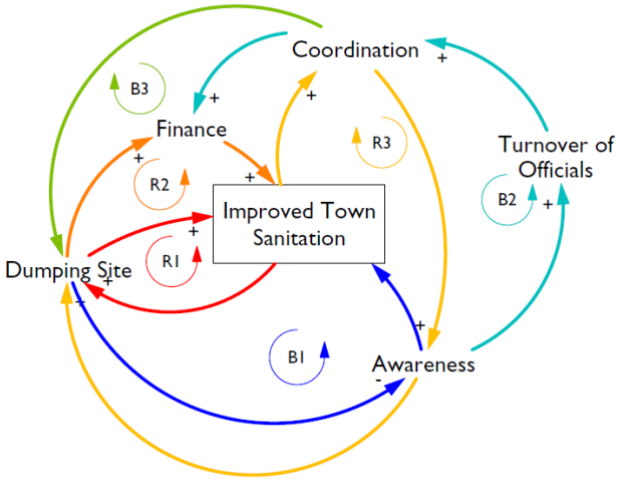


Figure 36 Woliso Prioritized Causal Loop Diagram

Insights

- Analysis of the feedback loops indicate the top-three dominant loops all include the factors *Dumping Sites* and *Finance*. The directionality of these loops implies the *Dumping Site* can positively influence the amount of *Finances* generated, which will in turn positively influence overall *Improved Town Sanitation*.
- The third reinforcing loop includes the addition of both *Coordination* and *Awareness*, key factors identified in both the influence map and centrality analysis. This indicates an improvement in *Coordination* could lead to an improvement in *Awareness*, which could in turn improve the *Dumping Site*, presumably through the actions of local government officials and the community who serve as its customers.
- A review of the balancing loops also indicates that over time it is possible operational aspects of the *Dumping Site*, combined with (1) a decrease in *Awareness* and (2) an increase in the *Turnover* of Town Officials, could limit *Finances* and limit *Improved Town Sanitation*.

The potential dynamic scenarios described above can be generally illustrated as a relationship of overall *Improved Town Sanitation* over time as shown in Figure 37.

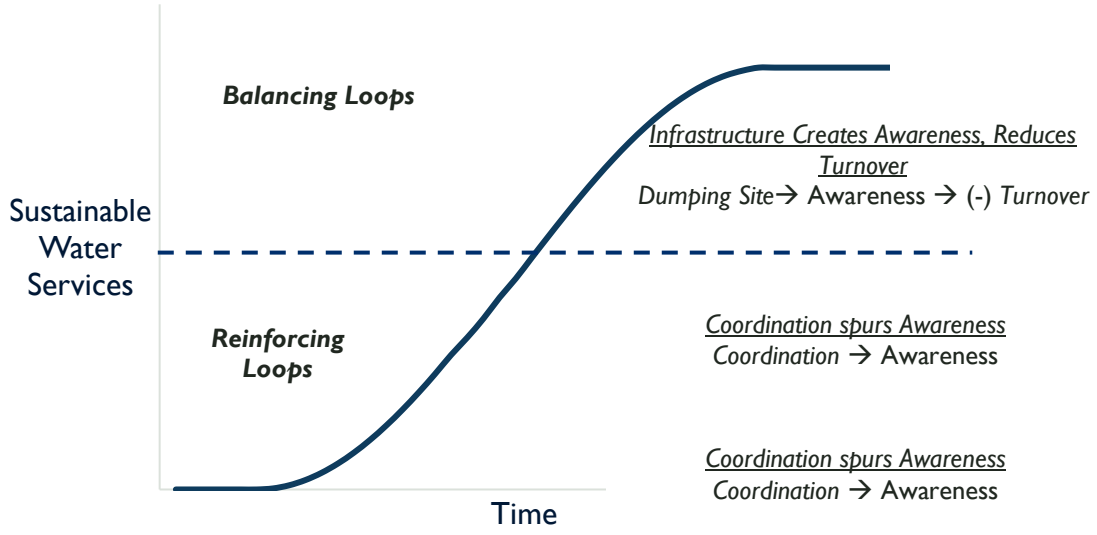


Figure 37 Woliso Potential Dynamic Behavior

Participant Feedback

As part of the factor mapping activity, UCB administered a post-activity questionnaire to evaluate how useful the workshop was to participants and solicit feedback on how it could be improved. The questionnaires asked participants to rate the value of the activity and what actions, if any, they or their organizations may take as a result of learning more about the interconnections of factors within their local system.

"I have learned that one factor has direct and indirect effect on other factors"

"It helped me understand how much one factor influences the other factors"

- Woliso Participants

The questionnaires were translated and summarized by IRC staff after the workshop and analyzed by the UCB team. Overall, participants shared positive feedback about the workshop, giving the factor mapping activity an average rating of 4.3 on a scale of 1 to 5. In the comments section of the questionnaire, many participants reflected on how the activity highlighted the direct and indirect relationships between factors that influence *Improved Town Sanitation* (Side Box). Considering the relatively short duration of the session, this shows the potential of the factor mapping activity to quickly build participants' understanding of the complex nature of local issues and encourage them to develop a systems thinking mindset.

Findings

Finding I: *Improved Town Sanitation* practically requires a Dumping Site

The Influence map showed the *Dumping Site* was the least influential and most dependent factor in the system. While this implies it is very sensitive to other factors, the causal loop analysis showed it as an essential element of all the top-ranked reinforcing and balancing loops. This indicates it is a prerequisite to any change within the system, through its effect on *Awareness* and *Finance*s. In other words, no improvement in *Town Sanitation* can occur without a properly constructed and operated *Dumping Site*.

Finding II: *Coordination* and *Awareness* are the key leverage points

These factors were most directly influential on all the factors (influence map), indirectly more influential, specifically on the *Dumping Site* (Factor Map), most central within the system (centrality analysis), and completed one of the strongest causal loops driving an initial change in *Improved Town Sanitation* (causal loop analysis). Enhanced *Coordination* could also help address the issue of *Turnover of Officials* (see Finding IV) by creating a mechanism within the town administrative structure to sustain important relationships across agencies that endure changes in staff.

Finding III: *Finance* is central to the system overall, but unlikely to be a driving factor

While *Finance* was not identified as an influential factor in the influence mapping, the centrality analysis showed it is an equally important link between other factors such as *Coordination* and *Awareness*. It was also in half of the top balancing and reinforcing loops, indicating it is a critical part of the dynamics of the system, but perhaps not the driving or limiting factor. When considering the role of *Finance* in the system, it is important to recognize participants included both tariffs and financial flows from government under the same definition. Any action to address *Finance* will therefore need to parse out these two sources and investigate how they play different roles in the overall system.

Finding IV: *Turnover* of local officials will continue to limit progress on improving town sanitation

The continuing trend of *Turnover of Officials* was of particular concern to many participants who explained it was one of the main reasons why the *Dumping Site* had not been completed. According to the group, former town officials had reached agreement with local farmers and relevant woreda offices for the location of the *Dumping Site*, but there was a lack of follow-up after these officials left their positions. This limiting nature was reflected in the second balancing loop of the CLD where it served as a key piece of a long causal chain which could possibly limit overall *Improved Town Sanitation*. *Turnover of Officials* was rated as the most independent factor in the influence map and the least central factor in the centrality analysis. This points to there currently being no mechanisms in place to address the issue, despite its effect on progress of the *Dumping Site*.

It is also important to look at which factors were not considered as part of the analysis as their exclusion may indicate a possible missing link within the system. An important discussion theme was the impact of existing local infrastructure, including household and communal latrines, drainage, and Kebele planning. Participants explained improvements in town services for waste collection and disposal were limited by how well existing infrastructure was maintained and the areas disposal trucks could access. At

the end of the session, several participants remarked that even though the majority of the group agreed infrastructure and planning had significant impacts on overall *Town Sanitation*, it was not voted as one of the top factors for the activity and so it was not considered in the mapping discussion.

Recommendations

Recommendation I: Improve coordination and awareness among key stakeholders

Results of the systems analysis strongly suggest primary actions need to focus on simultaneously coordinating key local stakeholders and building awareness among government officials and community members. Such efforts have the potential to positively influence financing (via tariff collection for services), which could lead to a higher probability of establishing and operating a dumping site and improve the overall level of sustainable sanitation services.

Many participants expressed strong support for establishing a coordination mechanism among those involved in sanitation-related issues in the town indicating significant backing for such a mechanism is already present. A lack of coordination appeared to be issue specific, therefore the key to making coordination effective is determining which actors need to be engaged and how. Examples of different stakeholder-issue groups include farmers in proximity to the proposed dumping site, or Kebele leaders in areas requiring better infrastructure planning to make pit emptying more feasible.

Addressing awareness by the community and government officials will no doubt be a more complicated task as it does not refer to broad awareness but rather increasing the understanding of sanitation issues among a targeted group of individuals. In order for awareness to have an effect on the system, promotion activities will need to: (1) encourage local government officials to prioritize sanitation in administrative decisions, and (2) inform community members of the availability and value of town sanitation services to encourage them to pay for these services. Thus, activities for improving stakeholder coordination and building awareness require a keen focus on the demographics and issues to be addressed.

Recommendation II: Prioritize the development of a functioning dumping site

In order for the community to be aware of and utilize town sanitation services, there needs to be an operational dumping site in Woliso. Throughout the session, participants highlighted that while the town had acquired a well-functioning vacuum truck, there was no place to dump the collected waste. In follow-up interviews with local technical staff, it was clear the dumping site was a multi-faceted issue including: its location in a master plan, enforcement of regulations for improper dumping by environmental authorities, cross subsidizing fees from water tariffs, and the condition of a road to the proposed site.

Many of these items appear to be administrative or political in nature, suggesting they could possibly be addressed by a coordination mechanism and awareness campaign among relevant officials. These efforts will undoubtedly require capital funds, planning, design, and construction among other elements. To investigate these elements further, a separate factor mapping session could be conducted on this aspect of town sanitation alone. On a positive note, officials from the town utility office indicated there is a significant amount of demand from residents for pit emptying services. Further, the utility is fairly

confident that if a functional dumping site exists, it can deliver an affordable and effective emptying and disposal service to the residents of Woliso.

Iteration

Within the Woliso context, there is a need to better understand all the factors that would lead to the successful establishment and operation of a *Dumping Site*. The overall factor mapping activity focused broadly on *Improved Town Sanitation*, of which the *Dumping Site* could be considered a sub-system. The same is true for *Community Awareness* and *Infrastructure*. It is interesting that although local infrastructure (drainage, public and community toilets, etc.) was discussed as an important issue, it was not included as a top factor in the activity. In a future iteration of the factor mapping workshop, these factors merit a closer look to better understand their role in influencing the larger sanitation system.

To learn more about the Sustainable WASH Systems Learning Partnership, visit:
www.globalwaters.org/SWS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