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How does water information flow? Intersectionality in water information networks in a rural Ugandan community

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Abstract

This article presents evidence of a Ugandan community's information network related to water services and argues that an intersectional perspective is key to understanding information exclusion processes. Using questionnaire data and social network analysis, the article compares access to water information channels by gender and educational level. While men primarily share information with other men, women mainly exchange water information along educational lines. Low-educated women are least likely to receive information from other gender-education groups. Women are also underrepresented in the network of local government officials and consequently lack bridging ties, remaining more dependent upon informal information channels.

Keywords: intersectionality; gender; education; water information; networks; Uganda

Introduction

In this article, we study a Ugandan community's information network with regard to water services and illustrate that an intersectional gaze is key to understanding the processes of exclusion and inclusion in bottom-up and top-down information streams. The article uses both questionnaire and social network data to compare four population groups by gender and educational level in terms of their access to information about water, the information channels through which they receive this information and the people they share water information with and receive information from. Furthermore, we explore the implications of these findings for potential water interventions, both in terms of targeting and information channels to focus on.

Two-way information streams

Information is a key economic resource and the academic and practitioners' literature increasingly recognizes information poverty as a barrier to development (Romer, 1993; Chowdury, 2006; Fletschner & Mebah, 2011; Kibler, Biswas, & Lucas, 2014). Interventions in the water sector and beyond often assume that two-way information streams (i.e. both top-down and bottom-up information exchange) already exist, or aim to stimulate such streams. Both directions of information exchange are considered crucial, as their combined force can strengthen the efficiency, effectiveness and accountability of interventions. Top-down information streams, on the one hand, inform the community about water management and facilitate the implementation of government policies on the ground. To achieve this, community members need to be aware of policy aims, targets and tools. At the same time, the information available at higher government levels, for example on water quality[1] and budgets, should be shared transparently with citizens so that they can hold those responsible accountable for service delivery. Such top-down information sharing also ensures that citizens are aware of the costs associated with water service delivery and maintenance, which can create support for the introduction of water fees. Bottom-up information sharing, on the other hand, is crucial as community members – the service users – possess much knowledge about water and local conditions. Participatory decision-making not only creates a sense of ownership, but also ensures that villagers' knowledge, preferences and water needs are shared with policy makers, so that more effective water interventions can be designed and implemented (Honkalaskar, Sohoni, & Bhandarkar, 2014).

Gender and intersectionality

The gender and development literature has shown that it is essential for women to be included in water-sharing networks and for them to be able to make water-related decisions (Green, Joekes, & Leach, 1998; Zwarteveen, 2006). This is because water is a resource that women encounter frequently in their daily lives as a result of the gender division of labour. It is women who fetch water, often walking long distances; queue at taps; prepare food using water, perhaps taking additional steps to ensure that the water is potable (e.g. boiling or chlorination); and take care of people suffering from waterborne diseases (see e.g. Baguma, Hashim, Aljunid, & Loiskandl, 2013 on Uganda). Consequently, women's knowledge on the subject of water (e.g. distance to water sources, functionality of the source) is extensive and should be passed along the governance chain so that policies can be designed that are appropriate and suitable for local circumstances. Research has nevertheless shown that, in practice, women are often excluded from formal water committees and therefore from formal decision-making about the subject. Despite the fact that the water-using community disproportionally consists of women, the decision-making community is usually predominantly male (Cleaver & Elson, 1995) and women's involvement limited to the implementation phase (Cornwall, 2003). Indeed, women are likely to be the ones implementing water initiatives and policies because of their daily domestic tasks, as described above. Moreover, evidence has shown that if women are excluded from interventions, these are likely to fail (Cornwall, 2003). For example, when only men receive training, the knowledge they acquire is often assumed to reach women 'automatically'. Yet research has shown that information is not always shared between husbands and wives within the household (Fletschner & Mesbah, 2011).

When women are not part of formal decision-making bodies, they not only miss out on opportunities to share their knowledge and to influence water decisions, but they are also excluded from important top-down information sharing. Research finds that Ugandan women are disadvantaged when it comes to receiving information (Fattah, 2016), and the UN considers

women's lack of access to information as the third major challenge faced by women in developing countries, after poverty and violence (Primo, 2003).

The literature thus indicates that information poverty is a key challenge for women. However, other marginalized groups with limited resources are also subjected to this type of poverty. For example, Hoang, Castella, & Novosad (2006: 524) argue that "it is easier to reach larger, wealthier, better connected, and often more highly motivated farmers than it is to interact with small-holding, resource-poor, low-income farmers." In this regard, it is easier to share information with more highly educated citizens than with those who cannot read or write (Baguma et al., 2012). Citizens with a lower educational level are thus less likely to receive information about water interventions (Fletschner & Mesbah, 2011). Similarly, information reaches urban populations more easily than it does populations living in more remote areas (Afrobarometer, 2017).

These issues make it clear that an intersectional approach is required: the social category of gender cannot be addressed in isolation from other social and economic dimensions of social identity. Instead, categories such as gender, ethnicity, class and educational level reinforce and influence each other in shaping people's access to resources such as information (Shields, 2008). This phenomenon is what we refer to as intersectionality.

Social ties and information

Social ties are important channels for learning and information exchange. In particular, *whom* an individual has social ties with is crucial and determines the nature of the information that is shared in his/her social system (Haythornthwaite, 1996; Thuo et al, 2014). Depending on the type of channel a person receives his/her information through, he/she is likely to receive other information as well: for example, informal information about water is likely to relate to the functionality of water taps, while formal information could relate to budgets, water quality and

future projects. In the social network literature, it has also been argued that bridging relationships, in particular, bring new information into a network. Bridging relationships are those that serve as bridges between different heterogeneous or social groups (Barnes-Mauthe, Gray, Arita, Lynham, & Leung, 2015). Bonding relationships, on the other hand, are ties that link similar people together, and are more likely to bring in information that confirms what the other actors in the network already know (Ruef, 2002; Thuo et al., 2014).

Research questions and policy relevance

In this article, we focus on the aspect of information exchange. Taking the case of one village in rural Uganda, and using both questionnaire and social network data, we answer the following research questions. First, we explore which groups (by gender and educational level) receive information about water services in the village, and through which information channels. We distinguish between four categories – namely lower-educated men and women and more highly educated men and women – and two information channels – namely informal information sharing through family, friends and religious groups and direct communication with formal local government leaders. Second, we examine whether formal channels reach all groups in the village and whom local government officials themselves share information with. Third, we investigate how information about water services is exchanged between gender-education groups; in other words, how information travels or flows between these groups. Wherever possible, we pay attention to both bottom-up and top-down information exchange throughout the analysis. Finally, we discuss the implications for water interventions, with regard to both the targeting of beneficiaries and the information channels to focus on. Besides formal information channels, we also consider radio broadcasts and ICTs such as mobile phones. We ascertain, thus, whether the right choice of information channel can prevent or mitigate the exclusion of certain gender-education groups.

The findings of this research are relevant for interventions that focus on the water and climate change sectors. While the article focuses on revealing processes of inclusion and exclusion in information exchange concerning water, the same mechanisms could be at work in information exchange related to climate change and its effects. Previous research (Rodgers, 2003; Thuo et al., 2014) has indicated that farmers' adoption of adaptation strategies and new technologies is dependent upon their ability to obtain new information from relevant sources, so mapping information networks and exclusion mechanisms building on the findings from this article could be a crucial first step in understanding climate change adaptation (or the lack of it) among farmers.

In the remainder of the article, we first describe the methodology and case study village before presenting the results on who shares information with whom and through which channels, as well as who is excluded from the water information network. Finally, we discuss the implications for water interventions.

Methods

In this article we use two methods: questionnaire data and statistical analysis, and social network data and analysis. Social network analysis (SNA) is a method that is suitable for studying the 'social fabric', conceptualized as a set of actors (*nodes*) and relations (*ties*) between those actors (Marin & Wellman, 2011). SNA uses formal network measures to describe both the structural features of the entire network and the position of an actor in a larger network. While the former is key to understanding overall patterns of relations (e.g. information exchange in a village), the latter can improve our understanding of how a particular actor might be constrained or benefitted by the position he/she has within the overall network (e.g. an isolated actor).

The questionnaire and network data were collected between September and December 2015 by a team of six Belgian and Ugandan researchers[2]. All households in the village under study were visited in order to map the population in its entirety. We defined our population as all inhabitants over the age of 25 years who were residing in the village the majority of the time. Out of a total of 116 adults above the age of 25 years, 19 villagers were not selected because they worked outside of the village and were almost never resident there. Of the 97 inhabitants who met our selection criteria, 92 people were actually interviewed. Five inhabitants were either unavailable or unwilling to participate in an interview, thus producing a response rate of 95%. The 92 villagers retained in the study were included in the subsequent questionnaire and network data collection, organized in the form of face-to-face interviews in the local language. The research team collected data on socio-economic characteristics, water-related issues and political attitudes as well as a range of network data on different types of ties (full network data). In the network section, respondents were asked about the people they shared water information with (name generating technique): "During the last year, who did you share information with about water (e.g. availability, quality of water, functionality, time needed to collect water, cleanness of the well)?". Table 1 presents descriptive statistics and frequencies for the variables used in the analysis.

(Table 1)

Analysis

The questionnaire data were analysed using statistics (including cross-tabulation and t-tests) and focuses on top-down information sharing; in other words, whether survey respondents received information about water services or not, and through which channel(s). We constructed a dichotomous variable *lower/higher-educated*, where 'lower-educated' respondents had either

had no formal education whatsoever or had started primary education but not finished it. Respondents who were classified as 'higher-educated' had finished primary education and/or pursued secondary or tertiary education. The variable *information channel* was measured for the sub-sample of 53 (out of 92) respondents who indicated that they received information about water services in the village. The informal information channel included receiving water information via friends and relatives, a faith-based organization or an influential (but non-official) member of the community. The formal (local government) information channel included receiving information directly from village and/or parish leaders (i.e. the village chair (LC1) or parish chief (LC2))[3], in community meetings or via messages on notice boards.

Social network data and analysis offered a significant contribution to our research by allowing us to investigate bottom-up and top-down information exchange in tandem. We analysed three types of social network measures. First, we identified which nodes (or persons) were central in the information exchange network and potentially played an important role as brokers. Specifically, we found that the two local government officials living in the village were very central nodes in the information network, in terms of both betweenness centrality and degree centrality.[4] We subsequently investigated whom these two officials shared water information with and received information from by analysing their outgoing and incoming ties to the four gender-education groups. Second, network data contributed to our research by allowing us to analyse the densities of information networks among the four gender-education groups and thus establish which groups shared information with each other.[5] Third, we investigated blind spots in the information network – nodes that are not reached by any of the information channels (formal, mobile phone or radio) – and we investigated the characteristics of these individuals.

Study Area

The village under study was an average village in Bushenyi District in Uganda's Western Region[6]. Its population was relatively homogeneous, in terms of both language and ethnic composition. During the study, 62% of villagers reported having gone without clean water 21 to 30 times during the last month, and 98% of villagers recorded poor water quality as one of the water-related problems in the village. A round trip to fetch water took respondents 24 minutes on average, with values ranging from 1 minute to 60 minutes. Water quality can be considered the main water problem in the village, with 93.5% of the population fetching either surface water or water from unprotected shallow wells. It should be noted that although a water user committee had been formally established in the village, and seven villagers reported being members of the committee, the committee was in fact no longer functional (source: questionnaire data).

The aim of this article is not to empirically extrapolate findings to other villages in the region or indeed to Uganda as a whole. Instead, we wish to uncover key mechanisms of exclusion and inclusion in our study village's water information network. While these mechanisms may not function identically in other villages, the article's argument remains valid in any context: acknowledging intersectionality is crucial to understanding water information networks effectively. Indeed, social categories such as gender and education cannot be addressed in isolation from each other and from other social and economic categories; instead, they intersect to form social structures of inclusion and exclusion (Crenshaw, 1989; deleted for blind review). Before conclusions can be drawn for other villages or areas, in-depth research of the prevailing local networks and intersectionality is required.

Results

Water information received and channels used

The questionnaire results indicate that, on average, 60% of the respondents in the village did receive information about water services (i.e. 53 out of 89 villagers). Although the majority of the village did receive water information, it is clear that a considerable number of people were excluded from receiving information about water services. There appears to be no distinction in terms of gender or educational level: both men and women and high- and low-educated villagers received information to similar degrees.

Among the 60% who did receive information about water services, we used cross-tabulation and t-tests to investigate which channels villagers received the information through. We found that intersections of gender and educational level are key in determining whether people receive information through informal channels (mainly via friends and family members) or through formal local government channels (mainly through direct contact with the village chair or community meetings). First, we found that higher-educated villagers were more likely to receive information through formal channels. Specifically, among the higher-educated villagers, 48% received information through formal channels, while only 23% of the low-educated villagers used these formal channels.[7] In terms of gender, we found that 57% of the men who received information did so through the local government, while this was the case for only 22% of women.[8] We note that this difference is almost entirely due to higher-educated men (followed by lower-educated men) receiving significantly more information about water services through community meetings, as well as directly from local government leaders. Community meetings, in particular, seem to discriminate against women, as no women – regardless of educational level – indicated that they had received water information through this channel. Higher-educated men are well-represented at community meetings, as 45.5% of them receive information through this channel, compared to 20% of lower-educated men. While higher-educated women are more likely to receive information directly from local leaders than are lower-educated women (31% compared to 12.5%), their percentages are still well below

those for higher-educated men (54.5% compared to 30%). As a result, lower-educated women need to rely more on informal channels to obtain information about water services. Indeed, the figures in Table 2 show that 75% of low-educated women rely on informal channels to receive information about water services, which is significantly higher than in the three other gender-education categories.

(Table 2)

Formal local government channels thus mainly benefit or reach higher-educated men. These results indicate that intersections of gender and education are important: lower-educated women are the least likely to receive information through formal channels. At the same time, higher-educated women and lower-educated men are also somewhat disadvantaged in receiving information via this formal channel.

Social network data collected during in-depth field work can deepen our understanding of how information flows permeate different groups in the village (see also Methods section) and the results of the social network analysis are presented below. In the analysis, we focus on the two government officials.[9]

Local government officials' information network

In the next section, we focus our analysis on the social networks of two government officials, namely the village chair and the parish chief. The village chair is the local government official at village level (LC1) and our own previous research has shown that this actor is key in the social fabric of the village (ref blinded for review). The parish chief belongs to the parish level (LC2), but as he happened to live in the study village, he could potentially play a prominent role in village information sharing networks due to his official position. Both men belong to the

group of higher-educated villagers, and were found to be very central in the village information network[4]. This is in line with earlier studies on Uganda and other East-African countries, which have suggested that citizens share information with and seek support from the village chair in particular. This is because they trust the LC1 and consider him/her to be one of the villagers. At the same time, being the lowest level of local government, the village chair is also a convenient entry point or first point of contact with the local government structure (own field research; Francis & James, 2003; Stein, Ernstston, & Barron, 2011; source deleted for blind review).

The figures are presented in Table 3. Looking at both incoming and outgoing ties, we find that the two officials mainly have ties to other men (both high- and low-educated). The village chair primarily has links to higher-educated men, followed by low-educated men and then women. The parish chief primarily has links to low-educated men, followed by high-educated men. When we limit our analysis to the officials' outgoing ties, in other words the people to whom the officials provide water information (top-down information sharing), the results are even more skewed. We see that the village chair shares no information with women (regardless of educational level). Similarly, the parish chief shares information with no low-educated women and only one higher-educated woman. Both officials overwhelmingly share their information with other men.

(Table 3)

While the local government officials share little to no information with women, the total number of ties between the officials and the different gender-education groups indicates that women, on the contrary, do feed information to the local government officials. That is, women do share bottom-up information with officials. This finding is encouraging, as women possess

good indigenous and gender-specific knowledge of water and climate change due to gender divisions of labour in which they are responsible for water fetching. Although similar numbers of men feed information to the village chair, and slightly more men than women feed information to the parish chief, women are not as starkly underrepresented in the officials' incoming information ties (bottom-up) as in their outgoing ties (top-down).

To sum up, women – especially lower-educated women – are relatively excluded from receiving information about water services from the local government (top-down information stream). Consequently, they mainly rely on obtaining such information through informal channels such as family and friends. We also found, however, that they do feed information to local government officials (bottom-up information stream). This implies that information sharing is not always reciprocal.[10] It is therefore important to consider both directions of information sharing when designing water interventions and policies.

Information sharing between gender-education groups

If women are less likely to receive water-related information through formal channels, we must ask ourselves whether and how information on this topic can reach them. We therefore investigated how the four gender-education groups share information among themselves and whether those who receive information from the local government then pass that information on to women (and especially low-educated women). Table 4 presents the densities of the information sharing networks for the various gender-education groups.

The analysis reveals that the density of information sharing networks ranges from 0 (higher-educated men sharing information with low-educated women) to 0.056 (low-educated men sharing information with higher-educated men).[11] Specifically, we find that low-educated men share information primarily with other low-educated men and with high-educated men. In turn, high-educated men primarily share information with other high-educated men, as well as with lower-educated men. For low-educated women, the picture is more diverse. They share

information primarily with low-educated men, followed by (to similar degrees) high-educated men, low-educated women and high-educated women. Finally, we find that high-educated women share information primarily with high-educated men and high-educated women.

(Table 4)

Earlier studies have shown that information flows are stronger among individuals who have similar characteristics (e.g. Conley & Udry, 2005 on Ghanaian farmers). This is borne out by our field research on water information exchange in our study village. However, we also found fundamental differences in whom men and women share information with. In particular, we found that, among men, there is much homophily[12] in terms of gender: men primarily share information with other men. Furthermore, this information sharing is largely independent of educational level: both high- and low-educated men share information with each other. Among women, on the other hand, we find homophily in terms of educational level rather than gender. Especially among higher-educated women, there is a stark contrast between the relatively high density of information sharing with higher-educated men and women and the low density of information sharing with lower-educated men and women. Thus, while men share information with each other, regardless of their educational level, the educational divide appears to be harder for women to bridge, as women are more likely to share information with someone who has the same educational level than with someone of their own sex who has a different educational level.

Looking at the receiving end (incoming ties), it is clear that low-educated women receive little information from all groups. They are most likely to receive information from other low-educated women. After low-educated women, higher-educated women are the least likely to receive water information. Like lower-educated women, they are most likely to receive information from their own peers, in this case other higher-educated women. Among men,

higher-educated men are more likely to receive information than are lower-educated men, though the difference is minimal.

The data clearly reveal the importance of the intersectionality aspect (i.e. looking at intersections of gender and educational level). In particular, the reality of receiving and sharing information differs between high- and low-educated women. This is one of the key contributions of network analysis, which allows us to consider two-way information streams as well as the density of information exchange across different groups. Such analyses shine a spotlight on important intersectional issues.

Implications for interventions

In this section, we focus on some of the implications for interventions that rely on top-down information dissemination.[13] As we discussed in the previous sections, women, and in particular low-educated women, are currently excluded from the village's formal water information network. The fact that a large proportion of the population is denied access to water information may have detrimental impacts on water interventions. We therefore examine other information channels that could ensure women's inclusion in the information network. Besides formal information channels, we explore the potential role of radio broadcasts and 'new technology' mobile phones as these are increasingly being heralded for their potential to reach more isolated groups and foster mass information dissemination. Table 5, below, details the gender-education groups' access to mobile phones and use of radio.

Table 5 indicates that the majority of the villagers in all of the gender-education categories possessed their own mobile phones, with the exception of low-educated women, 56% of whom used someone else's phone. Two of the 78 respondents reported never having used a mobile phone; both were lower-educated (one male and one female). Almost all higher-educated men and women possessed their own phones. The second panel of Table 5 focuses on radio use. We found that the majority of villagers in each of the gender-education groups received news via

the radio on a daily basis. Nevertheless, women's percentages were somewhat lower and a significant proportion of low-educated women never listened to the radio, while a significant portion of higher-educated women did so only sporadically.

(Table 5)

To sum up, and as shown in Table 6, women – and especially low-educated women – are less likely to receive information through the formal channel. Gender and educational level appear to have a strong influence on the structure of local power relations, and hence access to information. At the same time, low-educated women have the least access to personal mobile phones. Finally, while information is likely to reach a large proportion of women via radio broadcasts, a significant proportion of them never or only rarely listen to the radio.

(Table 6)

The question arises as to whether it is always the same low-educated women who are excluded from receiving information via the three aforementioned channels. The village network is presented visually in Figure 1. A larger symbol implies that the node has been reached by fewer interventions; in other words, the largest nodes have not been reached by any of the three possible channels (formal, mobile phone nor radio). The smallest nodes have access to all three information channels. We refer to the nodes that are not reached by any of the interventions as blind spots. In the village's water information network there are nine blind spots in total (i.e. an average of 10% of the network), and six of these are low-educated women (i.e. 67 % of all blind spots). Indeed, Figure 1 visualizes the overrepresentation of low-educated women (inverted triangles) among the blind spots (the largest symbols). The figures indicate that the majority of low-educated women (56%) receive information through just one (out of

three) channels; 24% are blind spots; and 20% have access to two information channels. No low-educated women receive information through all three channels. Among high-educated men and women, on the other hand, the majority have access to two information channels (65% and 62.5% respectively). To sum up, the majority of low-educated women can be reached by at least one intervention, but they are less likely than other gender-education groups to be reached by more than one intervention. In addition, there is a sizable group of low-educated women who are not currently reached by any of the three interventions. These women are most at risk of being excluded from valuable water information.

(Figure 1)

Our empirical evidence therefore implies that for many villagers who are not part of the officials' information network, information dissemination via radio or mobile phone could be a viable alternative. However, these alternative information channels are also less likely to reach women, especially low-educated women, who consequently remain dependent upon family members, friends and neighbours for water information. Water interventions aiming to rely upon radio and/or mobile phone information dissemination should therefore be aware that it is essential to include a number of low-educated women directly among their beneficiaries. Without the direct targeting of disadvantaged groups in mobile phone interventions, for example, the information is likely to reach only the higher-educated.

We also argue that interventions would benefit from combining formal information channels with radio and mobile phone channels. If interventions do not use these combined information channels, they must ensure that the information channel is accessible to everyone, not only to the higher-educated. This could be achieved by explicitly targeting disadvantaged groups such as low-educated women (see also Fletschner & Mesbah, 2011, who also argue in favour of directly targeting rural women). As network densities (Table 4) indicate, low-

educated women are likely to pass information on to their peers through informal communication channels.

Conclusion

In this article, we analysed how water information flows among the inhabitants of one village in rural Uganda, using questionnaire and social network data collected during field research. We find that similar numbers of men and women and of high- and low-educated villagers receive information about water services in the village (60% of the population on average). However, villagers do not receive this water information through the same channel, and are therefore likely to receive different pieces of information. We distinguish between formal and informal information channels. Formal information stems from direct contact with village officials and community meetings, while informal information is typically received from friends, family members and neighbours.

With regard to formal information channels, the questionnaire data show that low-educated women are least likely to receive water information from officials. High-educated men, in contrast, are most likely to receive information through formal channels, followed by high-educated women and low-educated men. Looking at the social network data of the two local government officials, we learn that they share (top-down) water information with men, rather than with women. Of the officials' eight outgoing ties, only one was with a woman. This is problematic, as bridging ties with officials are crucial to ensuring the supply of new and policy-related water information. Indeed, people who have few bridging ties are deprived of information stemming from different parts of the social network, and they are therefore confined to receiving information through their bonding ties. Information received in this way is likely simply to confirm what they already know (see also Thuo et al., 2014). Despite not receiving formal information from officials, women do feed water information to them

(incoming ties, bottom-up). This is important, as women possess key knowledge of water sources as a result of a gender division of labour that puts them in charge of water fetching. However, future research should investigate what officials do with women's bottom-up information and whether bottom-up information flows also lead to better-informed policy decisions. It is clear, then, that information sharing is not reciprocal and that intersections of gender and educational level structure local power relations and, accordingly, access to information.

With regard to informal information channels, our questionnaire data indicate that low-educated women are more reliant on such informal channels than other gender-education groups. Social network data provide insights into information sharing between gender-education groups. Specifically, we find that men share water information with other men, across the educational divide. High-educated women, on the other hand, share their information primarily with other high-educated villagers, either male or female. This excludes low-educated women, as they receive little information from any gender-education group, and rely mostly on other low-educated women to obtain water information. We find an intersectional gaze to be key to understanding the different realities of receiving and sharing information for high- and low-educated women.

Discussion

This article suggests that interventions that rely on top-down information dissemination should take care not to deprive women of water information, since this could have a detrimental impact on the achievement of water management goals. How, then, can we ensure that low-educated women, in particular, receive important water information? Can interventions rely on modern technologies, which are increasingly used in information dissemination with the aim of reaching many people cost-effectively, and are often assumed to mediate local power relations? We find

that while ICTs such as mobile phones and radio broadcasts are able to reach more isolated groups within the community, low-educated women are the gender-education group that remains most difficult to reach. Our findings highlight that the majority of high-educated villagers have access to at least two out of the three interventions channels we studied (i.e. mobile phone, radio and formal channels). The majority of low-educated women, however, are reached by only one of the three interventions. Moreover, a small sub-group of low-educated women are not reached by any of the interventions; in other words, they are blind spots that are excluded from valuable water information. Hence, we argue that while mass information dissemination via radio and mobile phone could prove a viable alternative for those excluded from official information networks, a minority of mainly low-educated women remains excluded from water information. We therefore recommend that information and water interventions explicitly target low-educated women and rely on a combination of formal information channels and ICTs, such as radio and mobile phones, to minimize the exclusion of vulnerable populations.

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Notes

1. Water quality is a crucial challenge in Uganda as it was found in 2016 that 41% of rural water samples did not comply with national drinking water standards (Republic of Uganda, 2016: v).
2. The interviews with the local citizens were performed by the Ugandan researchers in the local language while the Belgian researchers conducted interviews (in English) with the political and technical duty-bearers. The Ugandan researchers were from the region in which the field study took place, so they were familiar with the local language and culture, but they did not live in the village so as to guarantee sufficient 'distance' and 'anonymity'.
3. In Uganda the local government is formed of a five-tier structure, in which Local Council (LC)1 is the village, LC2 the parish, LC3 the sub-county, LC4 the county, and finally LC5 is the district. All five levels have an elected chair as well as an administrative unit, and the district (LC5) and sub-county levels (LC3) also have technical staff (Francis & James, 2003).
4. Betweenness centrality identifies actors who are crucial in passing on information between two other persons who would not otherwise be directly connected (Barnes-Mauthe et al., 2015). This often implies that other people are dependent upon these central nodes for access to information (Ward et al., 2011). In our village information network, the parish chief scored highest in terms of betweenness centrality, while the village chair follows in third place. (In)degree centrality identifies local centrality, or the number of (incoming) ties an actors has in a network (Barnes-Mauthe et al., 2015). Indegree centrality measures the amount of information a node receives (incoming information). The village chair scored highest of all villagers in terms of indegree centrality (16 ties) and the parish chief achieved the fifth highest score (7 ties).
5. Density represents a population's degree of connectedness. The density of a group is measured by "the proportion of all possible ties that are actually present" (Hanneman & Riddle, 2005). Dense groups that are more tightly connected are often associated with solidarity (Ward, Stovel, & Sacks, 2011).
6. The village name is not disclosed because of the sensitive nature of social network analysis findings and the fact that certain individuals in the network might be easily identifiable.
7. Statistically sig.; $p < 0.1$.
8. Statistically sig.; $p < 0.05$.
9. Note that while trends from the questionnaire analysis remain valid, network data can provide more detailed insights into information sharing practices. Seemingly discrepant results from the two methods are caused by different question formulations and the richer nature of network data.
10. The reciprocity ratio is 0.050 (dyadic reciprocity), which is rather low. This means that of all pairs of actors who have any connection (all ties that are present), only 5% of the pairs have a reciprocal connection (Hanneman & Riddle, 2005).
11. Note that the overall densities in large networks tend to be low, and it is therefore most meaningful to compare densities to each other, rather than to consider absolute values.
12. Homophily "is the principle that a contact between similar people occurs at a higher rate than among dissimilar people" (McPherson, Smith-Lovin, & Cook, 2001: 416). Homophily has crucial implications for the information people receive, as the information "that flows through networks will tend to be localized" (McPherson et al., 2001: 416). The E-I Index is the number of ties external to the groups, minus the number of ties that are internal to that group, divided by the total number of ties. This value can range from +1 (complete heterophily) to -1 (complete homophily). E-I Index (gender) = -0.338 and E-I Index (education) = -0.227. The indices appear to reveal mild homophily effects. Nevertheless, crucial intersections are concealed by these indices, as it is primarily men who share information with men, regardless of their educational level, while women do not tend to share information across educational divides.

13. Note that we focus on top-down information dissemination only, as we found women's participation in bottom-up information sharing to be less problematic (see Table 3).

References

Afrobarometer (2017). *Afrobarometer Round 7 Survey in Uganda, 2017(compiled by Hatchile Consult Limited).* http://afrobarometer.org/sites/default/files/publications/Summary%20of%20results/uga_r7_sor_eng.pdf (accessed 8 June 2018)

Baguma, D., Hashim, J.H., Aljunid, S.M., Hauser, M., Jung, H., & Loiskandl, W. (2012). Safe water, household income and health challenges in Ugandan homes that harvest rainwater. *Water Policy, 14*, 977-990. DOI 10.2166/wp.2012.021

Baguma, D., Hashim, J.H., Aljunid, S.M., & Loiskandl, W. (2013). Safe-water shortages, gender perspectives, and related challenges in developing countries: The case of Uganda. *Science of the Total Environment, 442*, 96-102. DOI 10.1016/j.scitotenv.2012.10.004.

Barnes-Mauthe, M., Gray, S.A., Arita, S., Lynham, J., & Leung, P. (2015). What determines social capital in a social-ecological system? Insights from a network perspective. *Environmental Management, 55*, 392-410. DOI 10.1007/s00267-014-0395-7

Chowdury, S. (2006). Access to a telephone and factor market participation of rural households in Bangladesh. *Journal of Agricultural Economics, 57*, 563-576. DOI 10.1111/j.1477-9552.2006.00065.x

Cleaver, F., & Elson, D. (1995). *Gatekeeper Series No. 49: Women and Water Resources: Continued Marginalisation and New Policies*. London: International Institute for Environment and Development.

Conley, T., & Udry, C. (2005). *Learning about a new technology: Pineapple in Ghana* (Working Paper). New Haven: Yale University.

Cornwall, A. (2003). Whose voices? Whose choices? Reflections on Gender and Participatory Development. *World Development, 31*, 1325-1342. DOI 10.1016/S0305-750X(03)00086-X

Crenshaw, K. (1989). Demarginalizing the intersection of race and sex: a black feminist critique of antidiscrimination doctrine, feminist theory and antiracist politics. *University of Chicago Legal Forum 140*: 139–167.

Dewachter, S., & Holvoet, N. (2017). Intersecting social-capital and perceived-efficacy perspectives to explain underperformance in community-based monitoring. *Evaluation, 23*, 339–357.

D'Exelle, B, & Holvoet, N. (2011). Gender and network formation in rural Nicaragua: A village case study. *Feminist Economics, 17*, 31–61

Fattah, K.N. (2016). Right to information (RTI) legislation: the role of infomediaries in enhancing citizens' access to information. *Development in Practice, 26,* 3-14. DOI 10.1080/09614524.2016.1119248.

Fletschner, D., & Mesbah, D. (2011). Gender disparity in access to information: Do spouses share what they know? *World Development 39,* 1422-1433. DOI 10.1016/j.worlddev.2010.12.014

Francis P., & James R. (2003). Balancing Rural Poverty Reduction and Citizen Participation: The contradiction of Uganda's decentralization program. *World Development 31,* 325-337. PII: S0305-750X(02)00190-0

Green, C., Joekes, S., & Leach, M. (1998). Questionable links: Approaches to gender in environmental research and policy. In C. Jackson & R. Pearson (Eds), *Feminist Visions of Development: Gender Analysis and Policy* (pp. 259-283). Routledge: London & New York.

Hanneman, R.A., & Riddle, M. (2005). *Introduction to social network methods*. http://faculty.ucr.edu/~hanneman/nettext/C7_Connection.html (accessed 23 November 2016)

Haythornthwaite, C. (1996). Social network analysis: An approach and technique for the study of information exchange. *Library and Information Science Research, 18,* 323-342.

Hoang, L.A., Castella, J.C., & Novosad, P. (2006). Social networks and information access: Implications for agricultural extension in a rice farming community in northern Vietnam. *Agric Hum Values, 23,* 513-527. DOI 10.1007/s10460-006-9013-5

Holvoet, N., Dewachter, S., & Molenaers, N. (2016). Look who's talking: explaining water-related information sharing and demand for action among ugandan villagers. *Environmental Management, 58*, 780–796.

Honkalaskar, V.H., Sohoni, M., & Bhandarkar, U.V. (2014). A participatory decision making process for community-level water supply. *Water Policy, 16*, 39-61. DOI 10.2166/wp.2013.113

Kibler, K.M., Biswas, R.K., & Lucas, A.M.J. (2014). Hydrological data as a human right? Equitable access to information as a resource for disaster risk reduction in transboundary river basins. *Water Policy, 16(S2),* 36-58. DOI 10.2166/wp.2014.307

Marin, A., & Wellman, B. (2011). Social Network Analysis: an introduction. In J.S. Scott & P.J. Carrington (Eds), *The SAGE Handbook of Social Network Analysis* (pp. 11-26). Exeter: University of Exeter, Sage.

McPherson, M., Smith-Lovin, L., & Cook, J.M. (2001). Birds of a feather: homophily in social networks. *Annual Review of Sociology, 27,* 415-444. DOI 10.1146/annurev.soc.27.1.415

Primo, N. (2003). *Gender issues in the information society*. UNESCO Publications for the World Summit on the Information Society, Paris, France.

Rodgers, E.M. (2003). *Diffusion of Innovations (5th ed)*. New York: Simon & Schuster Inc.

Romer, P. (1993). Idea gaps and object gaps in economic development. *Journal of Monetary Economics, 32*, 543-573.

Shields, S. (2008). Gender: an intersectionality perspective. *Sex Roles, 59*, 301–311. DOI 10.1007/s11199-008-9501-8

Stein, C., Ernstston, H., & Barron, J. (2011). A social network approach to analyzing water governance: The case of the Mkindo catchment, Tanzania. *Physics and Chemistry of the Earth, Parts A/B/C, 36*, 1085-1092. DOI 10.1016/j.pce.2011.07.083

Thuo, M., Bell, A.B., Bravo-Ureta, B.E., Lachaud, M.A., Okello, D.K., Okoko, E.N., Kidula, N.L, Deom, C.M., & Puppala, N. (2014). Effects of social network factors on information acquisition and adoption of improved groundnut varieties: the case of Uganda and Kenya. *Agric Hum Values, 31,* 339-353. DOI 10.1007/s10460-014-9486-6

The Republic of Uganda (2016). *Water and Environment Sector Performance Report 2016*. Ministry of Water and Environment.

Ward, M.D., Stovel, K., & Sacks, A. (2011). Network analysis and political science. *Annual Review of Political Science, 14*, 245-264.

Zwarteveen, M.Z. (2006). *Wedlock or deadlock? Feminists' attempts to engage irrigation engineers* (Unpublished PhD thesis). Wageningen University, Wageningen, The Netherlands.

Table 1. Descriptive statistics

	Gender[a]	Highest level of education[a]	Low/high education[a]	Receiving info through informal channel[a]	Receiving info through formal channel[a]
Male	35 (38%)				
Female	57 (62%)				
No formal education		21 (22.8%)			
Some primary education		22 (23.9%)			
Primary completed		32 (34.8%)			
Secondary education		10 (10.9%)			
Tertiary education		7 (7.6%)			
Lower education (primary not compl.)			43 (46.7%)		
Higher education (primary completed)			49 (53.3%)		
Receive through informal channel				25 (47.2%)	
Not receive through informal				28 (52.8%)	
Receive through formal channel					19 (35.8%)
Not receive through formal channel					34 (64.2%)
N	92 (100%)	92 (100%)	92 (100%)	53 (100%)	53 (100%)
St. deviation	0.488	1.679	0.502	0.502	0.504

[a]Source: questionnaire

Table 2. Receiving information via formal or informal information channels, per gender-education group

	Channel through which respondent receives information [a]				
	Formal		Informal		Total
	%	N	%	N	
Low-educated men	40%	(4)	30%	(3)	(10)
Low-educated women	12.5%	(2)	75%	(12)	(16)
High-educated men	73%	(8)	45.5%	(5)	(11)
High-educated women	31%	(5)	31%	(5)	(16)
Total	100	(19)	100%	(25)	(53)

[a] Source: questionnaire (cross-tabulation). Note that the two categories are not mutually exclusive: someone can receive information through both formal channels and informal channels. Percentages are thus not row percentages.

Table 3. Ties between village chair, parish chief and gender-education groups.

	Low-educated men		Low-educated women		High-educated men		High-educated women		Total
	%	N	%	N	%	N	%	N	N
Total ties (incoming and outgoing)									
Village chair	25%	(5)	25%	(5)	30%	(6)	20%	(4)	(20)
Parish chief	40%	(4)	10%	(1)	30%	(3)	20%	(2)	(10)
Total (2 officials)	32.5%		17.5%		30%		20%		100%
Outgoing ties									
Village chair	75%	(3)	0%	(0)	25%	(1)	0%	(0)	(4)
Parish chief	25%	(1)	0%	(0)	50%	(2)	25%	(1)	(4)
Total (2 officials)	50%		0%		37.5%		12.5%		100%

Source: network data

Table 4. Density of information sharing between education-gender groups and absolute number of outgoing ties between the groups (between brackets)

	Low-educated men		Low-educated women		High-educated men		High-educated women		Total outgoing ties
Group sharing information									
	Density	N	Density	N	Density	N	Density	N	
Low-educated men	**0.036**	(11)	0.002	**(1)**	**0.056**	(17)	0.003	(2)	
Low-educated women	**0.031**	(14)	0.015	(9)	0.019	(8)	0.011	(9)	
High-educated men	**0.036**	(11)	0	**(0)**	**0.044**	(12)	0.006	(3)	
High-educated women	0.010	(6)	0.005	**(4)**	**0.028**	**(15)**	**0.026**	(26)	
Total incoming ties		(42)		(14)		(52)		(40)	(148)

Source: network data

Table 5. Use of mobile phone and radio by gender-education group

	Do you use a mobile phone?				How often do you receive news via radio?			
	Never	Someone else's phone	My own phone	Total	Never	Not frequently	Every day	Total
Low-educated men	7.7% (1)	30.8% (4)	**61.5%** (8)	100% (13)	11.1% (2)	0% (0)	**88.9%** (16)	100% (18)
Low-educated women	5.6% (1)	**55.6%** (10)	38.9% (7)	100% (18)	20% (5)	12% (3)	68% (17)	100% (25)
High-educated men	0% (0)	12.5% (2)	**87.5%** (14)	100% (16)	6.3% (1)	6.3% (1)	**87.5%** (14)	100% (16)
High-educated women	0% (0)	6.2% (2)	**93.5%** (29)	100% (31)	3.1% (1)	25% (8)	71.9% (23)	100% (32)
Total	2	18	58	78	9	12	70	91

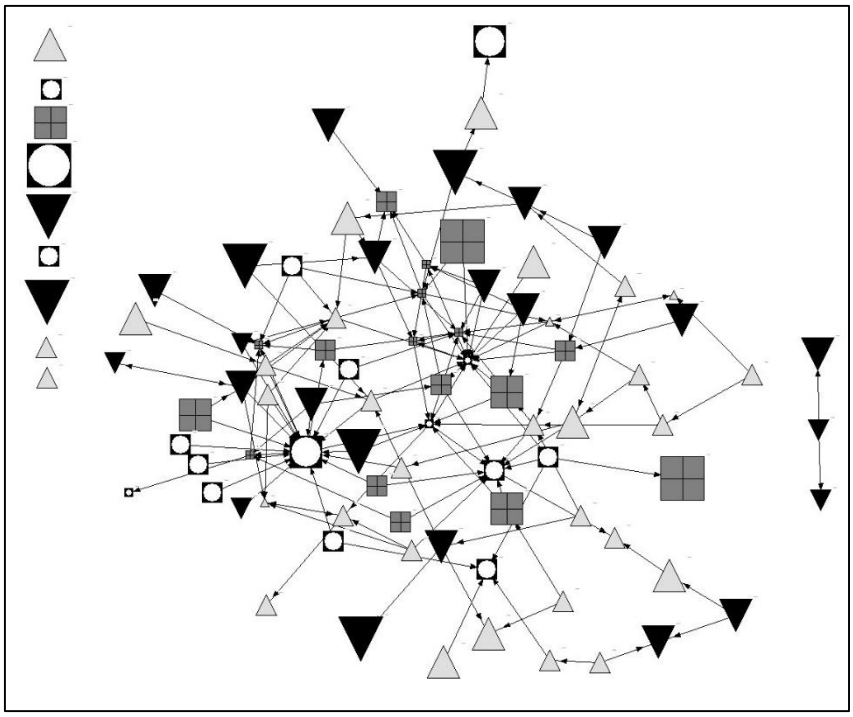
Source: questionnaire

Table 6. Beneficiaries of various information channels by gender-education groups

	Low-educated men	Low-educated women	High-educated men	High-educated women
Local officials[1]	✓ 50%	✗ 0%	✓ 37.5%	✗ 12.5%
Mobile phone[2]	✓ 61.5%	✗ 38.9%	✓ 87.5%	✓ 93.5%
Radio[3]	✓ 88.9%	✓ 68%	✓ 87.5%	✓ 71.9%

Notes: check mark (✓) is used when the gender-education group is likely to be reached by the information channel (✓when majority of gender-education group can be reached by the channel, but significantly less than in other gender-education groups); cross mark (✗) when none or only a small percentage of the gender-education group can be reached through the channel. Variables: [1] The official channel is measured as the percentage of the two officials' outgoing ties to each gender-education group (derived from network data; see Table 3). [2] The mobile phone channel is measured as % of each gender-education group possessing their own phone (source: questionnaire data; see able 5); [3] The radio channel is measured as % of each gender-education group that receives news through the radio on a daily basis (source: questionnaire data; see Table 5).

Figure 1. Blind spots - who is not reached by the three information channels (or ‘interventions’)



Notes: The size of the symbol = reversed scale of the number of interventions, i.e. the smaller the node, the more interventions reach this person. Score 0 = none of the three interventions; score 3 = one intervention; score 6 = two interventions; score 9 = all three interventions. The shape and colour of the symbol represents the four gender-education groups. Inverted triangle (black) = low-educated woman; upward triangle (light grey) = high-educated woman; box (dark grey) = low-educated man; circle in the box (white) = high-educated man.