Research Report

Sustainable WASH Systems Learning Partnership

NETWORK ANALYSIS OF ACTORS AFFECTING RURAL WATER SERVICE DELIVERY IN KAMULI DISTRICT, UGANDA

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Whave Solutions
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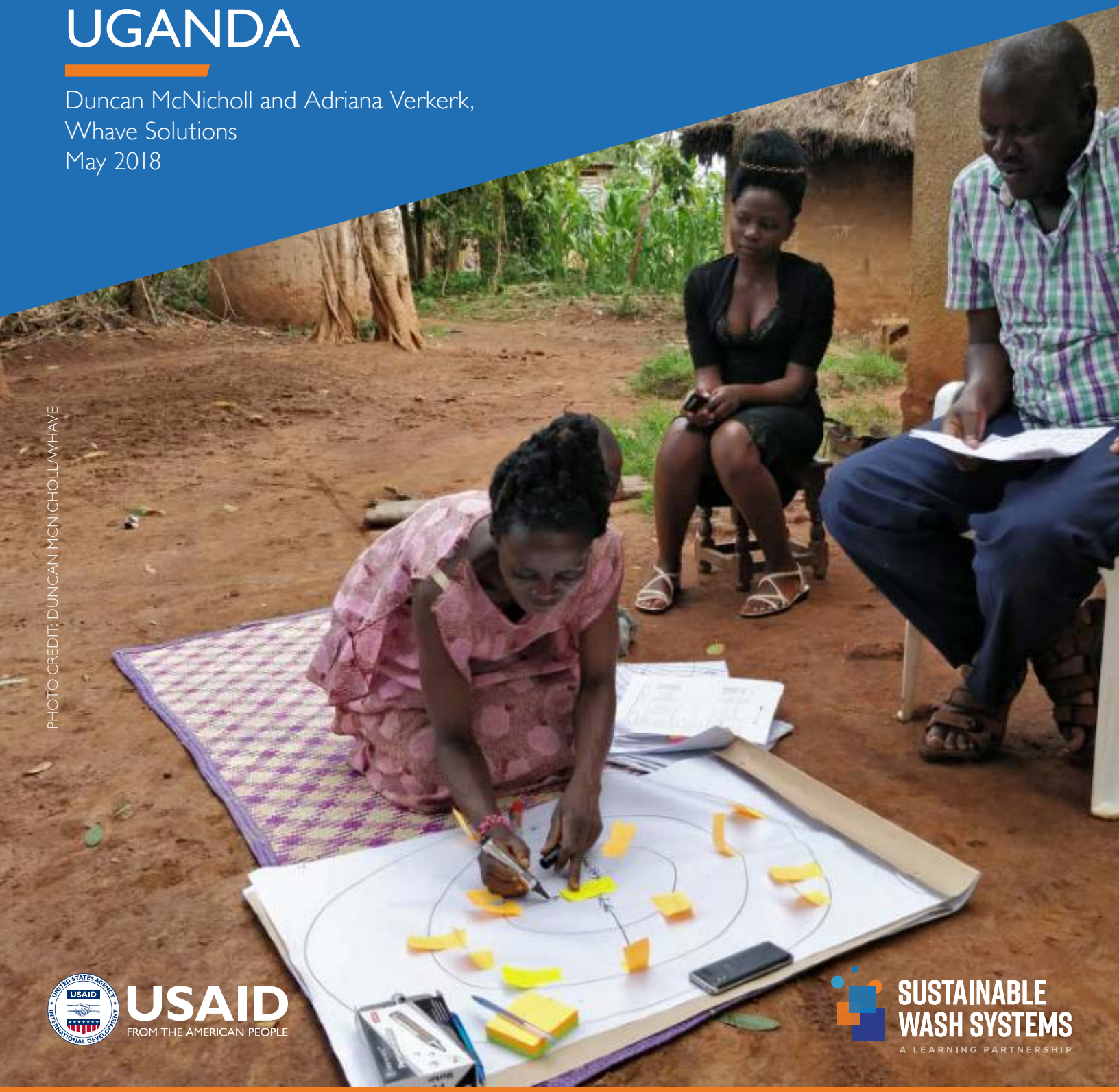

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Front cover: Nairuba Margrete partakes in a network mapping exercise in Ndalike Parish, Namwendwa Sub-county, Uganda. Photo Credit: Duncan McNicholl, Whave

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

AEO	Assistant Environmental Officer
CDO	Community Development Officer
DHI	District Health Inspector
DMF	Development Micro Finance
HA	Health Assistant
HPM	Hand Pump Mechanic
LC	Local Councilor
ONA	Organizational Network Analysis
SWS	Sustainable WASH Systems
UCB	University of Colorado Boulder
WSC	Water and Sanitation Committee

Executive Summary

Whave Solutions Ltd. conducted a study of actors involved in rural water service delivery in Kamuli District, Uganda in April 2018 as part of the Sustainable WASH Systems Learning Partnership (SWS). The study applied Organizational Network Analysis (ONA) to better understand the relationships between actors in the rural water supply network, and the factors they perceive as affecting rural water service sustainability. This nuanced understanding of actor interactions can be used to strategically influence how the network evolves to better support the establishment of a viable preventive maintenance model. The ONA is expected to help Whave improve actors' understanding of the water, sanitation, and hygiene (WASH) system in Kamuli District, support the development of strategic interventions, and potentially monitor changes to the network over time. The study aims to capture which issues actors perceive as affecting the sustainability of WASH services in the district, which might further identify opportunities for collaborative interventions.

At the outset of the study, Whave identified relevant actors involved in establishing a public-private partnership for preventive maintenance in Kamuli District and listed them on a roster. The study included a total of 51 actors representing different stakeholder groups at different levels of hierarchy in the rural water supply network.

The study had four main objectives:

1. To identify coordination gaps;
2. To identify gaps in technical support;
3. To identify challenges, positive factors, and how they relate to specific actors; and
4. To contribute to an understanding of how to study, analyze, and strategically act to influence water service delivery systems.

These objectives are intended to inform the co-development of strategic initiatives between Whave and Kamuli District local government to strengthen the preventive maintenance model that Whave is piloting in the district. Analyzing and then seeking to influence network interactions is expected to improve actors' understanding of systems affecting WASH services and to improve the quality of strategic interventions. Analysis of the same network can then be repeated at a later stage of SWS to understand how the network changes over time.

The analysis consists of both quantitative network parameters and qualitative description of factors identified by network participants as affecting service delivery sustainability.

Central actors: Analysis of the network found that Whave is most central actor to the network at yearly, quarterly, and monthly frequencies of interaction. This indicates that Whave currently plays a key role in, for example, passing information across different parts of the network. Whave and other network actors such as government can use this analysis to consider whether Whave can and should continue occupying its current role in the network or if a different network structure might better achieve desired service delivery outcomes.

Network gaps: Analysis of network gaps found that all but one actor have ties to others on at least a monthly frequency of interaction. This finding indicates that most actors have a consistent

connection to the broader rural water network in Kamuli District. Being connected to other network actors can provide opportunities for accessing information, technical support, or other resources necessary to sustain and improve service levels, depending on the type of tie between the two actors. Conversely, absent or infrequent ties between actors is a potential indicator that services might not improve if actors cannot access or provide support when necessary. The fact that most actors are consistently connected to the broader network suggests there is potential for network actors to collaboratively improve service delivery in Kamuli District.

Actors engaging communities: The networks around each community – as represented by a Water and Sanitation Committee (WSC) member or the Local Councilor (LC) – were analyzed to identify which actors at district and sub-county levels have the most interactions with communities in the sub-counties studied. The analysis was conducted for its potential to inform which specific actors can best help reinforce messages that support the uptake of the preventive maintenance model. Whereas betweenness centrality considers which actors serve as a bridge between different parts of a network, and an analysis of network gaps considers where ties are absent, this analysis simply identifies which specific actors directly interact with the greatest number of communities. The analysis finds that some actors interact with communities more than others, although the exact actors involved differ depending on the sub-county.

Perceived successes, challenges, and potential solutions: Actors interviewed commonly referenced preventive maintenance as a success that has improved the sustainability of rural water services in Kamuli District. Most actors also cited willingness to pay as a key challenge. Community mobilization and sensitization were frequently mentioned as a potential solution to address willingness to pay issues and improve rural water service delivery in Kamuli District.

In summary, the set of actors studied in Kamuli District shows a strong network of interactions with Whave playing a central role in connecting different parts of the network. The analysis presented in this report will be shared back with actors as a basis for codeveloping strategies to influence how the network evolves in coming years and months. This initial study can then serve as a baseline to evaluate how the network changes over time.

Whave will present these findings to local government and other network actors at a meeting scheduled for November 2018, at which time participants will have the opportunity to discuss findings and propose interventions for how network interactions might be strengthened or altered to further the preventive maintenance model that Whave is piloting. A similar network study is tentatively planned for 2020 or 2021 to assess network changes that may result from interventions by network actors between now and then.

Introduction

The Sustainable WASH Systems Learning Partnership (SWS) aims to identify locally-driven solutions to the challenge of sustaining water, sanitation, and hygiene (WASH) service delivery. SWS partner Whave Solutions Ltd., a Ugandan non-profit social enterprise, is developing a system for preventive maintenance of rural water sources through a public-private partnership with the Government of Uganda. For a small annual fee, communities sign service contracts with Whave. Whave then manages the supply of spare parts, monitoring, and performance payments of contracted technicians to ensure that water sources do not break or are repaired immediately if they do. Whave is currently piloting this model in five districts in Uganda, three of which are part of SWS, with the aim of establishing a financially viable maintenance model.

In addition to directly managing preventive maintenance services, Whave partners with local government to develop the regulatory and enabling environment necessary to make preventive maintenance viable. Other actors, such as local government, ideally will fill this dual role as both a change facilitator and service provider in the future. Understanding the current state of the rural water actor network in Kamuli District is useful for considering the roles Whave currently plays and those other actors in preventive maintenance play, and how these might shift to a new network structure over time.

The study presented in this report focuses on Kamuli District where Whave has been active since 2013. Whave is currently active in 14 sub-counties in Kamuli District and servicing approximately 150 hand pumps. Effectively collaborating with other actors that include the government, private sector, and communities, requires a nuanced understanding of actor interactions to strategically influence how the network can evolve to better support the establishment of a viable preventive maintenance model.

Organizational Network Analysis (ONA) was identified as a potentially valuable method for mapping and analyzing actor networks in WASH to identify strategic leverage points and monitor network changes over time. In this study, a set of knowledgeable individuals, each representing a specific network actor, were independently interviewed and asked about their relationships with other actors in the defined network. Using a software model that allows for rigorous analysis, the compiled interview data painted a picture of how actors in a WASH system interrelate. SWS is experimenting with ONA to assess its practicality, cost-effectiveness, and potential value for understanding complex systems as compared to more traditional methods such as stakeholder workshops. Other SWS partners have successfully applied ONA methods in multiple countries including Ethiopia, Cambodia, and other districts in Uganda. Applying ONA to the network of actors involved in rural water supply in Kamuli District is expected to help Whave improve actors' understanding of the WASH system, support the development of strategic interventions, and potentially monitor changes to the network over time. The study aims to capture which issues actors perceive as affecting the sustainability of WASH services in the district, which might further identify opportunities for collaborative interventions.

Aims, Objectives, and Scope

The aim of the study was to understand the rural water actor network in Kamuli District to inform Whave's strategies for collaboratively strengthening the network to improve the preventive maintenance system under development. The objectives of the study were to:

- To identify coordination gaps;
- To identify gaps in technical support;
- To identify challenges, positive factors, and how they relate to specific actors; and
- To contribute to an understanding of how to study, analyze, and strategically act to influence water service delivery systems.

Network boundaries were defined by the expert opinion of Whave staff, who have been actively collaborating with actors for the past three years through the public-private partnership. Under ONA, network actors are typically groups of stakeholders rather than individuals. Exceptions are when an individual, such as a district health inspector (DHI), is both a single person and a representative of an office with a specific institutional role. Network actors in the study included government offices, non-governmental organizations (NGOs), private sector companies, service providers that directly manage rural water supply, and communities to represent service users. For a network actor consisting of multiple individuals, such as an organization or a community, a knowledgeable individual was identified to represent that actor. For communities, a member of the WSC would typically represent the perspective of service users in that community. If the individual was unable to answer the relevant interview questions about network relationships, then another knowledgeable individual was sought. Subsequent interviews with other network actors corroborated data on network ties, thereby reducing the significance of data omitted in any one interview.

A roster of actors was defined prior to data collection and presented to all actors interviewed. The study focused on key actors related to rural water supply at the district level, and key actors at sub-county and community levels. An actor had to be either affecting or affected by rural water supply issues to warrant inclusion in the study. A total of 51 actors were identified, and the complete list of actors included in the study is presented in Annex B on page 40. Table 1 provides a summary of the different actor types and levels of hierarchy included.

Table 1. Summary of actors included in the network study by type and level of hierarchy

Hierarchy	Government	NGO	Private Sector	Service Provider	Service User	Total
District	6	2	1	3		12
Kitayunjwa Sub-county	7			1		8
Namwendwa Sub-county	8			1		9
Namisambya Parish					13	13

Hierarchy	Government	NGO	Private Sector	Service Provider	Service User	Total
Ndalike Parish					9	9
Total	21	2	1	5	22	

Actors came from all three levels of hierarchy in Kamuli: district, sub-county, and parish. A typical parish consists of approximately 12 communities or "zones" that this study defines as service users. Because interviewing all communities in Kamuli District would be impractical for the scope of this study, two parishes in different sub-counties were selected as a sample: Ndalike Parish in Namisambya Sub-county and Namwendwa Parish in Kitayunjwa Sub-county. A representative of each community was included as a network actor, along with other actors in the parish or respective sub-county that were deemed relevant to rural water service delivery. Therefore, the whole set of network actors in this study included all communities from two parishes, actors from their respective sub-counties, and district-level actors.

Fieldwork Summary

Data were collected through facilitated network drawing interviews conducted with each actor individually as described in the research protocol (see Annex A on page 30). Participants drew network maps on flip chart paper to illustrate whom they have interacted with and how over the past year. Participants were given a pre-defined roster of actors to select from that included all other actors interviewed. Actor interactions were defined according to four tie types: information, skills, resources, and authority. The information interaction indicates where actors might learn about new services or regulations. The skills interaction indicates where technical support is given or received. The resources interaction reflects an estimated annual value of resource flows (resources were not divided into sub types such as financial, human resources, materials). The authority interaction represents the ability to influence the interests of others indirectly and enforce consequences for non-compliance.

The four tie types represent relevant linkages within the actors participating in the Whave preventive maintenance model. The direction, strength (also referred to as weight), and frequency (yearly, quarterly, monthly, or weekly) of each tie were also defined. These frequencies are relevant because Whave monitors each source it maintains quarterly and technicians are paid for maintenance monthly. It is therefore important to understand other interactions occurring at this frequency, as well as those more and less frequent. The visual network exercise was followed by a recorded interview in which participants qualitatively describe factors (successes, challenges, and possible solutions) affecting the sustainability of rural water services in Kamuli District.

Initial training of Whave staff was conducted on April 6, 2018, and most interviews were conducted by three field teams of two people each from April 9–11, 2018. Some additional interviews were completed April 12–19, 2018 as participant availability allowed.

Figure 1. Senior WASH Officer John Zironda interviews Kamuli District Speaker Dorothy Mbalule

Figure 2. Senior WASH Officer Ibrahim Mbadhi facilitates an interview in Kitayunjwa Sub-county

Interviewees responded positively to being interviewed by demonstrating a willingness to participate and providing seemingly candid perspectives on how the rural water actor network functions in Kamuli District. Forty-six of the 51 actors included in the study were available for interview, representing a response rate of 90.2 percent.

Analysis and Findings

Analysis of data includes both quantitative and qualitative components. Data from drawn networks captured during interviews were compiled into a list of actors, or network nodes, and a list of network ties. Conflicting data occurred when two actors would describe the same relationship differently; these conflicts were resolved by taking the average of the tie strength. This method for resolving conflicts implies that the absence of a relationship between two actors indicates that neither actor perceives there to be a relationship. The final lists of nodes and ties were then imported to the open-source network software Gephi for analysis and visualization.

Qualitative responses to interview questions were processed through manual coding. Interview recordings were reviewed in order to identify and group key emergent themes related to successes, challenges, and potential solutions identified by actors. The coding process is intended to provide a preliminary analysis that can be presented back to participants in advance of more detailed transcription and qualitative coding conducted by the University of Colorado Boulder (UCB).

Results presented in this section are based on both quantitative network analysis and qualitative analysis of key issues identified. Four types of quantitative network analysis are presented:

- An overview of general network properties;
- Centrality analysis to identify which actors are most central to the network;
- Analysis of connected components to identify network gaps; and
- Analysis of community ego networks to identify which actors communities most consistently interact with.

The section concludes with a discussion of the qualitative issues identified to understand which types of actors identify different types of issues most consistently. These findings will subsequently be presented to actors who participated in the study to discuss their implications and codevelop strategies for future interventions.

Network Properties

Some basic network properties are presented first. These quantitative properties are used to characterize how tightly connected the network is, how many degrees of separation exist between any two actors, and how many ties exist out of the total number possible. Although these quantitative values do not speak to the quality of relationships, they do provide some indication of how readily actors are able to interact with others to access the support needed to coordinate and improve service delivery.

The network studied is relatively tightly connected from a quantitative perspective when including all tie types. An analysis of network diameter finds that only three connections between actors are needed to cross from one side of the network to the other at its widest point, and analysis of network density finds that nearly 50 percent of the total possible number of ties in the network are present (see Table 2 on page 14). A more detailed analysis could consider each tie type individually, but this level of analysis is enough for considering whether actors have any type of relationship with others.

Table 2. Summary of basic network properties when considering all tie types

Network Diameter	**The number of ties needed to span from one side of the network to the other at its widest point.**	**3**
Network Density	The proportion of ties that exist out of the total number of ties possible. A network with a density of 1.0 means that every actor is directly connected to every other actor.	**0.498**

Analysis can also consider the prevalence of different tie types. Four tie types were used to define actor relationships during interviews: information, skills, resources, and authority. Of the 1,450 ties identified from actor interviews, information ties are the most common, followed by authority, skills, and then resources (see Table 3). This suggests that information ties, being the most common, are the basis of most network relationships. Actors engaged in authority, skills, or resource relationships are also likely sharing information. A potential implication for the network is that establishing an information tie between two actors might provide an opportunity to develop a relationship that can later be built on with additional tie types.

Table 3. Summary of ties identified in the network

Tie Type	Number of Ties
Information	675
Authority	373
Skills	286
Resources	116
Total	**1,450**

These quantitative findings do not automatically demonstrate a positive or negative finding on the effectiveness of the actor network with respect to rural water sustainability, but they do offer some practical insight into the nature of the network. The network's relatively small diameter and relatively high density suggest it is already relatively well connected. Increasing the network's overall connectivity will not necessarily impact its effectiveness. More focused interventions in specific parts of the network might be better strategic options. Whave will present these findings back to network actors to codevelop strategic interventions for evolving the network. The findings suggest that a broad network objective such as "increasing coordination" is unlikely to have a significant impact on the preventive maintenance model. More targeted interventions in specific parts of the network are likely needed.

Actor Properties

Central Actors

The network was analyzed using "betweenness centrality" to identify which actors are most central. Betweenness centrality quantifies the number of times an actor acts as a bridge along the shortest path between two other actors or nodes in the network.

Network ties are defined by three aspects: type, weight, and frequency of interaction. Betweenness centrality was analyzed against these parameters. Figure 3 on page 16 looks at information ties, which were found to be the most common network tie type.

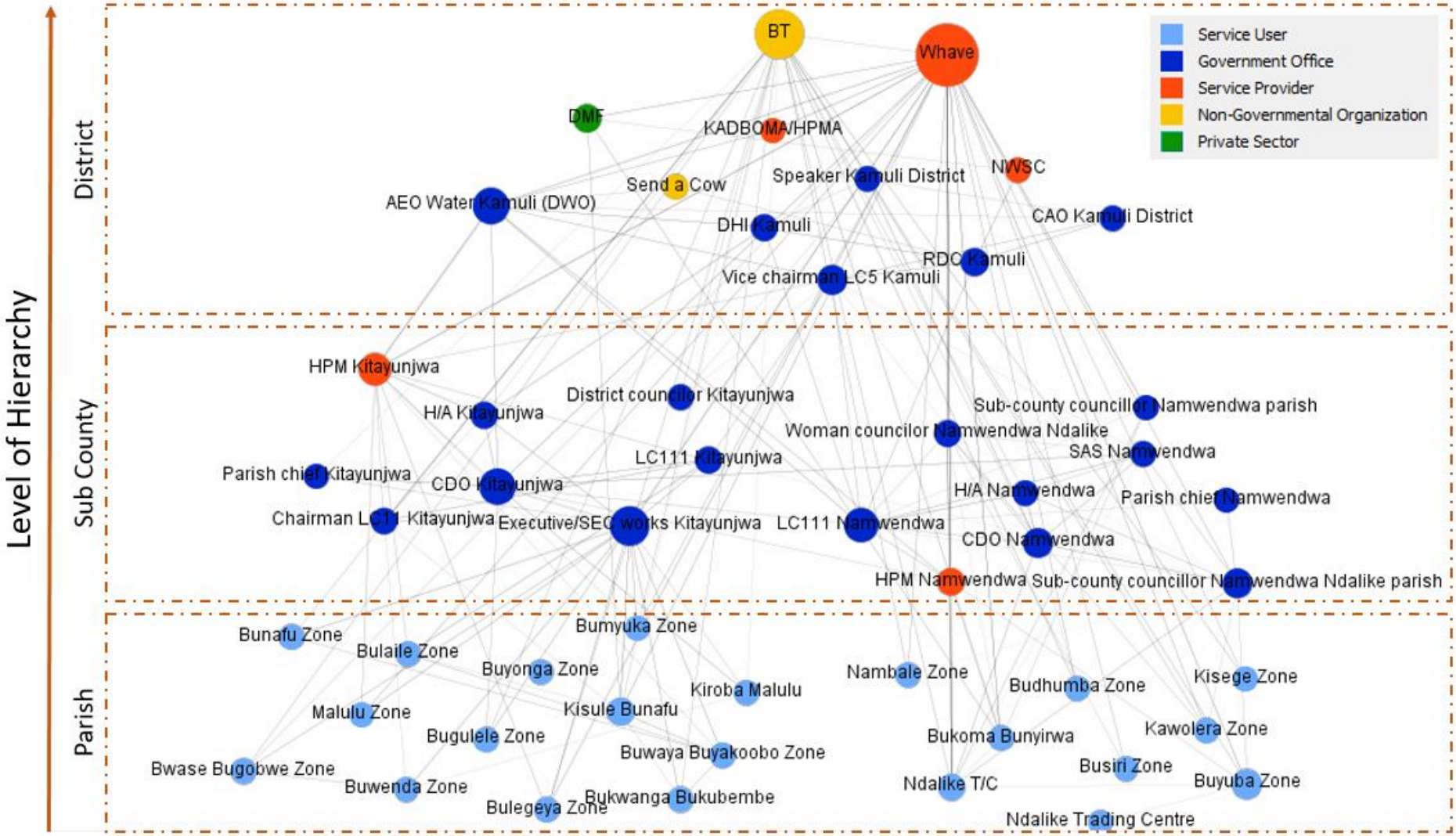

Figure 3. Network of Kamuli rural water actors and all yearly ties arranged by level of hierarchy. Node size is proportional to its betweenness centrality.

Betweenness centrality is analyzed for four different frequencies of interaction: yearly, quarterly, monthly, and weekly. The centrality of each actor can change depending on the frequency of interaction considered. For example, the number of monthly ties in the network is less than the number of yearly ties in the network. Analysis of betweenness centrality for information ties at different frequencies of interaction is presented in Table 4.

Table 4. Ranking of actors most central to the network by frequency of interaction for information sharing

Rank	Yearly	Quarterly	Monthly	Weekly
1	Whave	Whave	Whave	Busoga Trust
2	Busoga Trust	Busoga Trust	Busoga Trust	Executive/Secretary for Works Kitayunjwa
3	Executive/Secretary for Works Kitayunjwa	Executive/Secretary for Works Kitayunjwa	Executive/Secretary for Works Kitayunjwa	Woman Councilor Namwendwa Ndalike
4	Development Micro Finance (DMF)	LC3 Namwendwa	Assistant Environmental Officer (AEO) Water Kamuli	Whave
5	LC3 Namwendwa	LC11 Kitayunjwa	LC3 Namwendwa	LC3 Namwendwa
6	AEO Water Kamuli	CDO Namwendwa	CDO Kitayunjwa	CDO Namwendwa
7	CDO Namwendwa	AEO Water Kamuli	HPM Kitayunjwa	Ndalike Trading Center
8	LC11 Kitayunjwa	CDO Kitayunjwa	Buyuba Zone	Speaker Kamuli District
9	CDO Kitayunjwa	WSC Member Kisule Bunafu	Sub-county Councilor Namwendwa Ndalike Parish	HPM Kitayunjwa
10	DHI Kamuli	HPM Kitayunjwa	CDO Namwendwa	LC3 Kitayunjwa

Ranking tables of betweenness centrality for each tie type and frequency of interaction are presented in Annex C on page 42. Whave is the most central actor for information, resource, and skill tie networks at most frequencies of interaction. An NGO, the Busoga Trust, is the most central actor in the authority tie network at all frequencies of interaction. While a government actor might be expected to be the most central actor in the authority network, authority ties also contain relationships of influence making it possible for other actors, such as NGOs, to occupy central roles in authority networks.

Betweenness centrality analysis of the actor network finds that Whave is the most central actor, followed by the Busoga Trust. Both organizations maintain relationships with actors at all levels of hierarchy in Kamuli District. However, they will have to consider whether sustaining a central network position is the ideal arrangement for long-term service delivery in Kamuli District, or these positions

might be increasingly shifted to other actors, such as government, that might be in a better institutional position to bridge relationships between actors.

Centrality itself is neither good nor bad. This analysis shows the network positions occupied by different actors so that practitioners might intentionally shape the future of network development depending on the desired outcomes and agreed roles of the actors involved.

Connected Components

Identifying gaps in actor relationships can be useful for developing strategic interventions. Understanding where actors lack access to information, skills, resources, or authority may indicate areas were service delivery is not improving. These gaps can then become points for strategic intervention by network actors to deliberately create relationships in key parts of the network.

The first quantitative assessment used to assess network gaps is an analysis of "connected components" to determine whether network pathways exist that connect all actors in the network. For clarity, this text refers to each connected component as an isolated network component. A fully connected network would have only one component, whereas a network with two clusters of connected nodes without a path between them would have two isolated network components. Quantifying the number of isolated network components can indicate how many parts of the network are separated from each other.

The analysis finds only one isolated network component for yearly and quarterly frequencies of interaction for all tie types, meaning that network pathways exist to connect all parts of the network at more than a monthly frequency of interaction (see Figure 4 on page 19). The number of isolated network components only increases when considering a weekly frequency of interaction. Whave manages preventive maintenance on a monthly basis unless there is a breakdown at the source which warrants a more immediate response. The implication of these findings is that most of the network studied shows actors interacting with each other on a monthly basis which is considered sufficient for a functional preventive maintenance model.

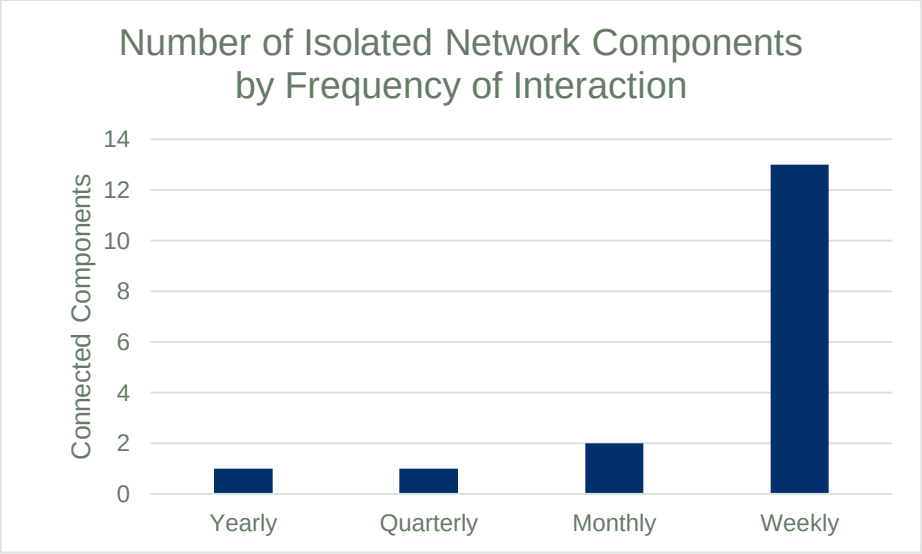

Figure 4. Number of isolated network components for each frequency of interaction for all tie types

Network Gaps

The analysis can be extended by considering how many actors become isolated from the network at different frequencies of interaction. The number of isolated actors differs slightly from the number of isolated network components because a small group of actors connected to each other but not to the larger network is considered an isolated network component. Quantifying the number of isolated actors only considers the number of actors with no ties at all for each frequency of interaction (see Figure 5).

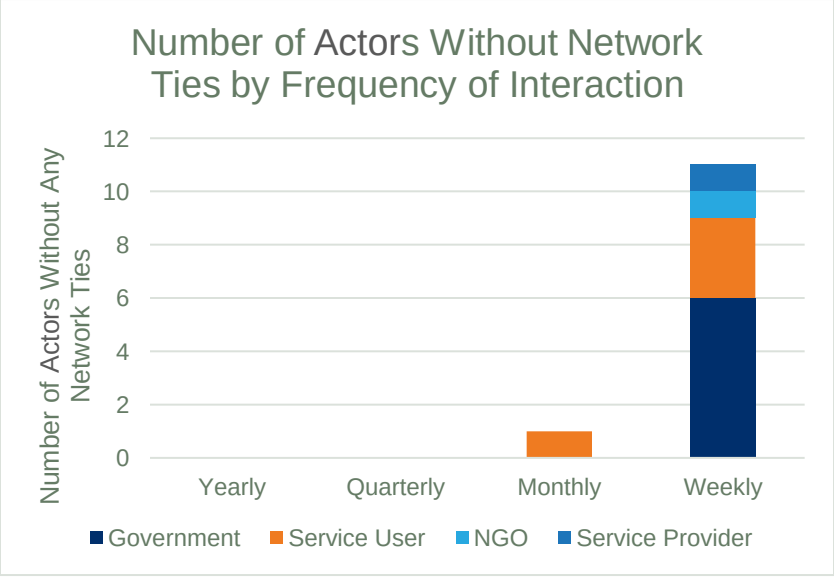

Figure 5. Number of actors without any network ties for each frequency of interaction

Most actors have at least one network tie on a monthly basis, while many do not have ties to any others in the network on a weekly basis. This indicates a lack of connection at a weekly frequency of interaction. Most of the actors without ties at a weekly frequency of interaction are government actors.

Overall, analysis of connected components and the number of isolated actors at different frequencies of interaction finds that few actors are isolated from the broader network. All but one of the 51 actors studied in the Kamuli rural water network have ties to other actors on at least a monthly basis. The lone actor without any ties on a monthly frequency of interaction is a community in Namisambya Parish that does not yet have a preventive maintenance service agreement with Whave. The analysis indicates that all actors consistently have ties to the broader network and therefore may have opportunities to access support for improving rural water service delivery.

Community Networks

Centrality analysis finds that Whave is central to the overall network because of its active relationships with actors at all levels of hierarchy. Sustaining these interactions, however, has cost implications. Whave will need to reduce expenditure in order to achieve a financially viable preventive maintenance model, partly by transferring some of the costs currently borne by Whave to other actors. Network analysis might be useful for identifying opportunities where other actors can actively engage communities instead of Whave. It is necessary to understand whom communities interact with most consistently to identify champions that can reinforce support for preventive maintenance, and potentially assume some of Whave's responsibilities previously undertaken to mobilize communities to subscribe to the service.

Each respondent was asked to identify whom they interact with from a list of all network actors included in the study. The network of immediate interactions – also known as an "ego network" – can be investigated for each community. For example, the ego network for Buyonga Zone shows who is immediately connected to the community and how different actors are connected to each other (see Figure 6 on page 21). Network visuals for each community for all tie types and frequencies of interaction are presented in Annex D on page 45. This process can be repeated for each community interviewed to quantify the total number of times that other actors appear in community ego networks to identify which actors interact with the most communities in each of the respective sub-counties.

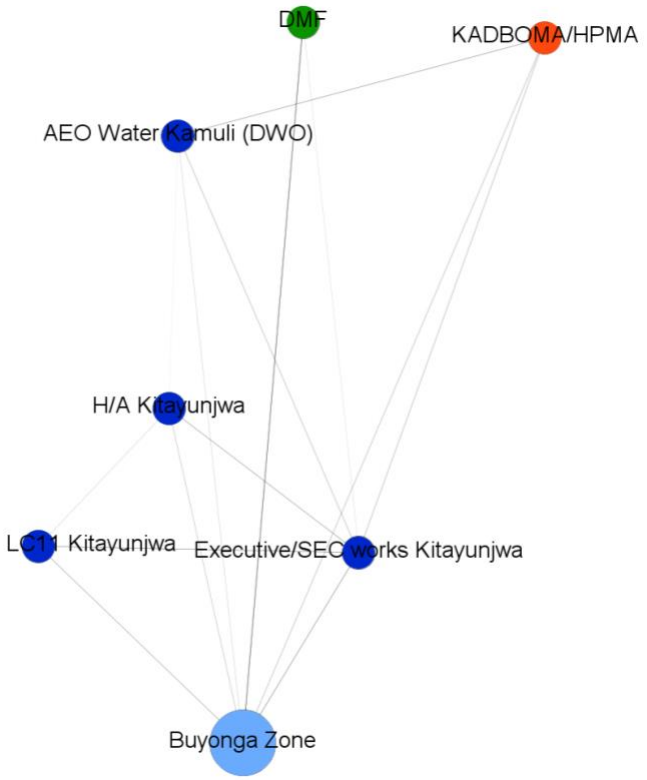

Figure 6. Ego network of Buyonga Zone (enlarged) showing actors that directly interact with this community for all tie types at all frequencies

The analysis considers the monthly frequency of interaction to identify which actors are frequently in touch with communities. This is relevant because Whave manages preventive maintenance and the performance payment of technicians that maintain water sources on a monthly basis. The number of times that each actor appears in community ego networks is presented in Namisambya Parish (see Figure 7 on page 22) and Ndalike Parish (see Figure 8 on page 22). Actors that appeared fewer than three times in the community networks are excluded from the figures.

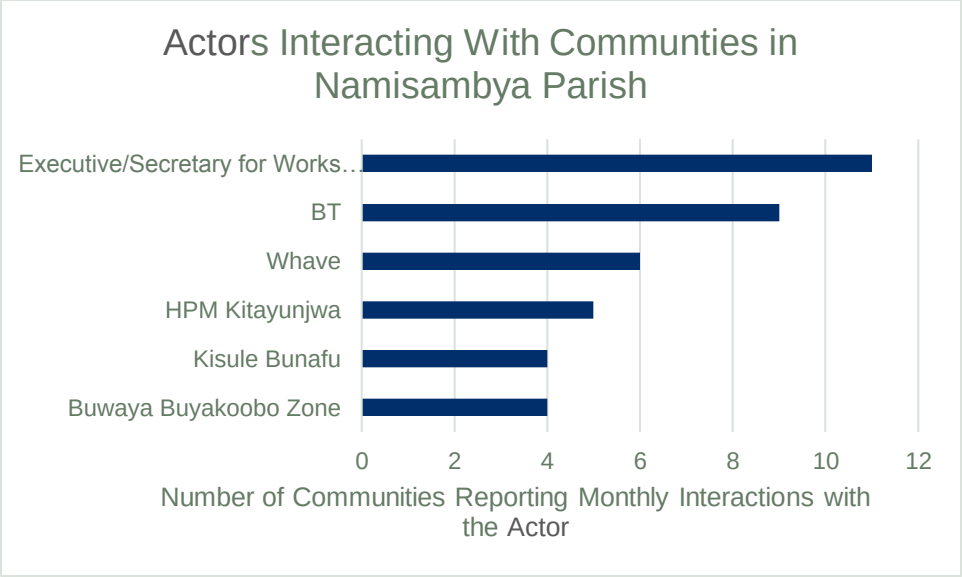

Figure 7. Number of times each actor appears in monthly community ego networks for Namisambya Parish

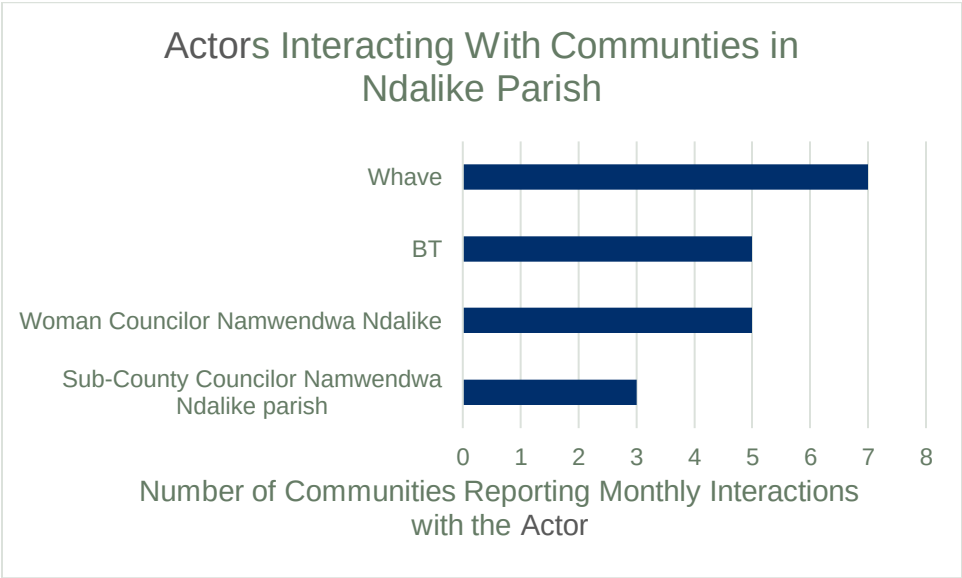

Figure 8. Number of times each actor appears in monthly community ego networks for Ndalike Parish

The analysis finds that a variety of different actors interact with communities in the two parishes on a monthly basis. Whave and the Busoga Trust, the actors most central to the overall network, appear in the analysis, but other government actors also emerge as frequently interacting with these communities.

At the same time, it is difficult to draw general conclusions about which types of actors most actively interact with communities across the two sub-counties. The community development officer (CDO) and health assistant (HA) feature frequently in Ndalike Parish, but less so in Namisambya Parish. This implies

that considering which actors are most important to engage may depend on both context and the individuals involved. For Whave, this means considering the relevant actors to invest in building relationships with for each location to determine who is most suitable to take up a given role depending on context and individual motivation and abilities.

These findings can be used to inform whom to prioritize engaging as potential champions within sub-county government that could potentially advance and reinforce support for preventive maintenance services in Kamuli District. Specifically, Whave can consider engaging actors such as the Woman Councilor Namwendwa Ndalike to explore what further roles she might play to reduce the costs Whave currently bears when managing preventive maintenance.

Factor Analysis

After identifying the actor networks, participants qualitatively described factors affecting the sustainability of rural water services in Kamuli District over the past year. Participants were asked:

1. In your opinion, what do you think is working well in sustaining rural water services in Kamuli?
2. In your opinion, what do you think are the main problems in sustaining rural water services in Kamuli?
3. What ideas or recommendations do you have about solutions to these problems?

This section of the interview was recorded and summarized in bullet points for each actor for successes, challenges, and solutions identified. The bullet points were then analyzed and summarized in short statements that were grouped into thematic areas. Thematic areas that contained less than five statements are not included in the overview. This section serves as a preliminary qualitative analysis, while a more detailed qualitative analysis by UCB is planned.

This section is grouped into successes, challenges, and proposed solutions. A brief description of each observed theme is provided, followed by a quantitative summary presenting how often each theme was identified according to different actor types.

Successes

Water services improved: Most actors described how water services have improved in Kamuli District. Sources are functional all the time, and actors perceive an improvement in water access.

Preventive maintenance strategy in place: Having a preventive maintenance strategy in place was the second biggest thematic area described by actors. Sources are maintained on an ongoing basis and closely monitored by the local technician.

Improved community management: Another key success mentioned by actors was improved community management. Community members are contributing money for maintaining the source, and WSCs are functioning.

Improved hygiene and sanitation: A less common theme identified was improved hygiene and sanitation, both at the source and in homes. Actors experienced a reduction in diseases because of having access to clean water. Although the focus of the study was on rural water supply, the theme was sufficiently common to warrant inclusion in this list.

Improved coordination among actors: Another less common theme mentioned was improved coordination among actors. Actors perceive there to be good coordination among different organizations and a strong partnership between Whave and the government.

A summary of how often each theme was identified is presented in Figure 9. "Water services improved" and "preventive maintenance strategy in place" were the two most common themes. Although the interview question did not specifically reference preventive maintenance, it was frequently cited as a success. However, there may be some bias due to the presence of Whave in each interview that could have made participants more mindful of the preventive maintenance approach. Nevertheless, preventive maintenance is widely recognized and viewed as a successful approach in Kamuli District.

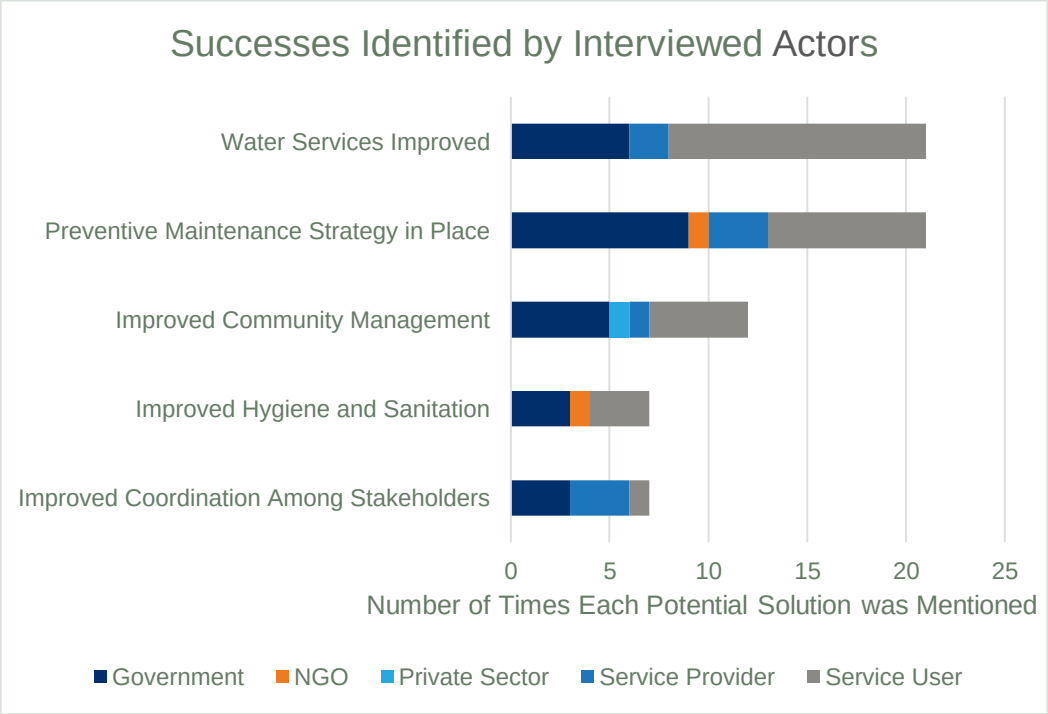

Figure 9. Summary of how often each success theme was identified by actor type

Challenges

Unwillingness to pay: Unwillingness to pay was the top theme mentioned by the actors as a challenge to sustaining water services in Kamuli District. Community members are not willing to contribute money for preventive maintenance of the source.

WSC not accountable: The second most common theme mentioned by actors was that committees are not accountable and sometimes even steal money contributed by the community.

Low levels of hygiene and sanitation: Low levels of hygiene and sanitation was also mentioned as a challenge in sustaining water services. People do not clean the source area, and jerry cans for transporting and storing water are dirty.

Communities are not cooperating: Another challenge mentioned was that communities are not cooperating. Communities do not want to work together with the government or other organizations and have a mindset that the government will pay for their water source.

Hand pump mechanics (HPMs) and spare parts: A small group of actors described challenges with local technicians that are not used to the preventive maintenance approach. Issues with the availability and quality of spare parts were also recognized.

Insufficient or inconsistent access to water: Insufficient or inconsistent access to water was also mentioned by some actors. Some sources break down, and in the dry season, there is the problem of insufficient water.

Misuse of boreholes: Another theme mentioned by some of the actors is misuse of boreholes. Communities often do not take care of the infrastructure (e.g., by controlling water drainage or maintaining rain run-off protection ditches and fencing) and children sometimes misuse the hand pumps.

A summary of how often each challenge theme was identified by actors is presented in Figure 10 on page 26. Despite the frequency that preventive maintenance was recognized as a success, most respondents identified unwillingness to pay as a key challenge. The other issues were relatively less common in comparison.

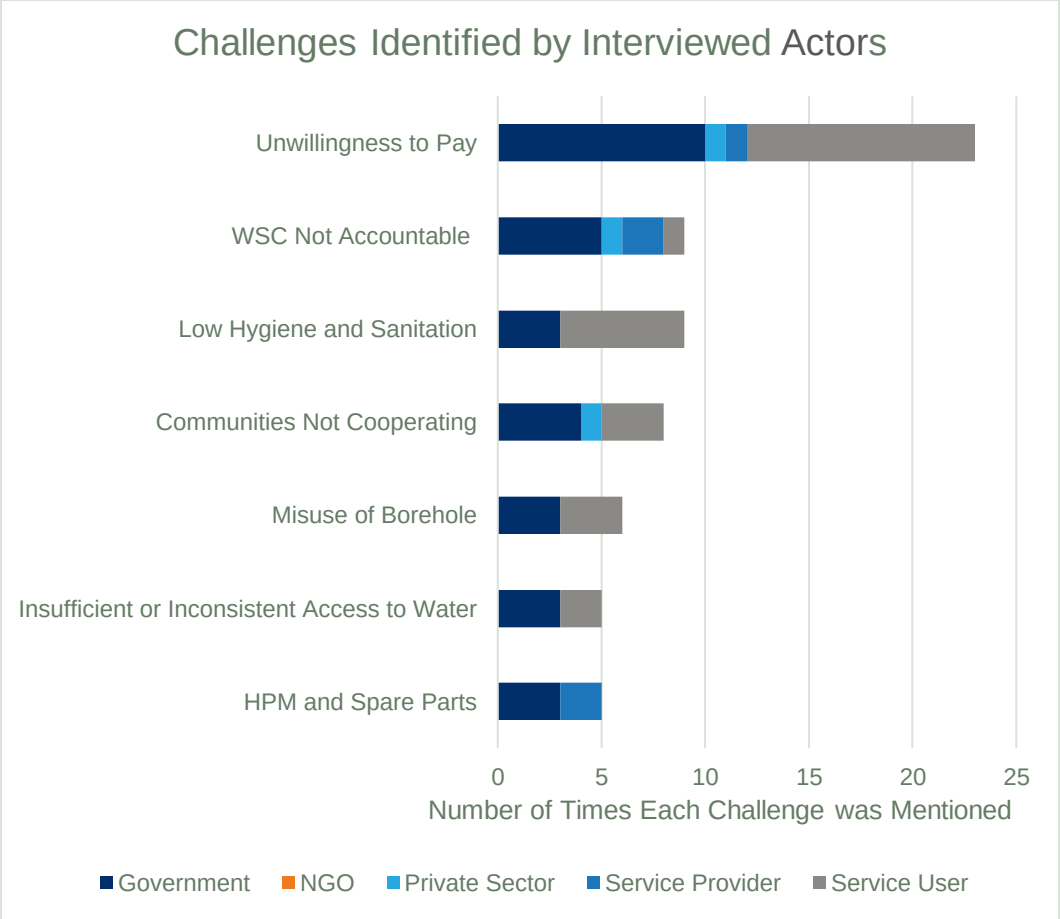

Figure 10. Summary of how often each challenge theme was identified by actor type

Potential Solutions

Mobilization and sensitization of community: The main solution actors mentioned for sustaining water access is mobilization and sensitization of communities. Communities should be well aware of preventive maintenance strategies for water sources so that they take care of the borehole and contribute to the maintenance of the source.

Reduce service fee: Several actors also mentioned reducing service fees, where the government subsidizes the cost of maintenance services. Often only a small group of people are using one source, and therefore need to contribute a lot of money per household to pay the maintenance fee. Actors perceive the water fee as being high compared to their income.

Capacity building of WSCs: One of the less commonly mentioned themes was capacity building of WSCs. WSCs should be trained to understand their roles and responsibilities which include collecting community contributions and maintaining source hygiene.

Improve water access: Some actors mentioned improved water access as a solution to sustaining water services in Kamuli District. Existing boreholes should be fully functional and closely monitored by a local technician to prevent breakdowns.

A summary of how often each potential solution was identified is presented in Figure 11. Mobilization and sensitization of communities was the most commonly proposed solution and was recommended by both government and service users. While other solutions such as reducing water fees were less common, they warrant further exploration as they have the potential to impact service delivery in Kamuli District.

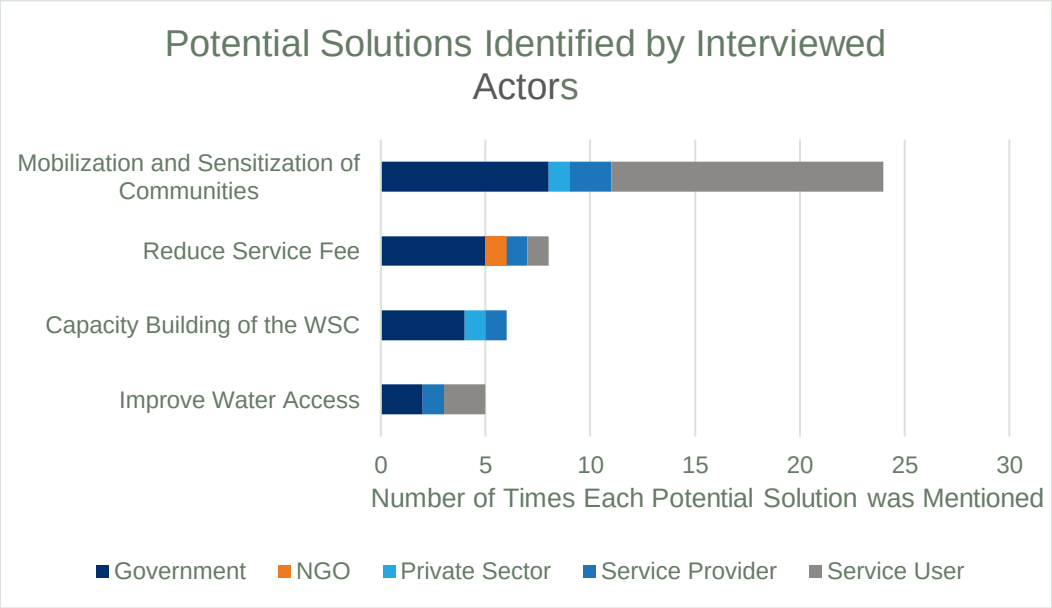

Figure 11. Summary of how often each solution theme was identified by actor type

Conclusions and Next Steps

Network Centrality

Whave was found to be the most central actor in the network for multiple frequencies of interaction. This finding makes sense because of the numerous relationships Whave holds at all levels of hierarchy in Kamuli District. Whave's position in the network is neither inherently good nor bad. The key questions for practitioners working in Kamuli District are whether this is the desired structure of the network and whether these interactions can be sustained indefinitely. Whave currently invests considerable resources in both community engagement and collaboration with government actors. Practitioners need to consider whether this level of engagement should be sustained or roles should be shifted to other actors. With a better understanding of the network structure as a result of this analysis, actors can make informed decisions to intentionally facilitate shifts in the structure if desired.

Connected Components

Analysis of connected components and the number of actors without any ties at different frequencies of interaction found that of the 51 actors included in the study, all but one have information ties to the broader network on at least a monthly frequency of interaction. This indicates that concerted efforts to bridge network gaps might have little discernible effect on the network from a purely quantitative sense. Practitioners might, therefore, focus on the quality of specific relationships and whether these interactions are creating the desired effect on service quality or sustainability rather than simply trying to establish connections where none exist.

Community Networks

Analysis of community ego networks found a variety of actors interact with communities in the two parishes studied, and some actors interact with communities more consistently than others depending on the area being considered. Government actors are identified as consistently interacting with communities, and these relationships might be leveraged to help expand and reinforce uptake of preventive maintenance services by communities. Determining which actors to engage, however, requires reassessment in each area to determine who is most active and able to influence how services are delivered in that area.

Key Factors Affecting Sustainability of Rural Water Services

Several factors were identified by interview participants as affecting rural water service sustainability in Kamuli either positively or negatively. Preventive maintenance appears to be widely viewed as a success. However, despite progress toward service sustainability, willingness to pay remains the most commonly cited challenge. Determining how to reduce costs and increase revenues to achieve a financially viable model remains a key area for inquiry in Kamuli District.

Considerations for the Kamuli Network

1. What role should Whave ultimately play in the network once the preventive maintenance service is fully established at scale? What roles might other actors begin to play more actively?

2. The network is already relatively well connected. How can existing connections be leveraged to ensure that the right information and support is passed on to the relevant parts of the network (i.e., community sensitization) so that preventive maintenance services can be sustained and expanded?
3. Which actors have existing relationships with communities that might become champions for sustaining and expanding preventive maintenance services? How can these actors be incentivized to play increasingly supportive roles?
4. Preventive maintenance is identified as a key success, but willingness to pay remains a key challenge. How might the network collectively address these issues, possibly by implementing some of the proposed solutions? Are the proposed solutions – such as increased community mobilization and sensitization – feasible with the available resources?

Next Steps

Whave is planning to present the findings from this report back to network actors in November 2018 for discussion and to codevelop intervention strategies for strengthening the preventive maintenance approach. The above considerations will be key points for discussion. Actors will have the opportunity to reflect on the current state of the network, possible future ideal states of the network, and possible approaches for deliberately evolving the network. A second ONA study is tentatively scheduled for 2020 or 2021 to understand how the network evolves in the coming years.

Annex A: Research Protocol

Overview

The USAID Sustainable WASH Systems Learning Partnership (SWS) aims to identify locally-driven solutions to the challenge of sustaining water, sanitation, and hygiene (WASH) service delivery. In Uganda, SWS is analyzing actor networks and factors affecting water service sustainability in Kamuli District. Data collected are also expected to contribute to SWS's broader research interests in partnership with the University of Colorado Boulder (UCB). This document presents the aims, objectives, scope, methods, and intended analysis that the study will perform, and further identifies possible implications and opportunities for follow up. This protocol has been developed in partnership with Whave and builds on research methods originally developed at Cambridge University. It is authored by Duncan McNicholl.

Study Aims and Objectives

The overall aim of the research is to inform the strategies of Whave in Uganda, specifically for Kamuli District. The most direct intent is to identify where relationships can be strengthened, which issues should be addressed, and who might be involved. Beyond this, the study further intends to contribute to broader research objectives under SWS that extend beyond Whave's scope.

Objectives

Specific objectives further define the questions that the research intends to answer. These objectives primarily focus on the first research aim of providing Whave with actionable insight, although all findings and data can potentially contribute to the project's broader learning agenda. The primary research objectives for Kamuli District are:

1. To identify coordination gaps;
2. To identify gaps in technical support;
3. To identify challenges, positive factors, and how they relate to specific actors; and
4. To contribute to an understanding of how to study, analyze, and strategically act to influence water service delivery systems.

Research methods and intended analyses are designed to focus on these questions, and additional analysis can be conducted to answer questions that emerge from the research process.

Scope

The research focuses on Whave and other actors that are central to water service delivery in Kamuli District. The list of relevant actors was provided by Whave and developed in collaboration with partners in Kamuli District. Additionally, data will be collected from all communities in two parishes – one from each of two different sub-counties – to provide network data on how actors relate to communities. A predetermined list of actors at district, sub-county, and parish levels, plus communities in the two parishes, define the boundaries of the network in this study. The provisional list of actors

planned for inclusion in interviews is presented in Annex B on page 40 and will be updated in consultation with Whave staff during enumerator training prior to fieldwork.

Other actors might be identified in the course of fieldwork. Their ties with actors interviewed will be captured in network data, but new actors will not be interviewed as part of the planned fieldwork. Newly identified actors can potentially be interviewed later if their inclusion is deemed relevant to the analysis.

Methods

Methods are adapted from recent research conducted by Cambridge University that studied rural water supply actor networks in Ghana, Malawi, India, Tajikistan, Bangladesh, and Bolivia. These methods are designed to capture actor network data that can be analyzed quantitatively, as well as qualitative data that can be used to identify factors influencing service delivery. The qualitative component further helps to identify relevant characteristics to examine in actor network properties.

Actor networks are defined by nodes and ties which have different properties. Node properties describe the type of actor, and definitions are consistent with descriptions provided by Whave. Service users, such as communities, have also been added to this list. It is possible that additional node properties can be added to network data after primary data collection if deemed relevant by Whave.

Table 5. Node properties

Node Property	Description
Type of Actor	Government Office
	Service Provider (such as water utility)
	NGO
	Community-based Organization
	Academic Institution
	Private Sector (including formal companies and micro, small, and medium enterprises)
	Service User
Scope	Rural Water Supply

Ties define the relationships between these nodes. Each tie is weighted and directional. Relationships can also be multiplex, meaning that multiple ties can exist in parallel. Tie definitions were originally developed as part of doctoral research at Cambridge University and are derived from definitions of social power (see Table 7 on page 32). Participants will also be asked to indicate how frequently they interact with each actor they have a relationship with, although this property relates to the overall relationship instead of specific ties (see Table 6). These tie frequencies may be updated prior to

commencement of fieldwork after further consultation with local partners on the appropriateness of these descriptions for the context.

Table 6. Tie frequency definitions

Relationship Frequency	Description
Weekly	At least once per week
Monthly	At least once per month
Quarterly	At least once every three months
Yearly	Less than monthly but within the past year

Table 7. Tie types

Tie Type	Sub-type (weight)	Description
1. Information	1.1 Download	Information sent from one to the other
	1.2 Discussion	Issues are identified, discussed, and clarified
	1.3 Dialogue	Exploring assumptions together leads to new understanding between actors
2. Resources	2.1 Low	Precise numbers to be confirmed with the Uganda team. Enumerators will be asked to write down the estimated annual size of a resource tie in Ugandan shillings on the network itself
	2.2 Mid	
	2.3 High	
3. Authority	3.1 Influence	Ability to influence the interests of others indirectly
	3.2 Authority	Control; the authority able to enforce consequences for non-compliance
4. Skills	4.1 Consulting	Temporary skill provision to complete a task
	4.2 Training	Providing temporary skill building activities
	4.3 Coaching	Ongoing customized interaction to support participants' ability to overcome challenges
	4.4 Co-development	Supporting another actor to develop their own way of doing things

Finally, interviews will include a qualitative verbal statement captured from participants to identify issues and understand how they relate to different actors or parts of the network. Questions are designed to solicit participant perceptions of challenges, benefits, and opportunities for change in the water service network that they interact with. Responses will be audio recorded for later transcription and analysis, and enumerators will summarize responses through handwritten notes during the interview. The questions are listed in the Interview Format section below.

Each interview begins with an egocentric network mapping exercise whereby the participant, as a representative of that particular actor, draws a network showing how they relate to the other actors also identified for inclusion in the study (see Figure 12). The interviewee's actor is written on a Post-it Note in the center of a sheet of flip chart paper, with Post-it Notes for other actors prepared in advance. These Post-it Notes are then placed by the participant in concentric rings that have been drawn on the paper to indicate the frequency of interaction – weekly, monthly, quarterly, or yearly. Colored, directional arrows are drawn by the participant to indicate ties, and the number of arrowheads is used to denote weight. Qualitative questions are then asked and recorded after completion of the network drawing.

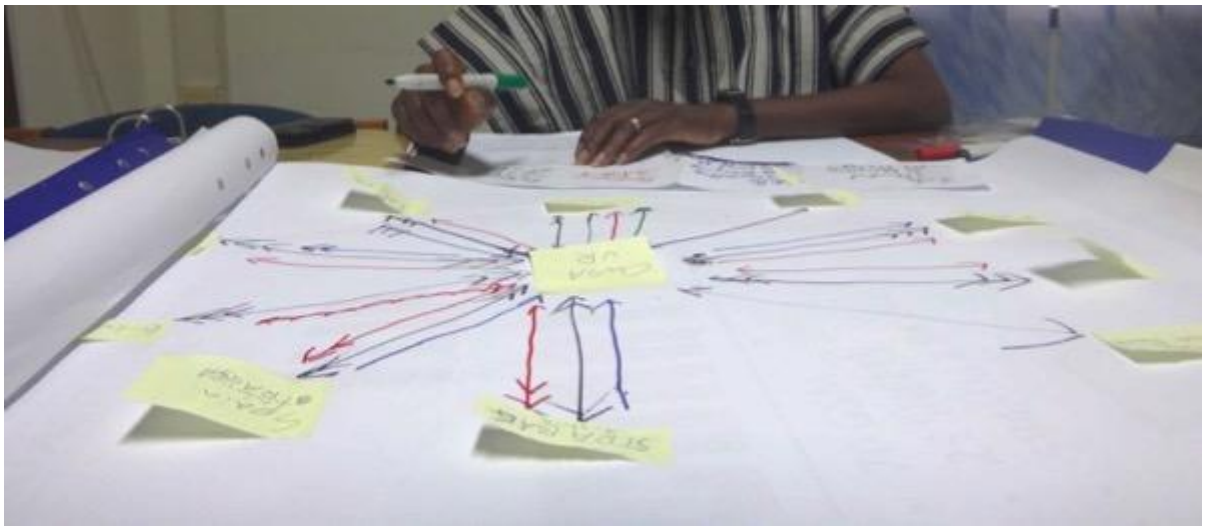

Figure 12. An egocentric network drawn by an interview participant

Interview Format

Prior to the interview, the enumerator should prepare:

- A legend showing different tie colors and descriptions;
- A sample image of a completed network on A4 paper;
- A list of actors in the network for participants to select from; and
- A sheet of flip chart paper with concentric rings labeled 'weekly,' 'monthly,' and 'yearly' (see Figure 13 on page 34). The enumerator's name and date of the interview should be written on the back.

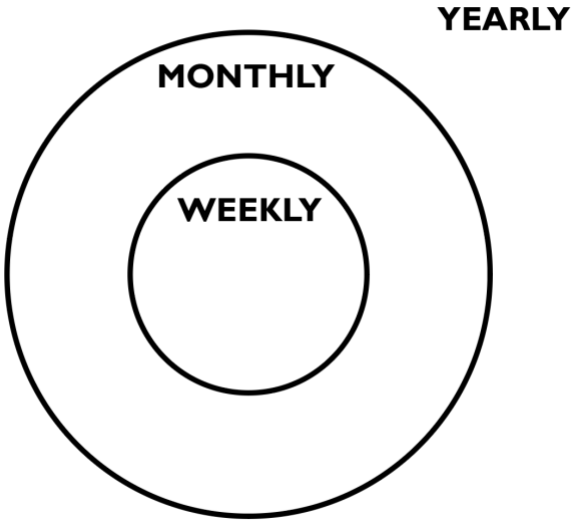

Figure 13. Template for network data collection

Additionally, the enumerator will require:

- Flip chart paper;
- Post-it Notes;
- Colored markers;
- Ballpoint pens;
- A notebook;
- A digital camera; and
- An audio recording device.

Part 1. Introduction and Node Properties

The interview commences with an introduction of the research aims and survey outline. Suggested phrasing is presented below in italics but will differ depending on the audience and spoken language.

Whave, in collaboration with Kamuli District Local Government, is conducting a study to understand the network of actors involved in water service delivery in Kamuli District, and issues affecting the sustainability of services. We are asking you to participate in a brief survey to draw the network of your organization/actor and to identify both benefits and challenges with this network. The survey should take approximately 30 minutes.

In the first step, we will draw a network to understand whom you interact with and how. The completed network will look like this:

The enumerator shows the example of a complete network, then produces the flip chart paper to be used for the interview. The enumerator writes the name of the actor being interviewed on a Post-it Note and places this in the center of the flip chart.

Firstly, let us begin with your contact information for any necessary follow up. We will not share your contact details outside of the analysis team.

The enumerator should then record, on the back of the flip chart, the respondent's:

- First name:
- Last name:
- Organization:
- Position:
- Mobile phone number:
- Personal email address:

Now, please select the term that best describes your organization/actor type and the scope of your work.

Answers are to be selected from the list of actor types and scope presented in Table 5 on page 31 and written on the Post-it Note with the name of the actor being interviewed.

Part 2. Network Mapping

The enumerator presents the list of actors involved in the study and asks the participant to identify with whom they have had information, skill, resource, or authority relationships over the past year. These can be either incoming or outgoing ties.

From this list of actors, please identify who you have had a relationship within the past year. This can be anyone you share information with, give or receive support from, pay or are paid by, or whom you influence or control in the water sector. Please also identify any important actors missing from this list.

As the participant identifies each actor, the enumerator writes the name on a Post-it Note and places it on the flip chart paper. Responses are expected to include actors already identified in the network and other actors that are perceived as important.

Please now move the actors on the flip chart to indicate how often you interact. Is it weekly, monthly, quarterly, or only once within the past year?

The participant should then move the Post-it Notes that label actors identified to the appropriate ring on the flip chart paper. Ideally, the participant does this instead of the enumerator doing it on their behalf.

The enumerator then presents the tie categories, starting with information. For each tie category, the participant is handed the appropriate colored marker and instructed to draw their ties. The enumerator should describe the tie categories and clarify any questions as appropriate. All enumerators will be trained and tested in facilitating this process prior to data collection.

We will now draw the relationships between you and the actors you identified. We will start with information, followed by skills, resources, and then authority. We will use colors to indicate the relationship type, arrowheads to indicate direction, and the number of arrowheads to indicate the strength of the relationship. Let's start with this actor. What is your relationship here?

Participants usually grasp the exercise quickly once they have completed one or two examples. It is important that they hold the markers throughout the exercise so that results are not unintentionally influenced by the enumerator. Enumerators should be prepared to clarify any questions as necessary while the participant draws the network.

The process continues until relationships for each tie type for each actor have been discussed. For resource ties, the enumerator should also write down the estimated annual size of the resource flow in Ugandan shillings. Enumerators should check for completeness at the end of the exercise and encourage participants to make any corrections or additions that they see fit.

Please check the network you have drawn and feel free to make any changes. Does anything need to be added or changed? Is anyone missing?

The enumerator can proceed to the final part of the interview when the participant is satisfied that the network is complete.

Part 3. Qualitative Interpretation of Factors

The final part of the interview captures participant perspectives of factors affecting water services and qualifies the importance of particular network relationships. The interview format is a semi-structured interview consisting of four questions. Responses are audio recorded, and enumerators are expected to make summarizing notes of key points simultaneously.

Importantly, for all questions, enumerators should encourage participants to elaborate on their responses through prompts including "tell me more" or "and," and simply pausing to encourage further detail. Other than necessary clarifications, enumerators should minimize specific follow-up questions that could influence responses, and instead allow participants to direct the conversation toward what they perceive as most important. If a response becomes too lengthy or redundant, enumerators can interrupt to summarize the point to ensure it is understood correctly, and encourage respondents to move on to new points with the prompt of "what else?" Responses are anticipated to not require more than 15 to 20 minutes. Training on these interview techniques will be included for all enumerators.

Finally, I would like to ask you a few questions about how this network works, and about water services in this district. [Begin audio recording]

1. In your opinion, what do you think is working well in sustaining rural water services in Kamuli?
2. In your opinion, what do you think are the main problems in sustaining rural water services in Kamuli?
3. What ideas or recommendations do you have about solutions to these problems?
4. Of the solutions you listed, which is the most important? Can you walk me through what next steps would happen if the solution occurs?
5. In your opinion, how effective is preventive maintenance of hand pumps in Kamuli?
6. In your opinion, what could be improved? What is needed to make preventive maintenance work?

On completion of the interview, the enumerator should thank participants for their time, and capture any further feedback, comments, or reflections from the interview. Enumerators should also photograph the drawn network and be sure that the audio recording is properly saved.

Data Processing

Egocentric networks drawn during interviews can then be aggregated to create whole networks for analysis. These drawn networks are manually converted to a node list and edge list for analysis by enumerators. Recorded verbal responses are transcribed by enumerators and translated to English where necessary. The result is:

- A node list;
- An edge (tie) list; and
- Transcripts of verbal responses from each actor.

Aggregating ties from separate interviews can produce conflicts where two actors perceive the same relationship differently. The final network will, therefore, include all ties reported from interviews, and conflicts will be averaged. If desired, future analysis can investigate the frequency of conflicts if discrepancies in perspectives are of interest to Whave. Original and averaged tie data will, therefore, be provided by the study.

Coding of verbal response transcripts will be handled by UCB and contribute to evidence for the SWS learning question: *How can the factors, and interconnections of factors that influence WASH service sustainability, be better understood by actors?* Simultaneously, enumerators are to summarize key points of the verbal responses during the interview. These summary points can also be used by Whave for learning about actor perspectives of successes, challenges, solutions, and preventive maintenance.

Anticipated Analysis

Detailed analysis of data collected should be informed by the interests of Whave so that findings might inform actionable strategies. Some analysis is proposed as a starting point to outline how data collected

can be used to produce initial findings. Interested actors can then consider these initial findings to develop hypotheses or new lines of inquiry that can be further explored in available data.

Force Atlas Visualizations

A force directed visualization orients network data to show actors that are most closely connected to each other. This algorithm is particularly useful for identifying clustering of actors, brokers, and network gaps. Actors can see where they are in the network, and where they might build new relationships in order to bridge gaps. These visualizations can be produced for each of the four tie types and for different frequencies of interaction (weekly, monthly, quarterly, and yearly). Additional visualizations can include new actors identified during interviews.

Network Analysis of Communities

Combining network data from community interviews with existing data on service levels provides an opportunity to explore how network properties might be linked to service levels. Recent research suggests that gaps in information and skill ties might be linked to lower levels of institutional development, and data from this study can be used to explore the relationship between network properties and service levels with greater rigor.

These initial types of analysis are likely to generate more specific hypotheses and questions to explore in network data. These types of analysis are assumed to be useful starting points for coalition members to answer two key questions that can inform future action:

1. Where are there gaps, and where do we want to strengthen the network?
2. What are key issues we want to address, and who should be involved?

Implications and Follow-Up

Network analysis can be particularly useful for identifying gaps in actor relationships. Such gaps can be missed opportunities for accessing capacity, resources, or information from a broader network that an actor might require to perform or improve in its service delivery role. Identifying network gaps can inform opportunities for strengthening service networks and identifying relationships to develop or improve.

Qualitative analysis of challenges, benefits, and opportunities can add to network analysis by helping key actors identify where different groups report similar challenges or capacity gaps. This can then provide a basis for collaborative action. The analysis can be used to prioritize where to focus, and whom to involve.

Finally, if specific network indications are identified as important for service delivery, Whave and/or partners might consider capturing data to monitor network activity over time. Such data might serve as a proxy indicator for service delivery, and the relationship between network activity and service levels can be formally explored. This is an example of a specific hypothesis that might be identified by Whave

from preliminary analysis, and supplemental analysis can be performed on data from the study as deemed strategically useful.

Follow up & Deliverables

Final report with the outcomes of the completed SNA: The final report will present the analysis of the actor networks involved in water service sustainability in Kamuli District. It is expected that the analysis will (1) generate evidence on the network that influences water service sustainability, and (2) identify relationships to be strengthened and strategies for improving the network.

Presentation or workshop: Once available, findings and data from fieldwork and preliminary analysis should be presented at a workshop with actors involved in the study to discuss findings and identify further questions for analysis. The workshop is expected to culminate in a set of proposed actions to influence water service networks and issues affecting service delivery in Kamuli District.

A follow-up network analysis could look at how the network changes after Whave has been strategically influencing relationships in the district. Repeating similar data collection would create opportunities for comparative analysis and investigating the utility of these methods as a monitoring and evaluation tool in the context of water service delivery.

Annex B: List of Network Actors

Table 8. List of network actors

ID	Label	Level of Hierarchy	Type
1	District Councilor Kitayunjwa	Kitayunjwa Sub-county	Government Office
2	LC3 Kitayunjwa	Kitayunjwa Sub-county	Government Office
3	CDO Kitayunjwa	Kitayunjwa Sub-county	Government Office
4	Executive/SEC works Kitayunjwa	Kitayunjwa Sub-county	Government Office
5	Kisule Bunafu	Namisambya Parish	Service User
6	Kiroba Malulu	Namisambya Parish	Service User
7	Chairman LC2 Kitayunjwa	Kitayunjwa Sub-county	Government Office
8	HPM Kitayunjwa	Kitayunjwa Sub-county	Service Provider
9	HA Kitayunjwa	Kitayunjwa Sub-county	Government Office
10	Parish chief Kitayunjwa	Kitayunjwa Sub-county	Government Office
11	Bunafu Zone	Namisambya Parish	Service User
12	Bulaile Zone	Namisambya Parish	Service User
13	Buwaya Buyakoobo Zone	Namisambya Parish	Service User
14	Bwase Bugobwe Zone	Namisambya Parish	Service User
15	Buwenda Zone	Namisambya Parish	Service User
16	Malulu Zone	Namisambya Parish	Service User
17	Bulegeya Zone	Namisambya Parish	Service User
18	Bukwanga Bukubembe	Namisambya Parish	Service User
19	Buyonga Zone	Namisambya Parish	Service User
20	Bugulele Zone	Namisambya Parish	Service User
21	Bumyuka Zone	Namisambya Parish	Service User
22	LC3 Namwendwa	Namwendwa Sub-county	Government Office
23	Senior Assistant Secretary Namwendwa	Namwendwa Sub-county	Government Office
24	CDO Namwendwa	Namwendwa Sub-county	Government Office
25	Woman Councilor Namwendwa Ndalike	Namwendwa Sub-county	Government Office
26	Ndalike Trading Center	Ndalike Parish	Service User
27	Bukoma Bunyirwa	Ndalike Parish	Service User

ID	Label	Level of Hierarchy	Type
28	Sub-county Councilor Namwendwa Ndalike Parish	Namwendwa Sub-county	Government Office
29	Sub-county Councilor Namwendwa Parish	Namwendwa Sub-county	Government Office
30	Parish Chief Namwendwa	Namwendwa Sub-county	Government Office
31	HA Namwendwa	Namwendwa Sub-county	Government Office
32	HPM Namwendwa	Namwendwa Sub-county	Service Provider
33	Ndalike Trading Center	Ndalike Parish	Service User
34	Busiri Zone	Ndalike Parish	Service User
35	Buyuba Zone	Ndalike Parish	Service User
36	Budhumba Zone	Ndalike Parish	Service User
37	Nambale Zone	Ndalike Parish	Service User
38	Kisege Zone	Ndalike Parish	Service User
39	Kawolera Zone	Ndalike Parish	Service User
40	Vice Chairman LC5 Kamuli	District	Government Office
41	AEO Water Kamuli (DWO)	District	Government Office
42	DHI Kamuli	District	Government Office
43	Speaker Kamuli District	District	Government Office
44	RDC Kamuli	District	Government Office
45	Chief Administration Officer Kamuli District	District	Government Office
46	DMF	District	Private Sector
47	Whave	District	Service Provider
48	Busoga Trust	District	Non-Governmental Organization
49	Kamuli Borehole Mechanic Association/Hand Pump Mechanic Association	District	Service Provider
50	Send a Cow	District	Non-Governmental Organization
51	National Water and Sewerage Corporation	District	Service Provider

Annex C: Centrality Tables

Table 9. Information ties

Rank	Yearly	Quarterly	Monthly	Weekly
1	Whave	Whave	Whave	Busoga Trust
2	Busoga Trust	Busoga Trust	Busoga Trust	Executive/ Secretary for Works Kitayunjwa
3	Executive/ Secretary for Works Kitayunjwa	Executive/ Secretary for Works Kitayunjwa	Executive/ Secretary for Works Kitayunjwa	Woman Councilor Namwendwa Ndalike
4	DMF	LC3 Namwendwa	AEO Water Kamuli	Whave
5	LC3 Namwendwa	LC11 Kitayunjwa	LC3 Namwendwa	LC3 Namwendwa
6	AEO Water Kamuli	CDO Namwendwa	CDO Kitayunjwa	CDO Namwendwa
7	CDO Namwendwa	AEO Water Kamuli	HPM Kitayunjwa	Ndalike Trading Center
8	LC11 Kitayunjwa	CDO Kitayunjwa	Buyuba Zone	Speaker Kamuli District
9	CDO Kitayunjwa	WSC member Kisule Bunafu	Sub-county Councilor Namwendwa Ndalike Parish	HPM Kitayunjwa
10	DHI Kamuli	HPM Kitayunjwa	CDO Namwendwa	LC3 Kitayunjwa

Table 10. Skill ties

Rank	Yearly	Quarterly	Monthly	Weekly
1	Whave	Whave	Whave	Whave
2	DMF	CDO Kitayunjwa	CDO Kitayunjwa	CDO Kitayunjwa
3	CDO Kitayunjwa	Executive/ Secretary for Works Kitayunjwa	Executive/ Secretary for Works Kitayunjwa	Executive/ Secretary for Works Kitayunjwa
4	Ndalike Trading Center	Vice Chairman LC5 Kamuli	Vice Chairman LC5 Kamuli	Vice Chairman LC5 Kamuli
5	Executive/ Secretary for Works Kitayunjwa	Ndalike Trading Center	Ndalike Trading Center	Ndalike Trading Center

Rank	Yearly	Quarterly	Monthly	Weekly
6	Vice Chairman LC5 Kamuli	CDO Namwendwa	CDO Namwendwa	CDO Namwendwa
7	WSC member Bukoma Bunyirwa	RDC Kamuli	RDC Kamuli	RDC Kamuli
8	CDO Namwendwa	LC3Namwendwa	LC3Namwendwa	LC3Namwendwa
9	RDC Kamuli			
10	LC3Namwendwa			

Table 11. Authority ties

Rank	Yearly	Quarterly	Monthly	Weekly
1	Busoga Trust	Busoga Trust	Busoga Trust	Busoga Trust
2	Executive/ Secretary for Works Kitayunjwa	Executive/ Secretary for Works Kitayunjwa	Whave	Executive/ Secretary for Works Kitayunjwa
3	Whave	Whave	Executive/Secretary for Works Kitayunjwa	LC3 Kitayunjwa
4	CDO Kitayunjwa	CDO Kitayunjwa	CDO Kitayunjwa	CDO Kitayunjwa
5	CDO Namwendwa	LC3Namwendwa	CDO Namwendwa	Whave
6	LC3 Namwendwa	CDO Namwendwa	AEO Water Kamuli (DWO)	LC3 Namwendwa
7	DMF	WSC member	LC3 Namwendwa	CDO Namwendwa
8	DHI Kamuli	DHI Kamuli	DHI Kamuli	Speaker Kamuli District
9	WSC Member	Woman Councilor Namwendwa Ndalike	RDC Kamuli	Bumyuka Zone
10	HA Namwendwa	LC3 Kitayunjwa	HA Kitayunjwa	Ndalike Trading Center

Table 12. Resource ties

Rank	Yearly	Quarterly	Monthly	Weekly
1	Whave	Whave	Whave	Whave

Rank	Yearly	Quarterly	Monthly	Weekly
2	HA Namwendwa	HA Namwendwa	AEO Water Kamuli (DWO)	Busoga Trust
3	DHI Kamuli	DHI Kamuli	DHI Kamuli	N/A
4	AEO Water Kamuli (DWO)	Busoga Trust	Busoga Trust	N/A
5	Busoga Trust	LC111 Namwendwa	HA Kitayunjwa	N/A
6	LC111 Namwendwa	Ndalike Trading Center	N/A	N/A
7	DMF	Buyuba Zone	N/A	N/A
8	Bumyuka Zone	Budhumba Zone	N/A	N/A
9	Buyuba Zone	Nambale Zone	N/A	N/A
10	Kisege Zone	Kisege Zone	N/A	N/A

Because there are relatively few resource ties at monthly and weekly frequencies of interaction, less than 10 actors have valid betweenness centrality values. Those with valid betweenness centrality values are ranked in Table 4 on page 17 accordingly.

Annex D: Community Networks for All Tie Types and Frequencies of Interaction

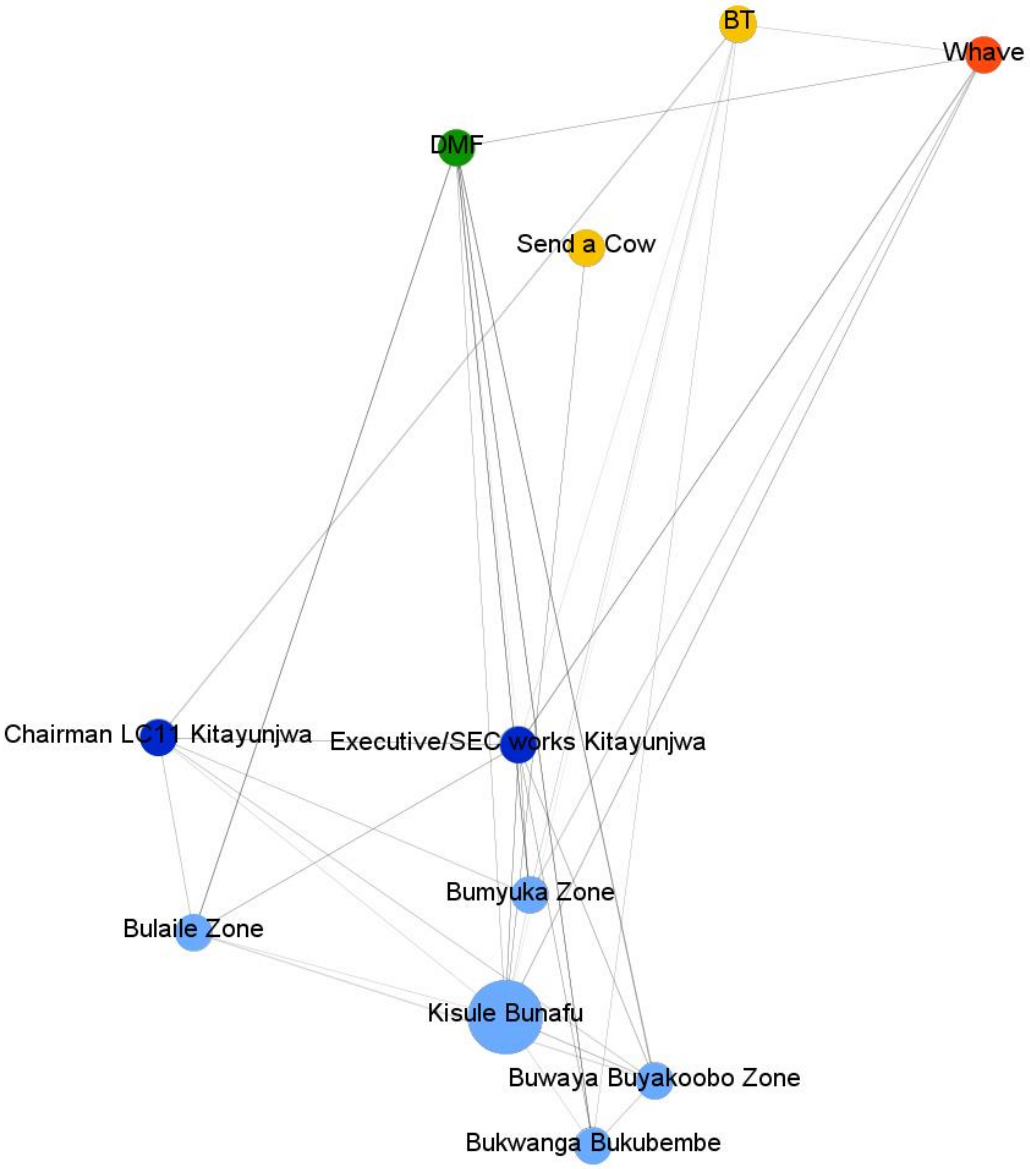

Figure 14. Kisule Bunafu ego network

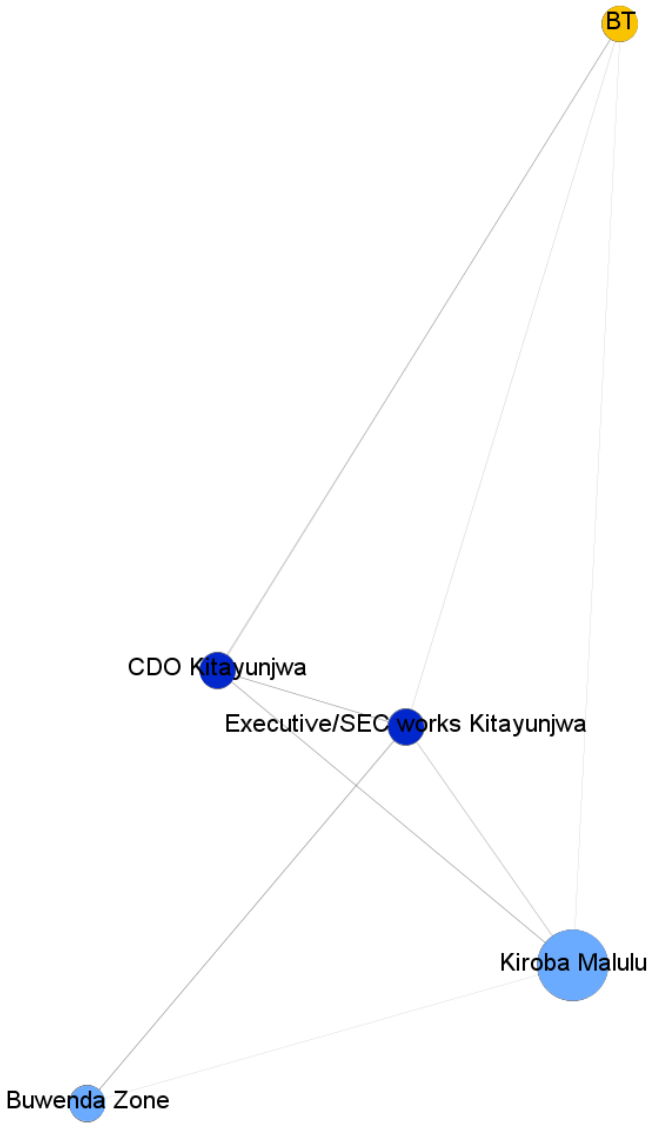

Figure 15. Kiroba Malulu ego network

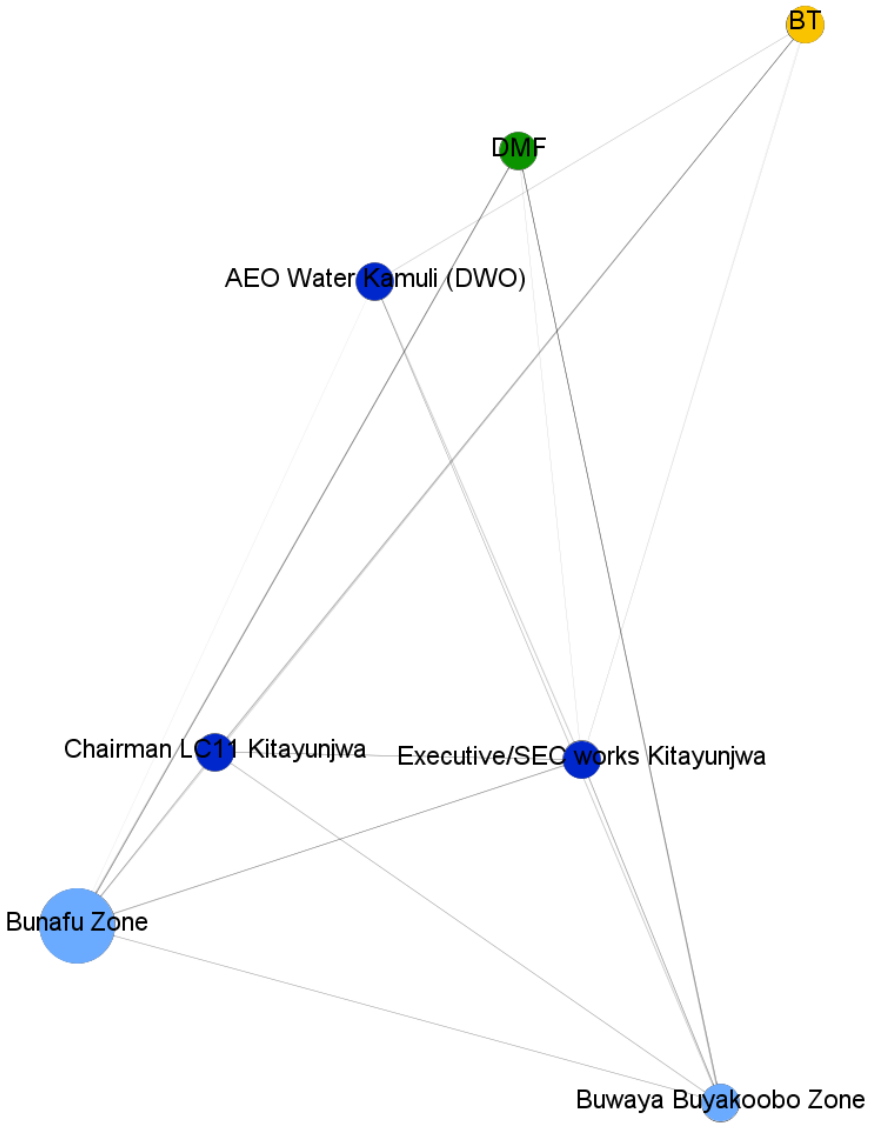

Figure 16. Bunafu Zone ego network

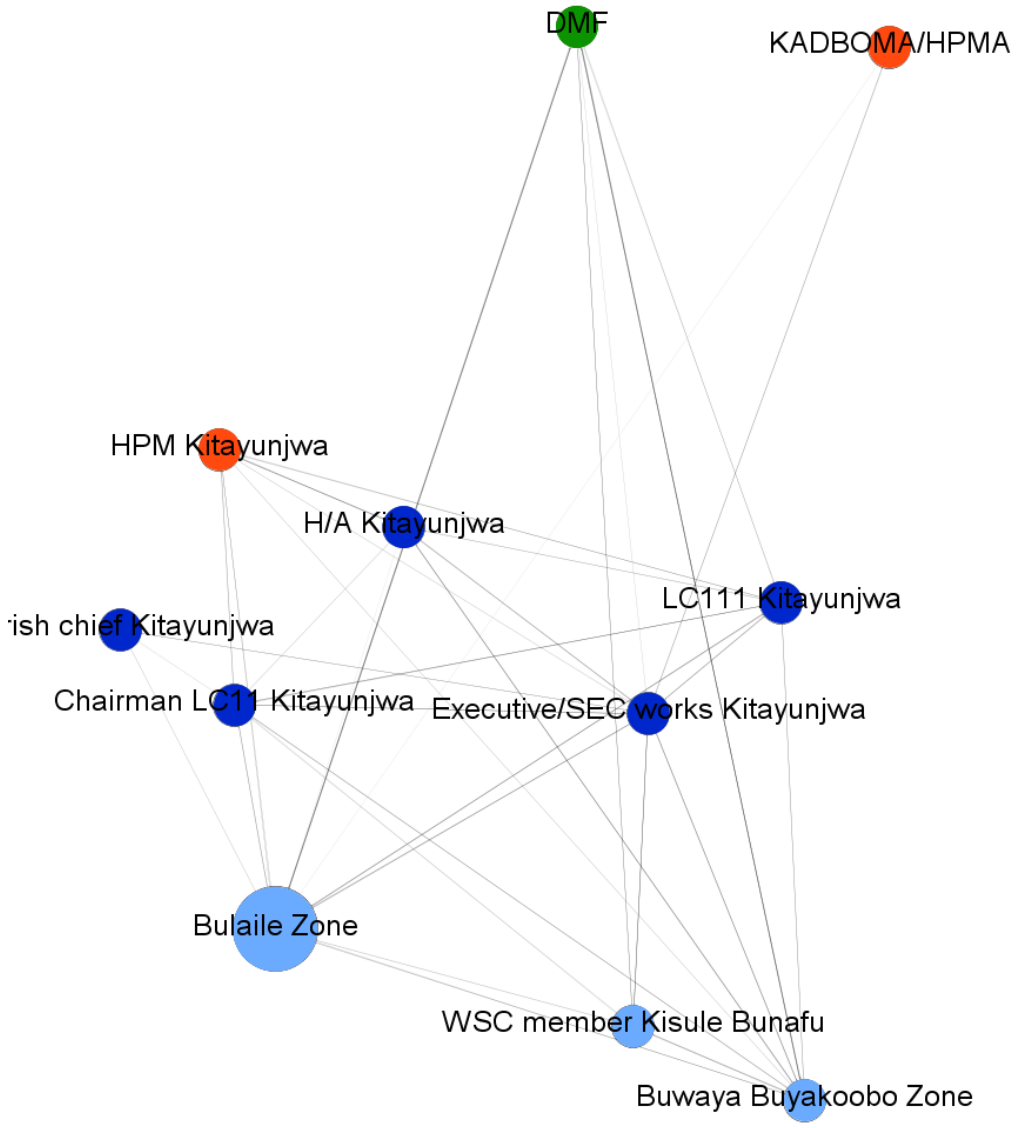

Figure 17. Bulaile ego network

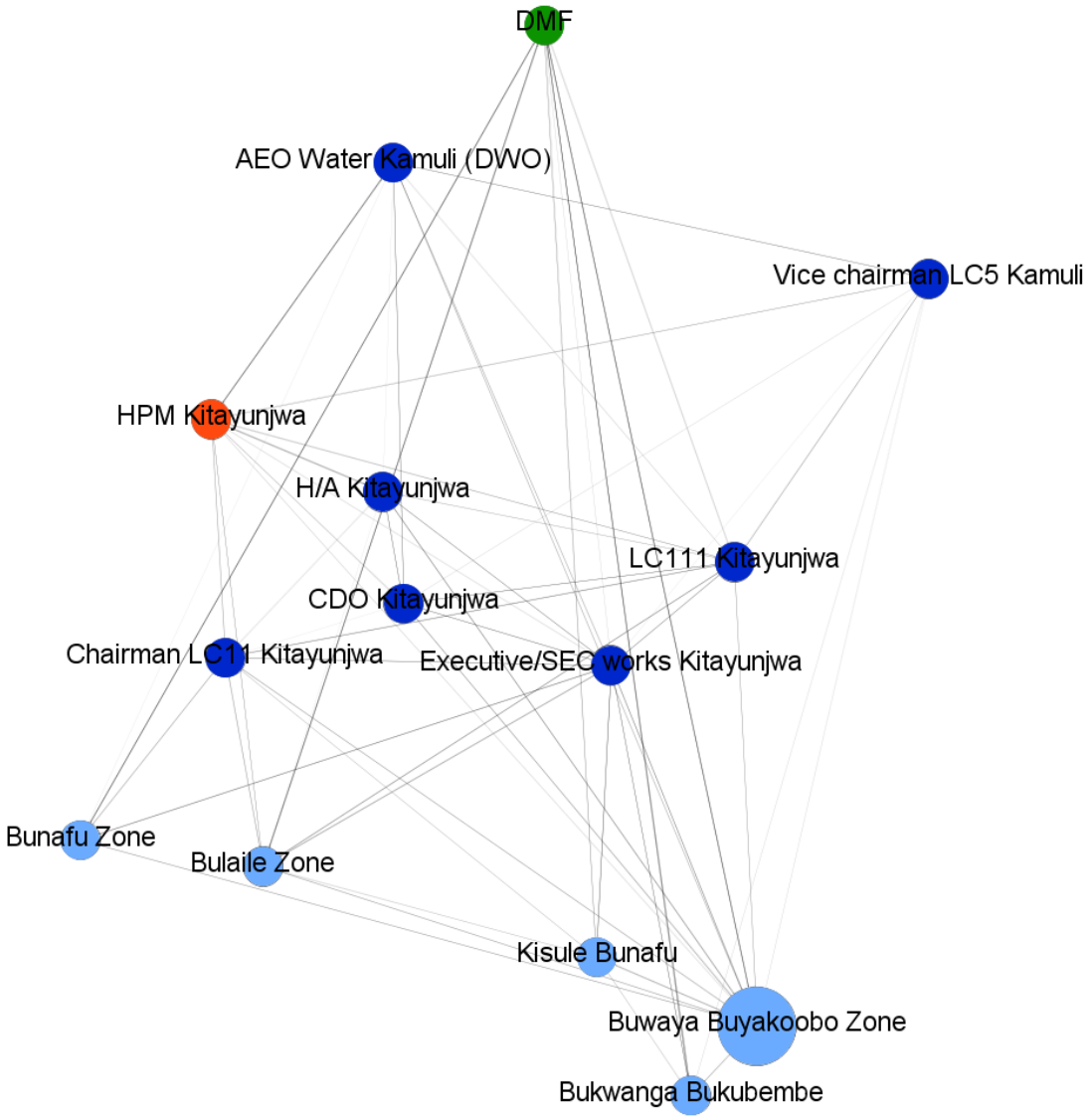

Figure 18. Buwaya Buyakoobo Zone ego network

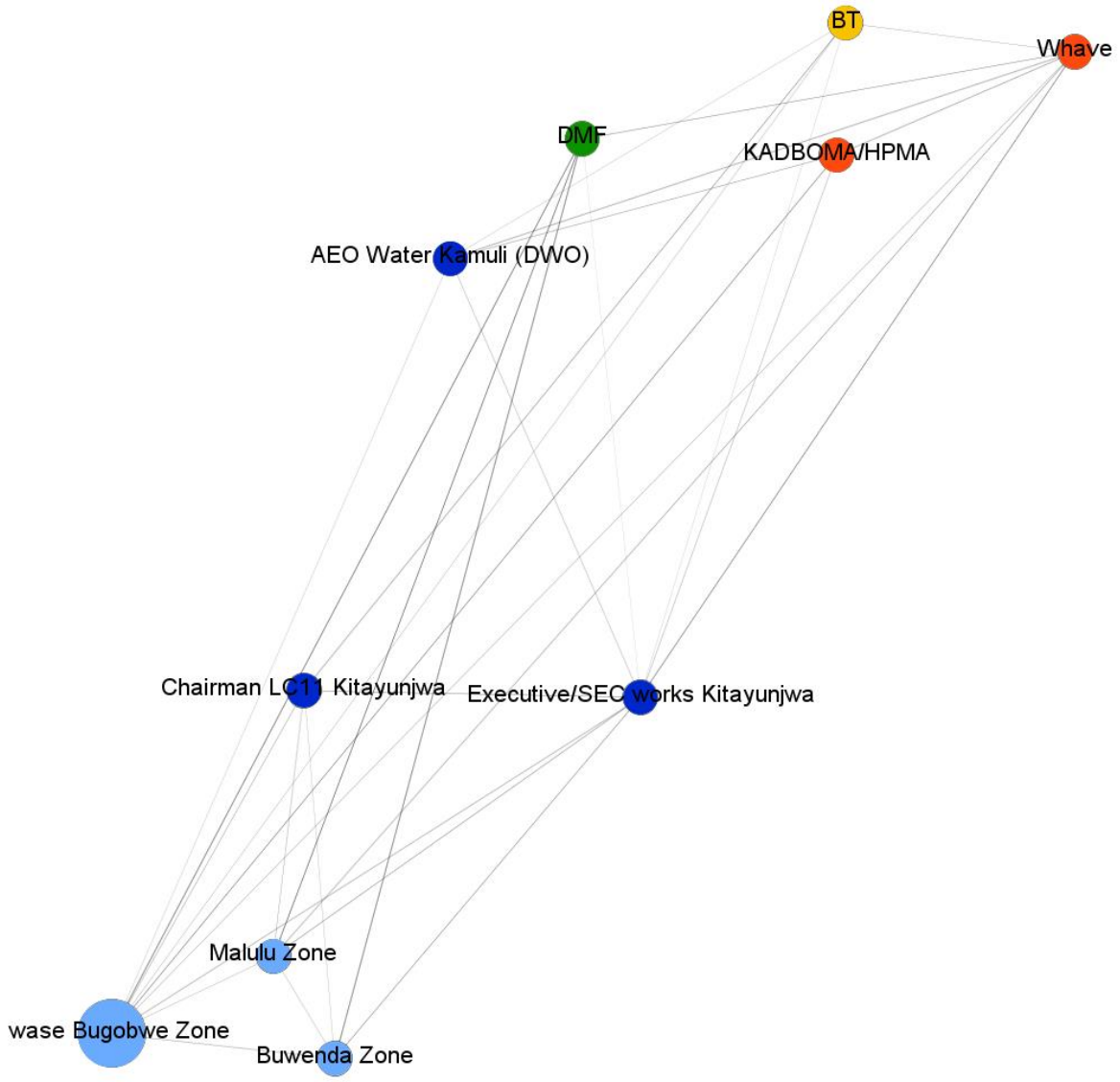

Figure 19. Bwase Bugobwe Zone ego network

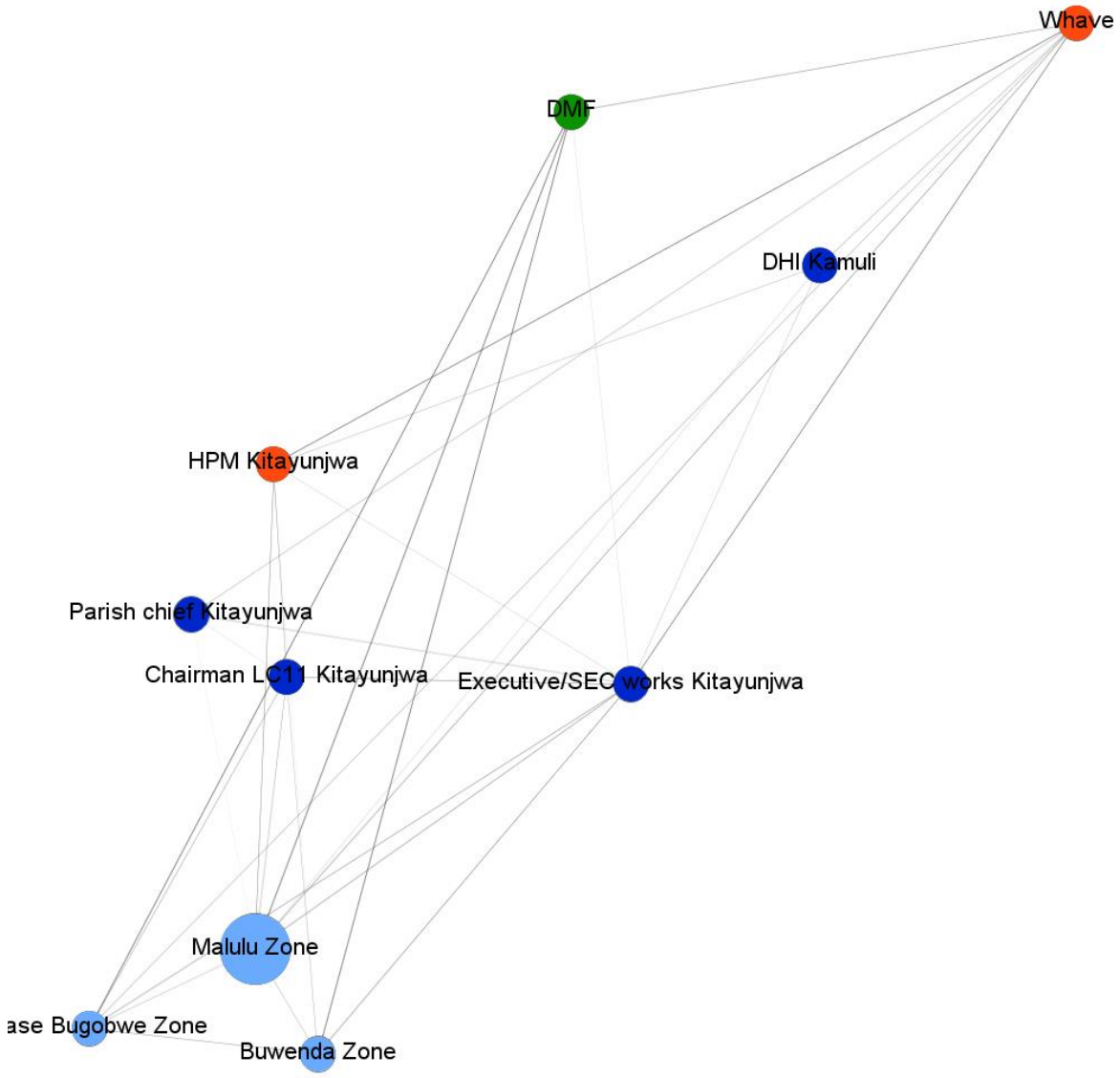

Figure 20. Malulu Zone ego network

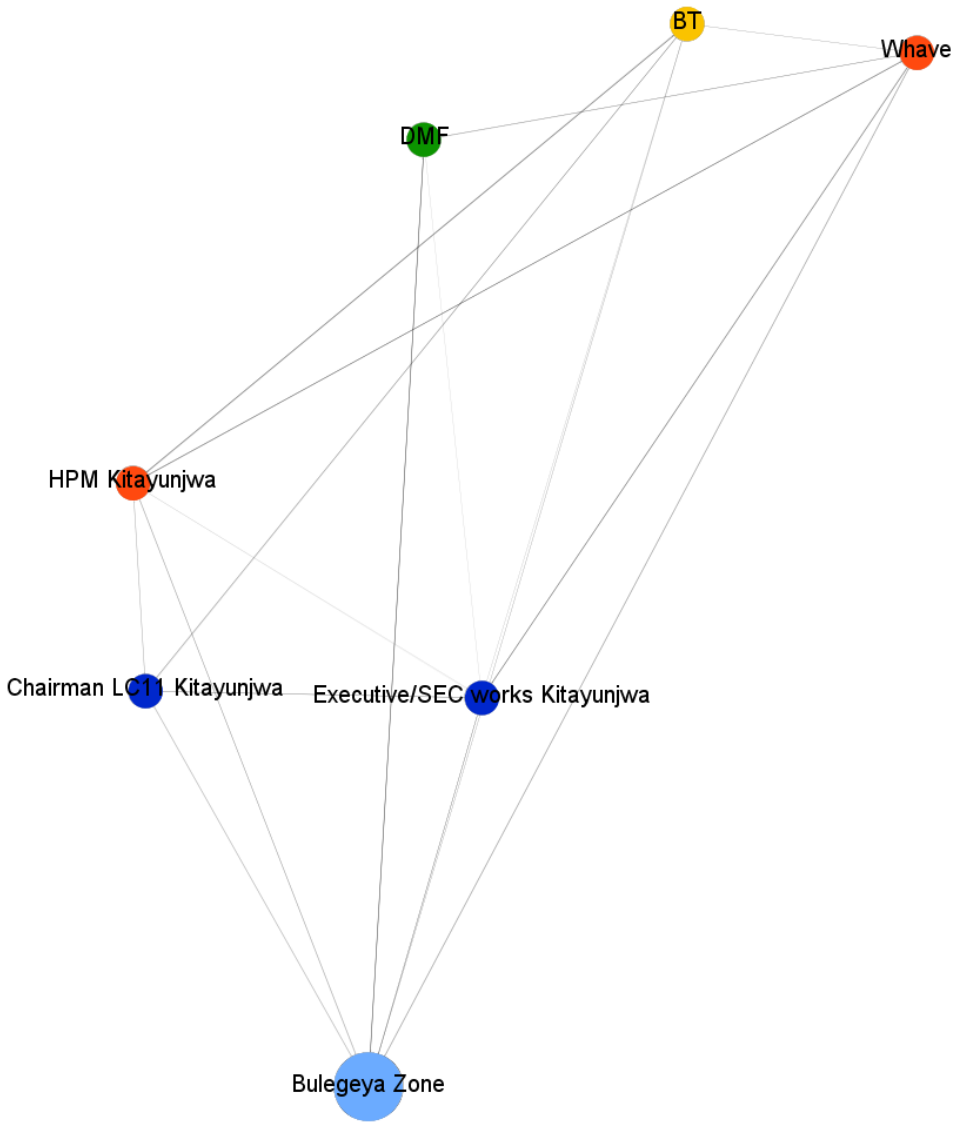

Figure 21. Bulegeya Zone ego network

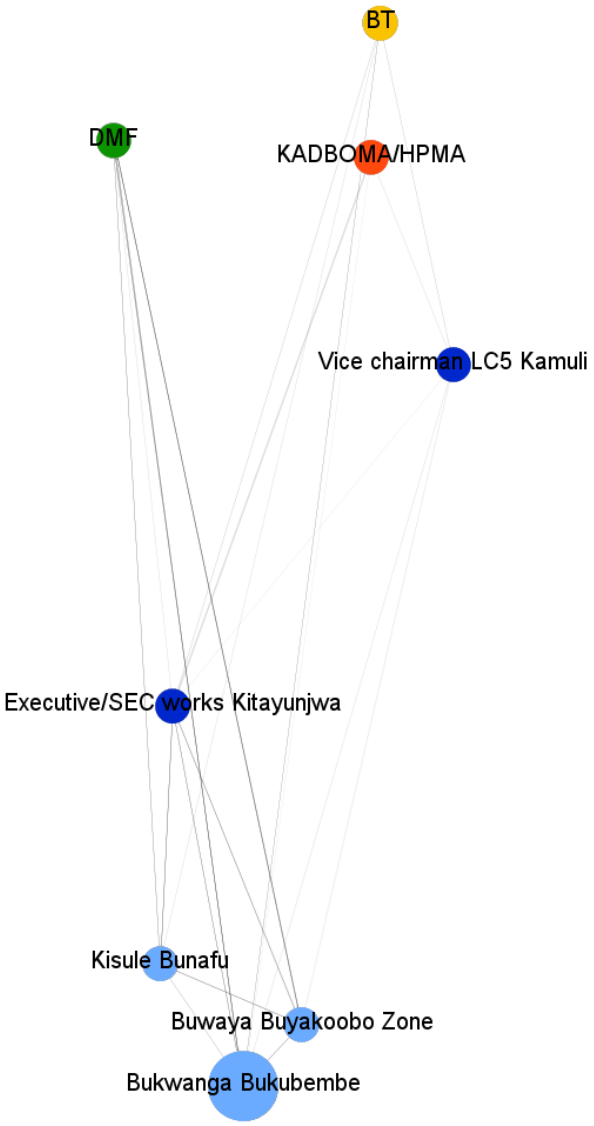

Figure 22. Bukwanga Bukubembe ego network

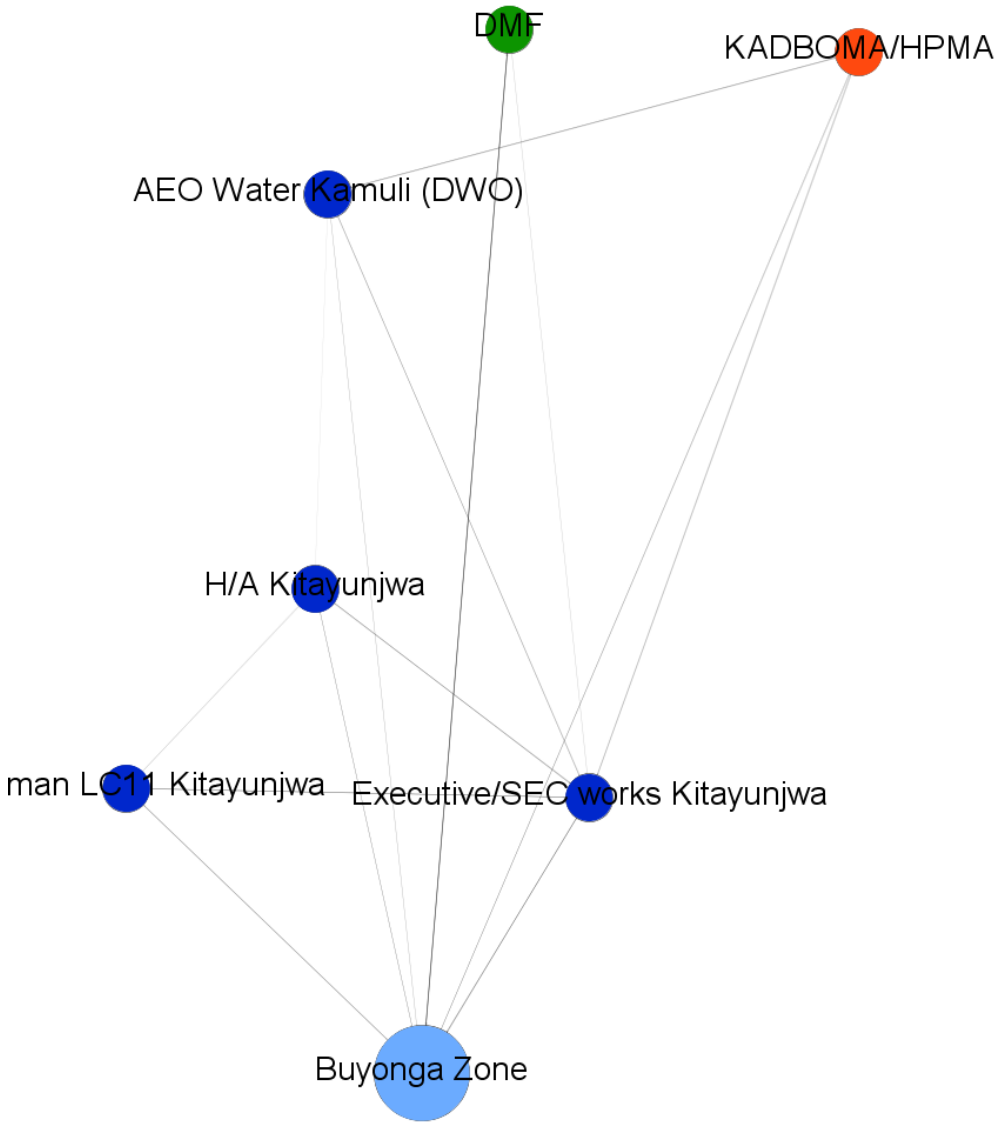

Figure 23.Buyonga Zone ego network

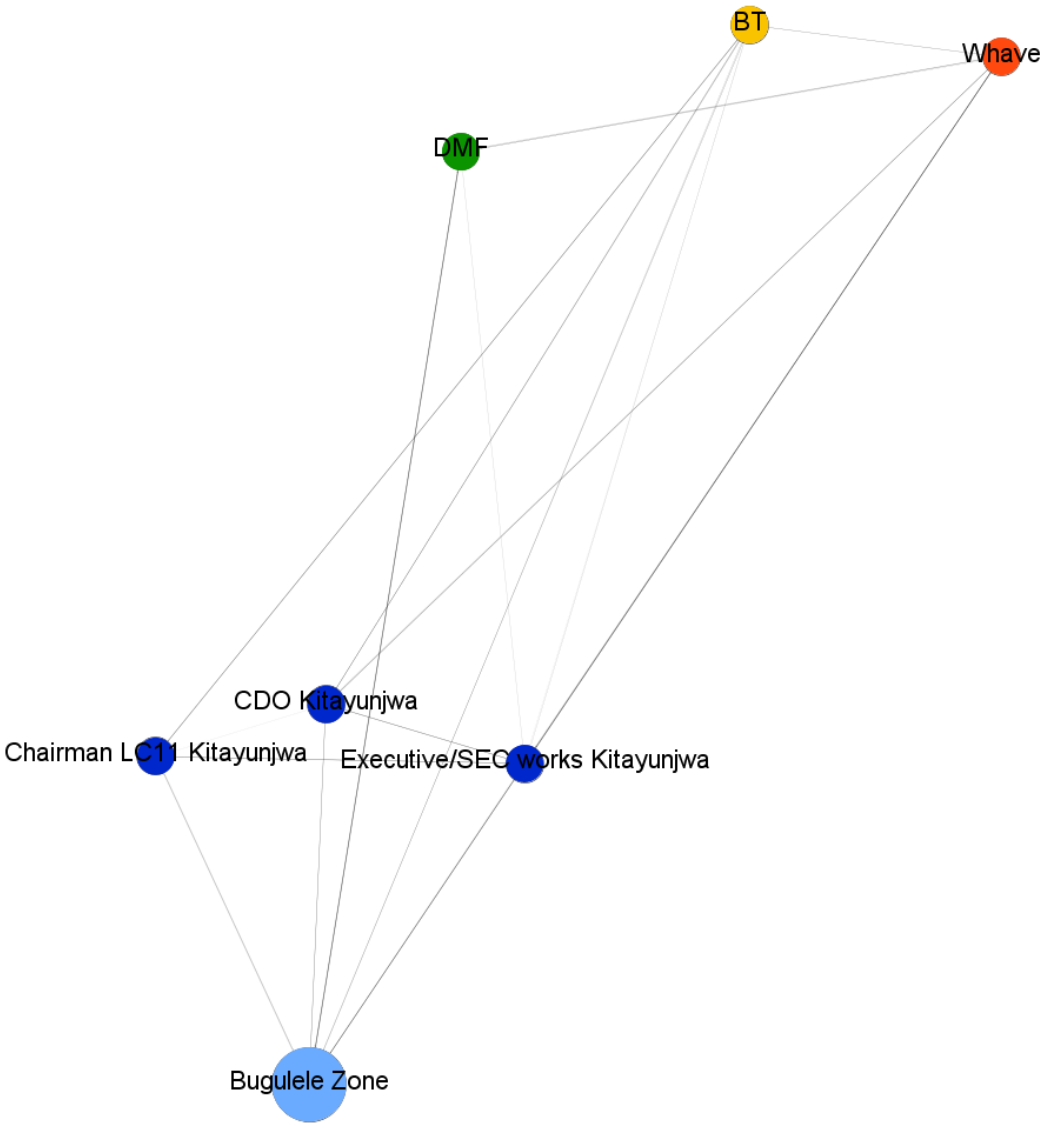

Figure 24.Bugulele Zone ego network

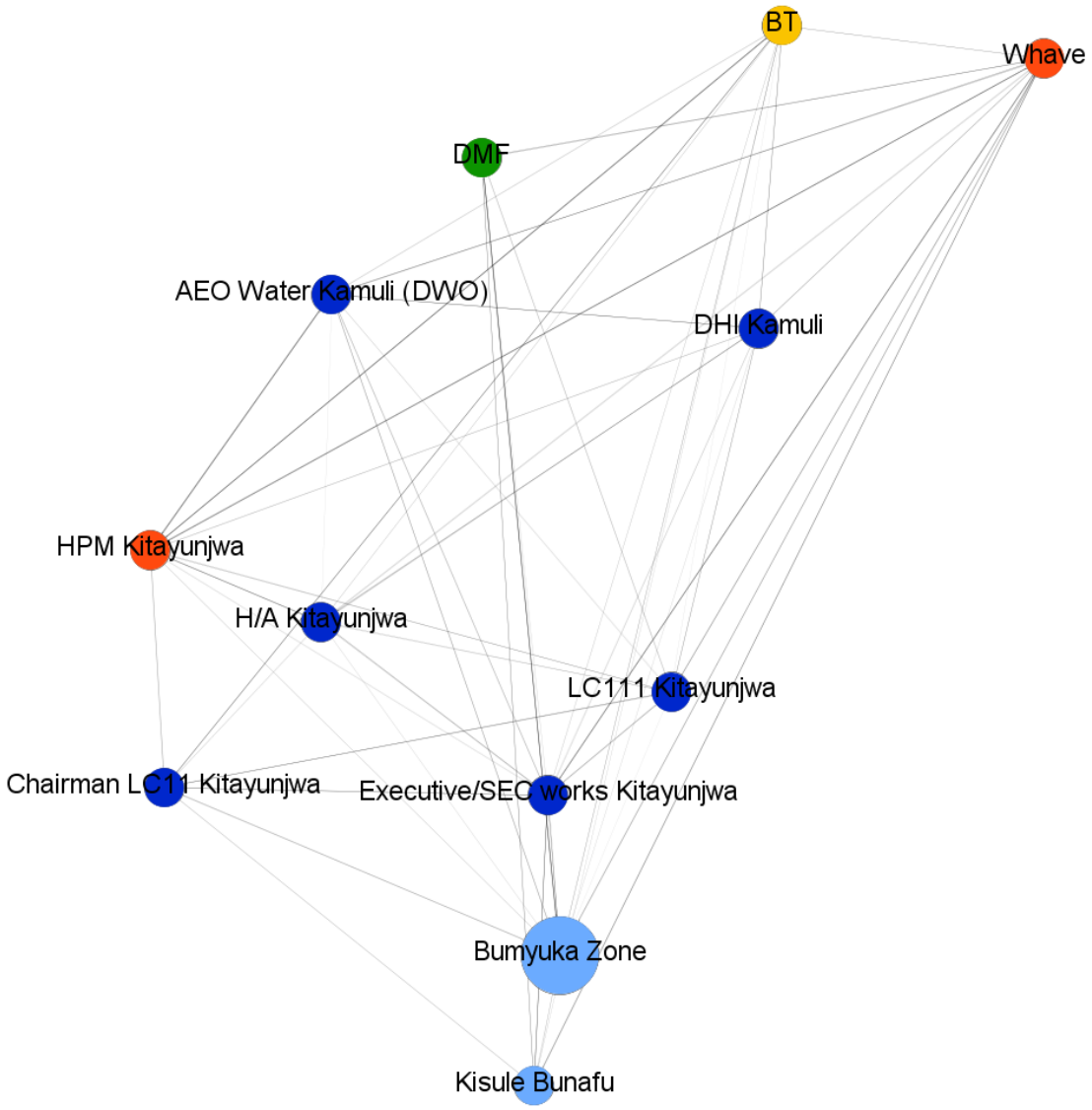

Figure 25. Bumyuka Zone ego network

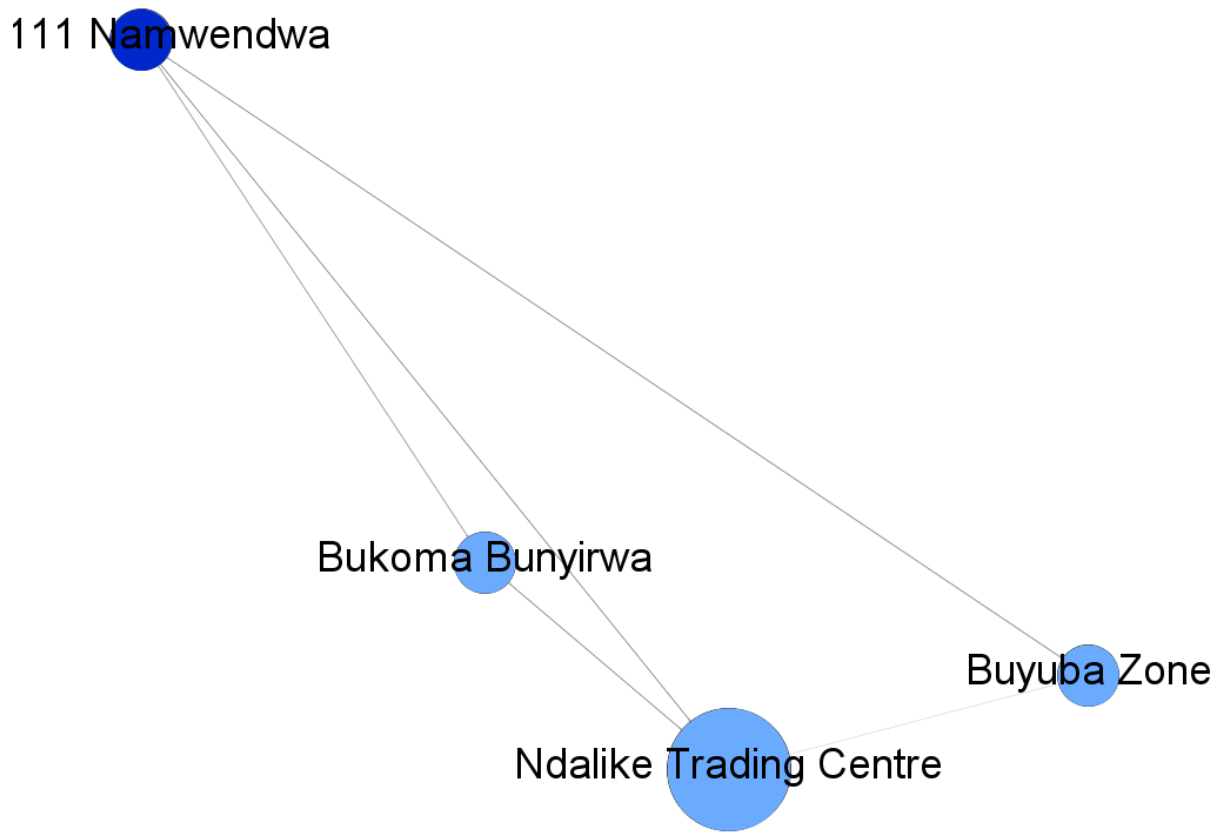

Figure 26. Ndalike Trading Center ego network

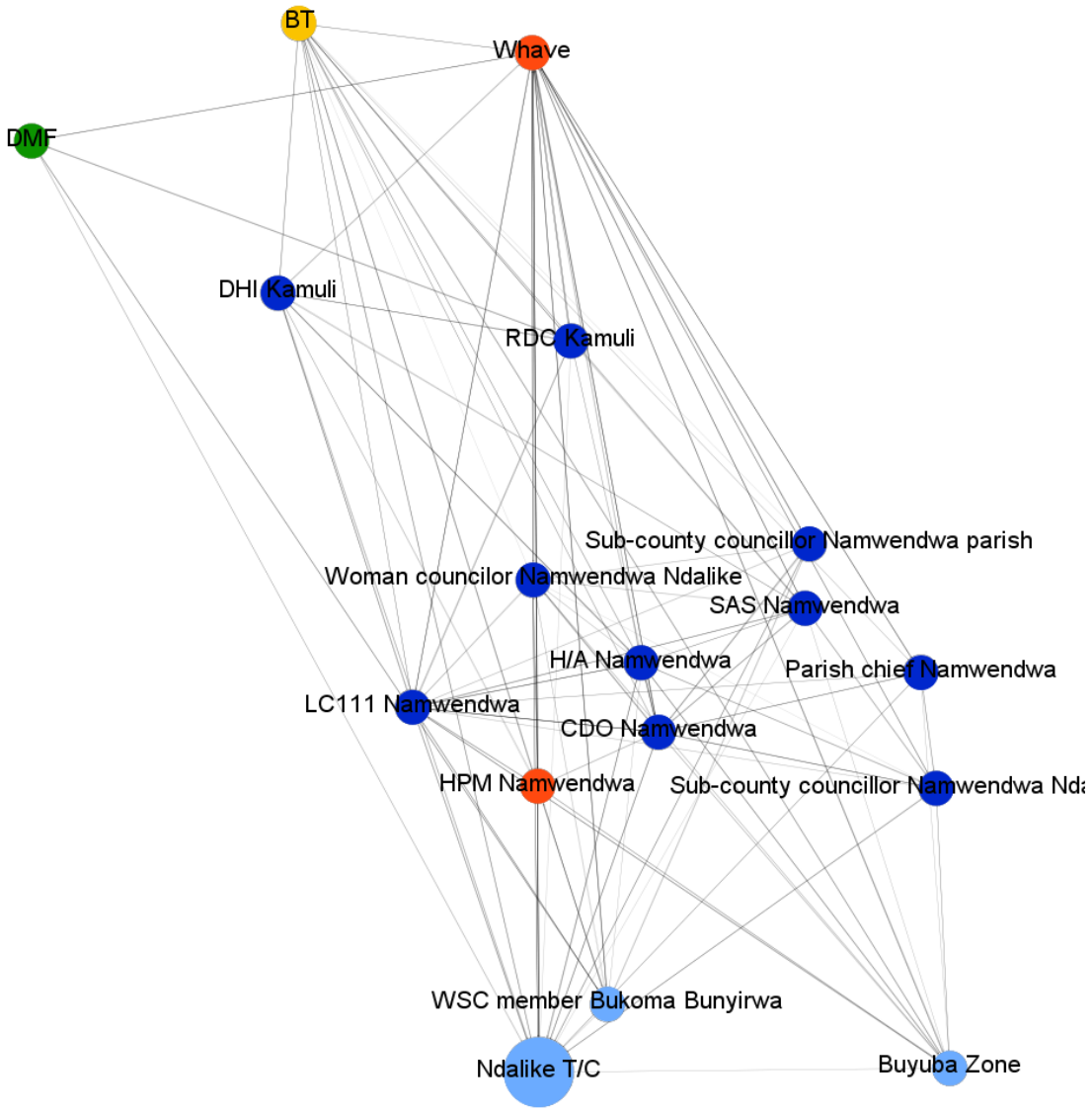

Figure 27. Ndalike Trading Center ego network

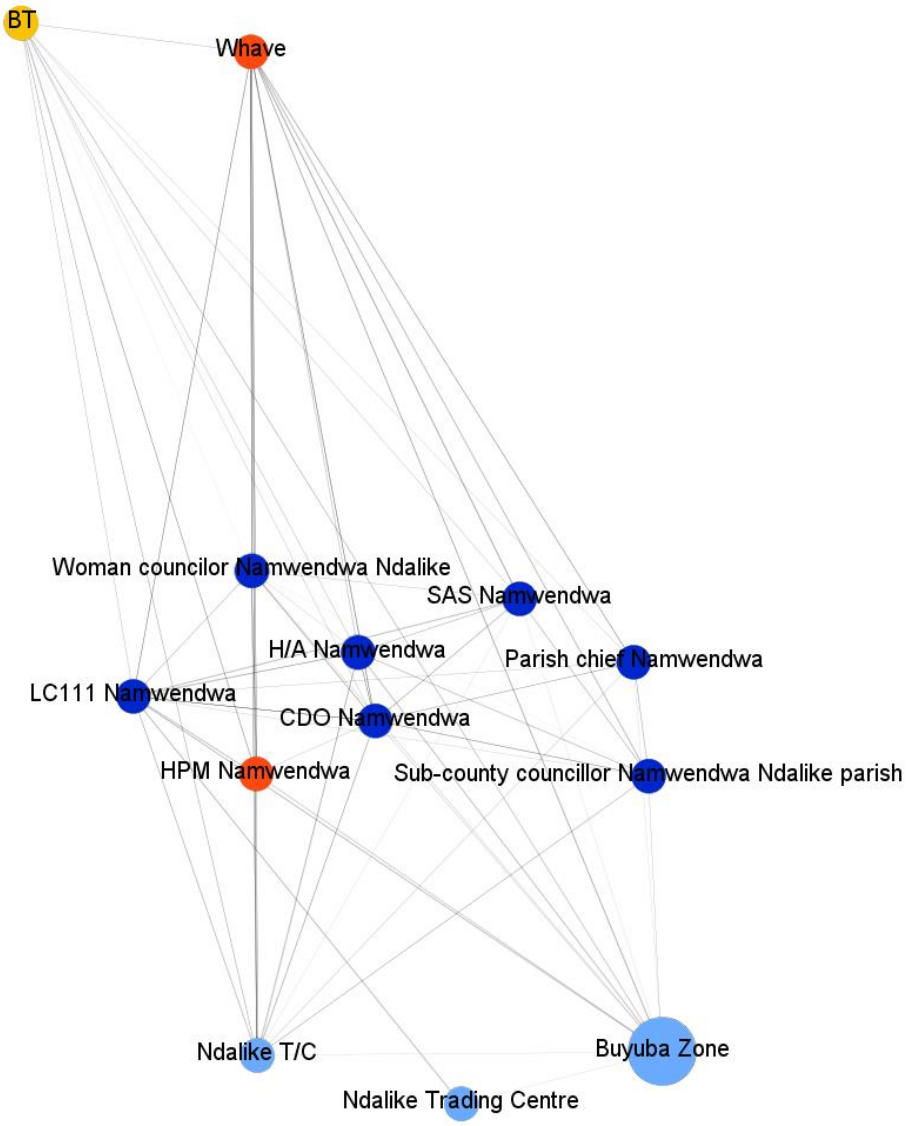

Figure 28. Buyuba Zone ego network

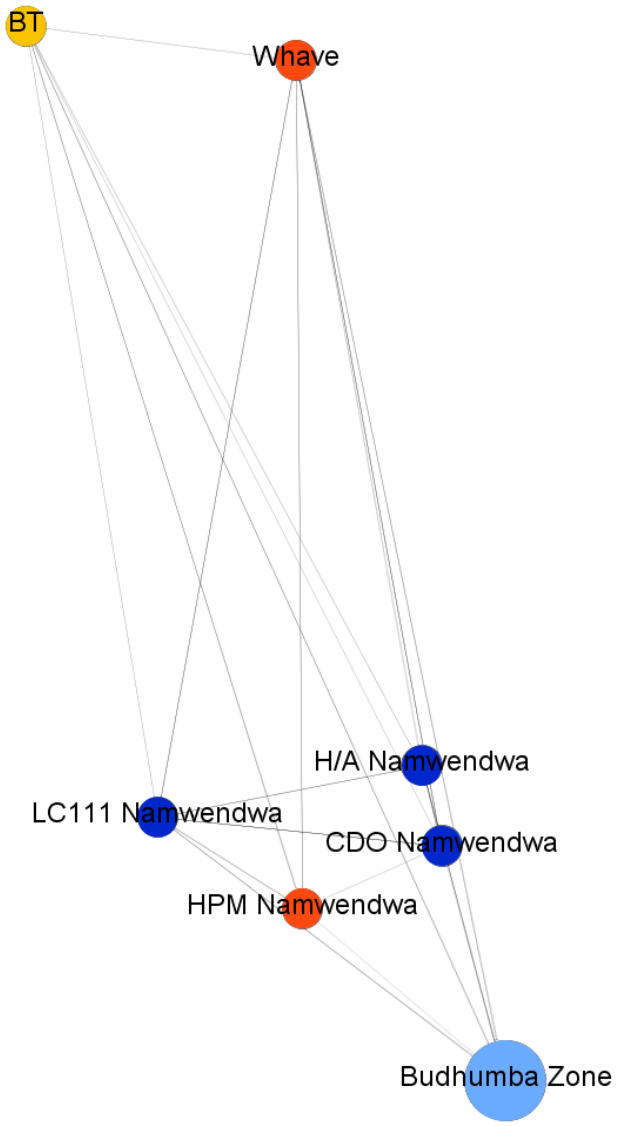

Figure 29. Budhumba Zone ego network

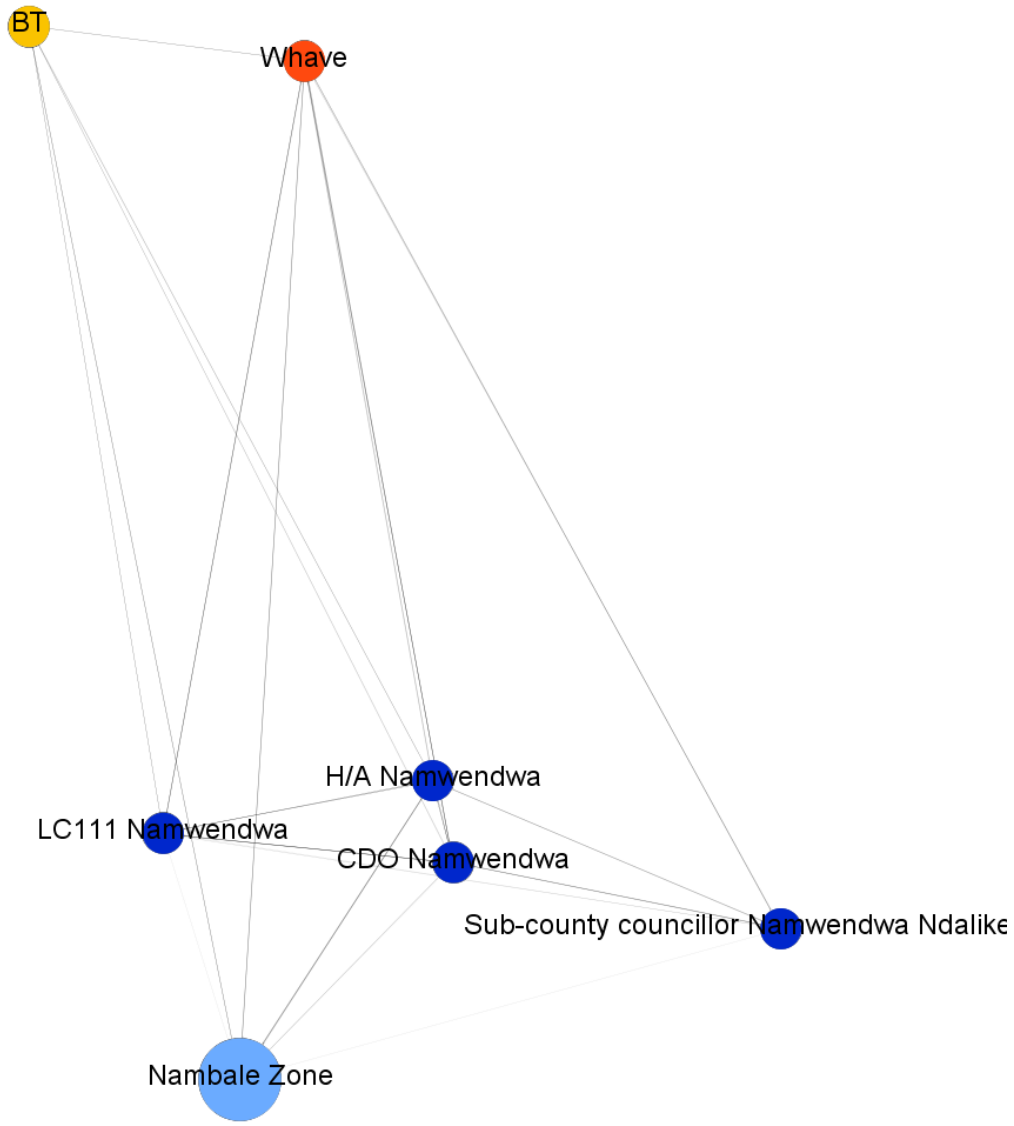

Figure 30. Nambale Zone ego network

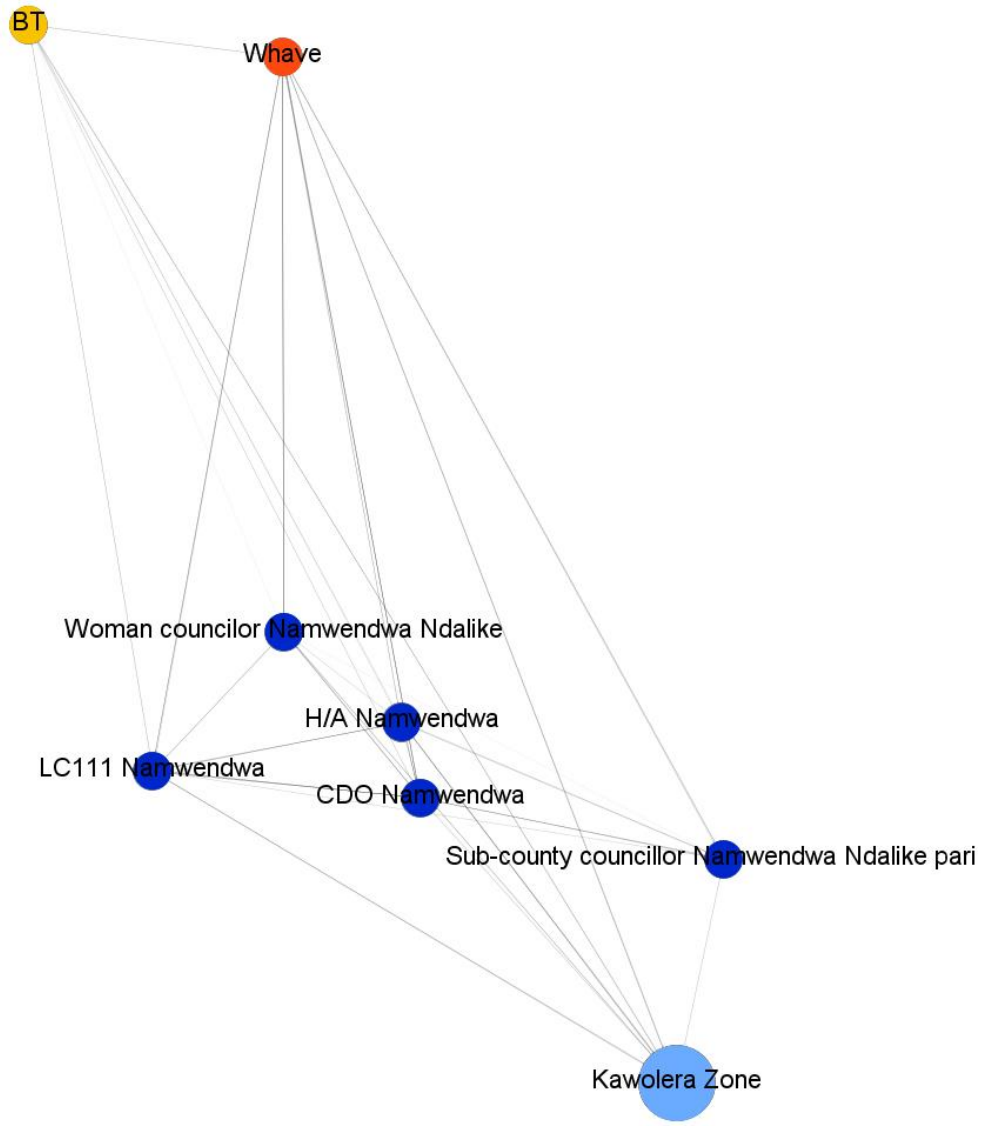

Figure 31.Kawolera Zone ego network

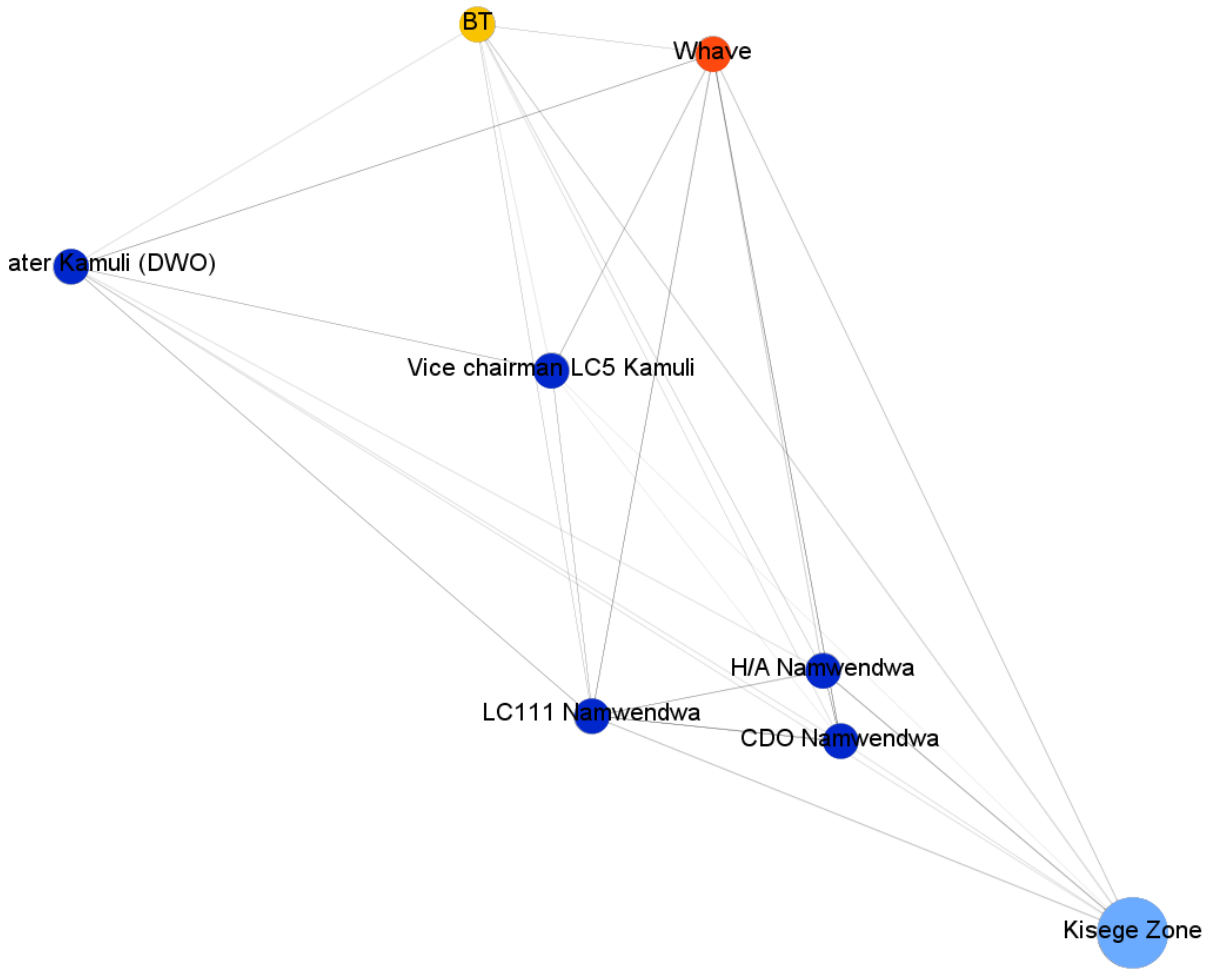

Figure 32. Kisege Zone ego network

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