Co-Designing with Communities to Support Rural Water Management in Uganda

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The use of Information and Communication Technologies (ICTs) in developing regions has gained momentum due to their increasing affordability, particularly in rural areas where other ICT infrastructures for information management are often non-existent. Giving potential technology users the opportunity to actively engage and contribute to the design of an artefact increases adoption and sustainable use. In this paper, we illustrate our application of Community-Based Co-Design (CBCD) that led to the development of an ICT intervention to support water management in three rural communities in Uganda. The community-based system helps water managers to track water users, payments and expenditures in a bid to improve transparency, accountability and trust. We present research learnings of the method and how engagement with rural communities can be improved through the use of intermediaries and paying more attention to community values as well as exercising ethics of reciprocity in community-based ICT initiatives.

Keywords: Co-Design; Communities; Water Management; Values; Intermediaries; Reciprocity; Appropriation

1 Introduction

Designing new technologies for developing regions has been approached in two ways according to Avgerou (2010): a transfer and diffusion approach and as socially embedded action. With the transfer and diffusion approach, knowledge and innovation emanate from a more developed context with innovations pre-conceived and only transferred into the beneficiaries' context. Avgerou notes that a socially embedded approach better identifies the relevant context than transfer and diffusion. Echoing Dearden and Rizvi (2008), as designers we accept that the participation of users is key to ensuring that tools are relevant, usable and sustainable. Furthermore, the changing relationship between technology and human experiences is forcing technologist to look beyond technical quality to the user and their context (Rivett, Marsden, & Blake, 2014).

Technologies have often been designed for users who are knowledgeable or experienced (Dearden, 2008). However, designing for communities in developing countries presents a different set of challenges. A recognition of the connectedness among community members and the differences in social aspects such as ethnicity, culture and attitudes towards technological solutions is required to foster successful implementations (Rodil, Winschiers-Theophilus, & Jensen, 2012).

Participatory Design (PD) and several variations of participative approaches such as co-creation and co-design are promoting new ways of engagement (Sanders & Stappers, 2008). Through the use of appropriate tools, methods and design processes, knowledge gaps and social-cultural differences between researchers and community members are bridged (Sabiescu, David, Zyl, & Cantoni, 2014). It is argued that,

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although PD enables active engagement, users need to have a basic understanding of what technology can achieve (Blake, 2010; Marsden, Maunder, & Parker, 2008). Using appropriate tools and techniques to encourage untrained users to participate in technology design facilitates learning about technology (Blake et.al., 2011; Hussain et al., 2012; Winschiers-Theophilus et.al., 2010). The role of the technologist is thus to facilitate the process by which participants learn about ICTs and eventually take on design roles (Winschiers-Theophilus et. al., 2010).

Co-design has generally been applied in environments where participants have limited understanding of technology, are marginalized but knowledgeable about their own needs and experiences that can shape and contribute to the design process. Such studies include; elderly people with indigenous knowledge Winschiers-Theophilus et al., 2010), the Deaf (Blake et al., 2014; Blake, Tucker, Glaser, & Freudenthal, 2011), the Homeless (Southern et al., 2014; Yoo, Huldtgren, Woelfer, Hendry, & Friedman, 2013) and children (Bossavit & Parsons, 2016; Sanders, 2000).

Introducing technologies within communities is likely to disrupt social relations or potentially threaten existing power structures (Blake & Tucker, 2006). Furthermore, traditional participatory development methodologies assume that technology users can articulate their needs and are similarly educated (Blake et al., 2014). Researchers advocate for a better understanding of the environments in which implementations take place through active engagement, thus the notion of community-centred design (Dearden, 2008).

In this paper, we provide a reflective account of the experiences of applying Community-Based Co-Design (CBCD) in three rural communities in Uganda. The aim of our study was to engage with the communities in developing a solution to support their communal water management needs and practices.

2 Background

2.1 ICTs for Service Delivery in Communities

The increasing affordability of ICTs in developing regions, principally in the form of mobile phones, has created opportunities for information access to previously unreachable groups. To understand the potential of such ICT systems, a number of interventions have been implemented in rural areas with the aim of empowering communities through technology (Chetty, Tucker, & Blake, 2004). However, many of the implementations remain pilot projects due to their inability to provide suitable content, failure to understand and address priority needs (Blake & Tucker, 2006) or foster local buy-in from the communities and supportive institutions (Chetty et al., 2004; Dodson et al., 2012).

Technology-centric initiatives for development have often been driven by international organizations with the financial resources to drive a developmental agenda (Ashraf et al., 2008). A common characteristic of these interventions is that they are externally conceived, address an assumed need or are developed in an institution prior to deployment in the community (Dodson et al., 2012). The risk of this approach is that the community interactions are often short term and externally imposed, resulting in uncertain sustainability when the implementer leaves the community. Sustainability has been shown to improve when interventions are embedded within established institutional policies, structures and adopted to complement existing processes instead of replacing them (Champanis & Rivett, 2012).

Based on learnings from failures of ICT initiatives in communities, we advocate the use of participative design approaches. We believe this allows for closer engagement with communities to understand cultural nuances that could easily negatively affect adoption of potential technologies (Ramachandran et al.,2007). Such

engagement should not only focus on eliciting requirements but foster in-depth collaboration with potential technology users by developing a co-design attitude. A long-term collaboration is created by identifying the problem that needs to be addressed, agreeing on how to tackle the problem and together decide on how to measure success.

2.2 Community-Based Co-Design (CBCD)

Working with communities involves groups of people as opposed to individuals in addition to recognising the different types of communities needing a voice within every design situation (Blake et al., 2014). Community groups can be differentiated by: age, gender, ethnicity and physical abilities (DiSalvo, Clement, & Pipek, 2012). Technologies for these groups should be developed with a *'community mind set'*. The concepts of 'Ubuntu' (Blake et al., 2014; Winschiers-Theophilus et al., 2012) which was described by the Kenyan Canon Mbiti (Mbiti, 1990) as: *"I am, because we are; and since we are, therefore I am"*, are broadly shared in many parts of sub-Saharan Africa.

Community PD differs from traditional organisational PD that is characterised by mutual familiarity, temporal proximity and affiliation that is driven by extrinsic factors such as employment (DiSalvo et al., 2012). With rural communities, connections are voluntary and the process of engagement involves spending a considerable amount of time in conversations not directly relevant to the design activities but essential for building trust and relationships. Appreciating these differences leads to better interactions and participation in decision making (Winschiers-Theophilus et al., 2010).

Creating spaces that allow participants to express themselves, sometimes deviating from planned activities, provides a sense of release as the participants lead the design conversation in unexpected ways (Winschiers-Theophilus et al., 2012). Muller and Druin (2003, p.1135) further highlight the use of stories as triggers for conversation. Within these conversations are knowledge contributions about needs, design concepts, aspirations and solutions. CBCD as a form of *'Action Research in a design setting'* further contributes to the alleviation of the viewpoints and bias of researchers in pursuit of collective skills development and learning (Blake et al., 2011).

2.3 Enhancing community engagement

Developing technologies with rural users often requires immersion into the culture of the community to build trust and negotiate expectations. Intermediaries (champions or gatekeepers) often facilitate this process. These are people within and trusted by the communities, who are familiar with digital technology and aware of the problems and context (Chetty et al., 2004; Marsden et al., 2008; Rey-moreno et al., 2014). Intermediaries provide linkages to communities, broker connections and facilitate relationships with participants. Additionally, they guide the implementation of interventions unhindered by language or cultural gaps (Blake & Tucker, 2006) and are seen as a means of encouraging the participation of the wider community with whom relationships are maintained.

As they bridge the gap between technology designers and prospective users, intermediaries reduce the suspicion that users could have of outsiders and encourage participation (Dearden, 2008). Howells (2006) calls them change agents with a powerful influence on the speed of diffusion and uptake of new technologies.

2.4 Technology Appropriation and Reciprocity

Community-based ICT tools are usually implemented to achieve a specific goal. However, the limited infrastructure in rural environments makes technology diffusion and adoption not straightforward. This means that even for the tools implemented within communities, new and unexpected interactions can emerge.

We use *appropriation* to refer to unexpected ways that people use technology. Like Marsden (2009), we agree that technological devices do not serve a particular goal but provide new opportunities for people. In developing regions, technology users try to fit technology into their lives. This means that we ought to support people into discovering the possible uses of the tools we provide. Dix (2007) intimates that although it might be difficult for technology designers to predict the different possible ways of use, we can design tools and support unexpected use.

In addition, the long-term nature of CBCD has consequences for both the researcher and participants who commit time and contribute to knowledge. In resource-constrained environments like rural communities, participants prioritise their time for research over economic activities on which they depend for livelihood. Although they may voluntarily take part in the study without asking for payment, the ethics of reciprocity require us to make provisions to compensate them for their time and effort. Reciprocity in any form can build mutual trust and more effective engagement (Brereton et al., 2014; Kapuire et al., 2015; Scheyvens, 2014).

2.5 Human Values and CBCD

Technologies have become ubiquitous consequently increasing ethical concerns about their moral and social impacts (Halloran et al., 2009; Iversen, Halskov, & Leong, 2012). Ethical considerations are becoming even more necessary as technology advances into people's social lives beyond traditional boundaries of workplaces. For PD approaches, achieving genuine participation and empowerment require deliberate efforts to embed democratic values into design. Iversen et al. (2012) argue that simply adopting PD methods is not sufficient to claim to practice PD unless the PD methods are used to engage with values or negotiate them through participation (Grönvall et al., 2016).

CBCD implicitly involves working with communal value systems with principles of participation, empowerment and mutual benefit for both the researcher and the community. Blake et.al. (2011) not only target technology development, but also use this method to influence government policies and building capacity with ICT training. Artefacts developed with people's values in mind may be more usable and adoptable (Friedman et l., 2008; Halloran et al., 2009).

In the following sections, we describe our study methods used to engage with the communities and the results.

3 Research Methodology

The first author is Ugandan (lives and works in Uganda) and has worked on several rural ICT projects in Uganda. The second and third authors live and work in another developing country and are experienced in working with rural communities to introduce ICT interventions through co-design and to improve service delivery.

3.1 Context: Rural Water Management in Uganda

Many rural areas in Africa have poor access to safe water as a result of weak governance practices and disempowered institutions (Jiménez et al., 2010). In Uganda, rural water facilities are managed by communities through the Community-based Management Model (CBM) (Author, 2015).

A caretaker (anybody living closest to the water source) maintains records of water users and collects water fees. The water committee treasurer then collects the money from the caretaker and hands it over to a water board member who deposits it with a community cooperative fund. The dependence on a caretaker being physically available to manually manage records made this arrangement vulnerable to loss of data

and without clear forms of accountability and transparency, communities increasingly became apathetic towards communal water management.

Our study to empower the communal structures was conducted in three communities (Kasenda, Buheesi and Rubona) in Kabarole district in western Uganda.

3.2 Methods of Engagement

Our CBCD method comprised six cycles (summarised in Figure 1 and Table 1) and alternated between action and critical reflection. Initial engagement with participants was achieved through semi-structured interviews (for individual feedback), workshops and focus group discussions organized by the water officer (intermediary). The research process was documented using notes, audio recordings and photographs. Participants were orientated to the study by the water officer and presented with the objectives for each co-design session. Participants were encouraged to express themselves in their preferred language.

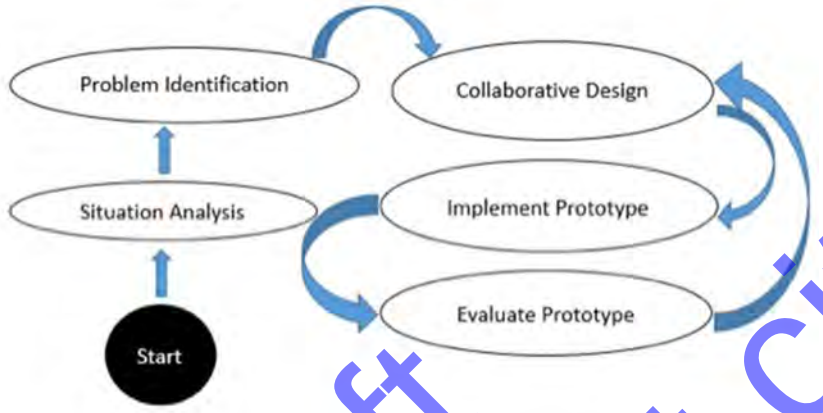

Figure 1. The cyclical and iterative CBCD research process

Table 1: A summary of the Research Cycles conducted for the CBCD study

Cycle	Objective	Procedure
1: Situational Analysis (July 2014)	- Understand access and water management challenges - Identify a study champion	- Conducted stakeholder analysis - Evaluated existing (non-technical) systems through community discussions
2: Problem Specification (October 2014)	- Community members assess communal management practices - Brainstorm solutions for improved water management. - Develop initial design specification	- Group participants in respective communities analysed their structures, identified causes of problems and possible solutions
3: Collaborative Design (October 2014)	- Communities to define their roles - Collectively refine requirements - Model aspirations and desired interactions	- Participants critiqued initial design decisions - Participants re-modelled desired design specifications
4: Prototype Implementation (January 2015)	- Develop initial prototype based on designs - Deploy version 1	- Conducted a training session on using the prototype - 10 water managers given devices to first explore and use on their own
5: User experience assessment (July 2015)	- Assess usage of PM4W and possible appropriation	- Individual discussions with the 10 participants given devices
6: Re-design (August 2015)	- Share assessment feedback with all participants - Respond to requests for design changes	- Collective re-design - Implement new changes (offline database, localise interface) - Trained 20 more water managers - Deployed version 2 of PM4W

The workshops varied in length from two to three days for six hours each day. At the end of each workshop we collected all the design products. The co-design ideas were expressed in the form of user stories, use cases, scenarios and interaction models. We use the pronoun 'we' to refer to the collective design decisions made by both the researchers and participants.

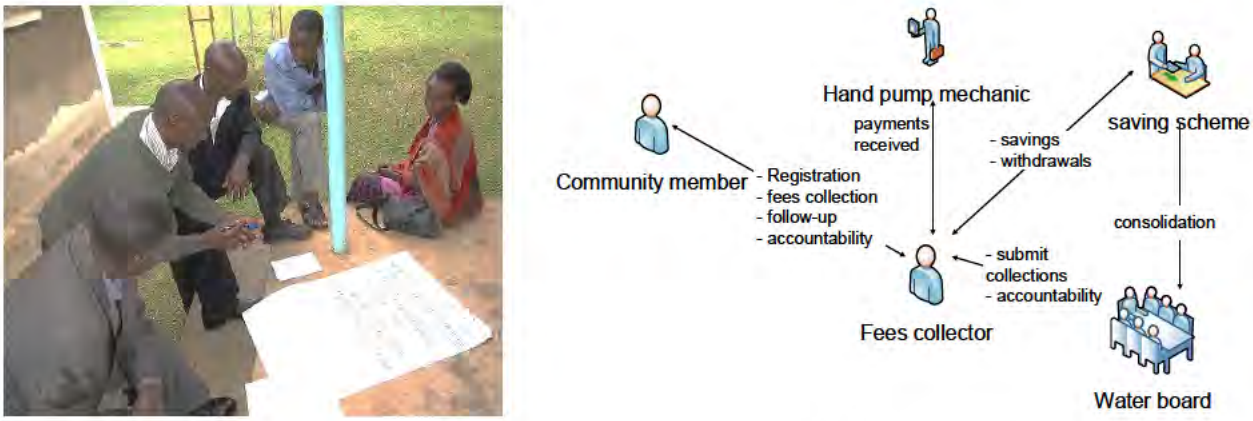

Figure 2. (a) Participants from Kasenda community assessing their communal structures and practices; (b) A model representing interactions between the different user groups

3.3 Participants

Cycle 1 had participants representing national stakeholder groups involved in rural water management (Directorate for Water Development in Uganda, 2011, p.18). Cycles 2 – 6 involved stakeholders within the communities (summarized in Table 2). The participants' ages ranged from 25 and 65.

Table 2: A summary of study participants in the different cycles

	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 5	Cycle 6
Ministry of Water (National)	3	1	1	-	-	-
NGO/CBO representatives	7	1	1	-	-	-
Local political/administrative leaders	3	3	3	1	-	-
District Water Office	1	1	1	1	-	1
Water Board representatives	2	2	2	1	1	2
Community treasurers	3	2	4	3	3	4
Water source caretakers	4	4	5	6	6	22
Pump mechanics	2	5	4	-	-	-
Water users	5	4	4	-	-	7
TOTAL	**30**	**23**	**25**	**12**	**10**	**36**

3.3.1 Using an Intermediary

Our initial link to the communities was a Community Learning Facilitator, working with an international NGO funding several community water projects. He introduced us to the important stakeholders to work with. Our intermediary left the community two months after cycle 1 when the NGO ended its operations due to funding cuts.

In finding another intermediary we wanted to work with an established local institution within the community. The district water office had been involved in the pre-liminary study and played a key role in mobilizing communities in water management. The water officer (DWO) agreed to be our intermediary for the rest of the study as he

appreciated our approach and potential contribution. Working with the DWO who forms part of the government structure provided continuity.

4 Research Process and Findings

4.1.1 The Environment

Central to communal water management in Uganda is having a sustainable financial management system. This means regular payment, collection and management of water-user fees. Participants highlighted that unwillingness to pay resulted from poor accountability and management by water managers. The communal water managers failed to maintain records of water users and were consequently unable to keep track of monthly payments. Through the discussions with the participants, we identified ways to improve user-fees management. The emergent need was to have an ICT tool to support efficient and transparent financial management procedures of water facilities.

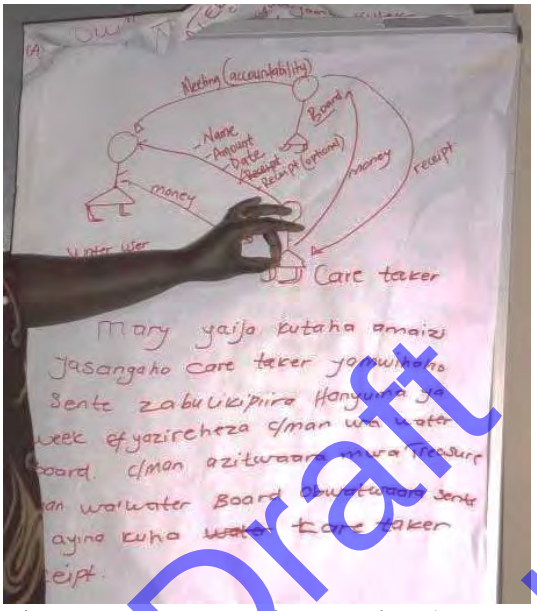

Figure 3: A community member (water user) presents her interaction model and scenario (in her local language) during the design workshop. *Mary goes to collect water and finds the caretaker to whom she gives her contribution and gets a receipt. The caretaker gives the money to the water board treasurer who then issues a receipt to acknowledge payment.*

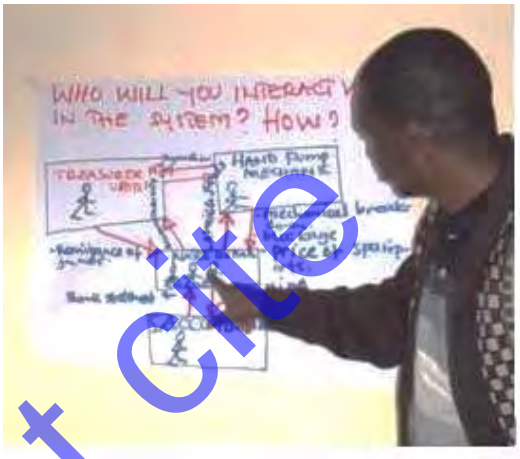

Figure 4: A Community treasurer presents a model depicting his desired interactions within the intervention

As participants reflected on their roles and communal management practices, issues of transparency, accountability and user management emerged as triggers of poor financial management practices. They exhibited a great sense of understanding of their individual responsibilities like the caretaker who mentioned: *"the caretaker is expected to keep a record of all the households using the water source. She/he collects monthly fees from each household to pay for water maintenance activities. The fee is set by the water user committee"* [Caretaker, October 2014]. From their presentations and feedback, we collectively generated use cases and an initial specification model (Figure 2b) representing the interactions between the different stakeholder groups.

4.1.2 The Intervention

PM4W – Pay Me For Water the resulting ICT tool was intended to facilitate the registration of water users, track payments and expenditures, follow-up on defaulters and support accountability of monthly transactions. We sought a solution that matched the local needs and local practices as much as possible and incorporate factors that would allow local appropriation of the intervention.

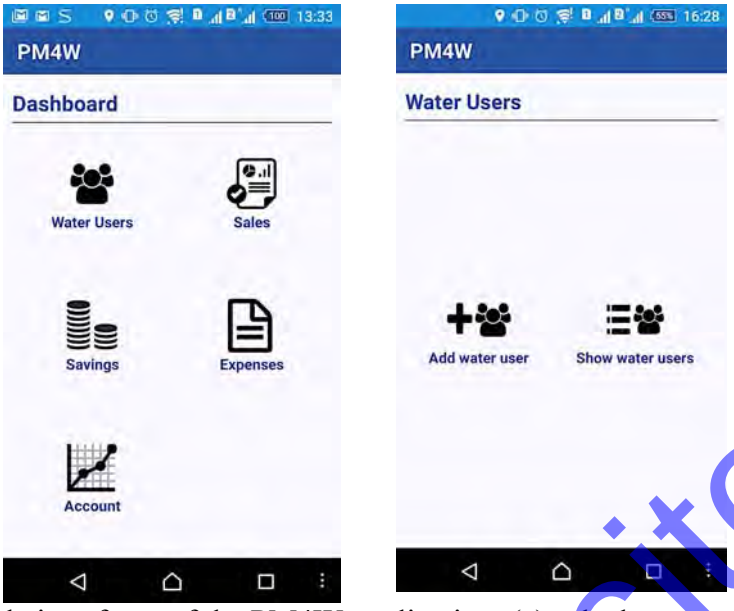

Figure 5: Sample interfaces of the PM4W application: (a) - the home screen for the caretaker to register, view water users (shown in b), log daily and monthly collections (sales), log expenses, post savings and view account activities

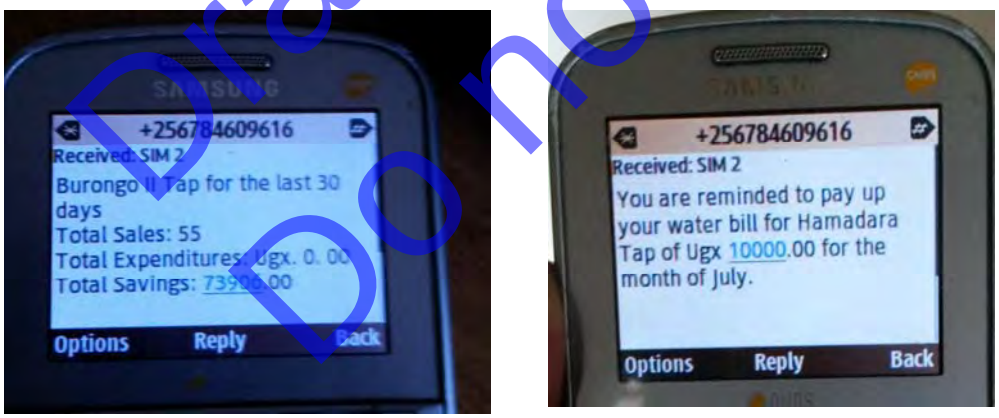

Figure 6: Sample screenshots of SMS notifications sent to community members to account for monthly collections and to remind water fees defaulters

Participants were allowed to continuously critique design decisions and this enabled us to refine requirements and demonstrate how the intervention would support them. The co-design space became an enabling environment for inexperienced users to create or model their aspirations. As the participants engaged in these tasks, insights emerged on community relationships, perceived roles and expectations from the technology.

The cyclical nature of our study required us to create avenues for critical reflection and flexibility through revisiting design decisions and support requests for changes.

Uganda is multilingual with over forty indigenous languages and no single national language. English is the *de facto* form of communication but within Kabarole district, variations of *Rutooro* (local language) are spoken. English was the preferred language for the initial implementation since 95% of the participants could express themselves in it.

User feedback (Cycle 5) necessitated a *re-design* workshop to share the assessment with all participants. Detailed results of this assessment have been published separately (Author, 2016). The goal of the workshop was to build consensus on localizing the system (into Rutooro – the most common local language), address the connectivity challenges and address any emergent requirements. Participants translated the interface and implementing an offline database solved the connectivity problems. Version 2 of PM4W was deployed in August 2015 for continued use.

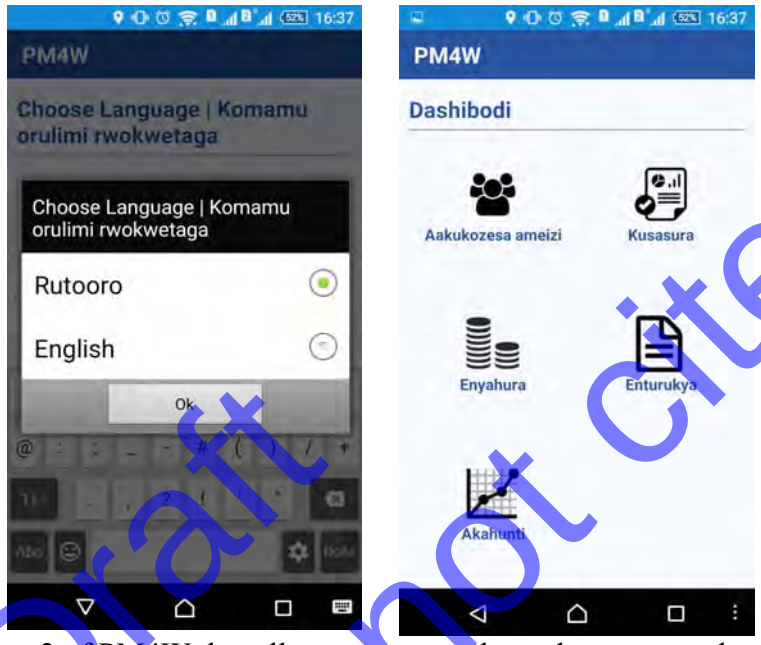

Figure 7: Version 2 of PM4W that allows users to select a language and a sample screen shot of the localised interface

4.1.3 Choice of Technology

Sustainability was a core component of the design and the choice of technology was dependent on what communities could readily access, afford and use. PM4W was implemented as a mobile-based application. With the declining costs of Android phones, greater computing capabilities and improved interactions, we decided to use an Android platform with low-cost Android phones (USD 50).

5 Discussion

The overall aim of our study was to explore co-design as an inclusive design approach to developing a usable community-based intervention. In this section, we reflect on our experience and hope that our method can inform similar initiatives.

5.1 CBCD as a form of active engagement

Successful development of community interventions requires substantial effort in coordinating various stakeholders often with conflicting goals and establishing connections to guide continuous engagement. Engaging with multiple stakeholders at the community, district and national level was cumbersome but eventually rewarding when consensus was

established regarding the priority needs (improving financial management) of communities. By adopting the CBCD method, we committed to an evolving understanding of users, their capabilities, their needs and relationships to create an appropriate and flexible solution. We further saw this form of engagement and community participation as a means of gaining local support, ensuring acceptance, building capacity, local ownership and empowerment.

Co-design is challenging when users have little understanding of technology. By creating ways and avenues to encourage participation, where users could articulate ideas, we realized that some participants did not realise how knowledgeable they were about their context and how their experiences could help in shaping the final product. With time and appropriate techniques (high-fidelity prototypes and workshop structures), participants became confident in sharing their knowledge. Long-term engagement also gradually overcame power differentials whilst increasing the confidence of participants new to technology design and voicing needs.

Being flexible and responding to changes led to the creation of a relevant technology. Such changes included; localisation of the application, offline data capture and updating data forms. Technology is adaptable and users should be helped to see how it changes in response to their changing needs. We saw that participants remained motivated to participate when they saw their feedback incorporated. They felt free to appropriate the tool and were confident to communicate these ways of appropriation.

Our approach to sustainability is in empowering the local people to manage their communal water activities using an affordable and accessible technology. Using established government institutions (district water office) and community structures (water boards, water committees) provided stability and continuity even when we have left the communities after the workshops.

5.2 Choice of an Intermediary

Meissner and Blake (2011) advocate using NGOs as intermediaries with more active roles than just community liaisons, but we argue that this is highly contextual, depending on whether the NGO in question is external or grass root. In our experience with external NGOs implementing projects in rural communities, long-term sustainability is not provided. Projects are developed on time frames and NGOs wind up and exit communities once projects conclude. Minkler et al. (2003) advise that Community-based organisations (CBOs) are better placed to act as intermediaries due to their approaches to longer term sustainability and empowerment. However, we remain cautious of the level of involvement and power of CBOs. In having community members actively involved and empowered to own the interventions, we mitigate the risks associated with any dependency on an organization with the potential to exit the community (Arcury et al., 1999).

Having the water officer as an intermediary provided a stable link to the communities and enabled us to integrate our intervention within existing government structures. Furthermore, he provided local support to the participants in helping them use and adapt to the system through regular meetings in our absence.

The loss of an intermediary, as happened in our case, can easily affect the momentum or level of engagement with the community. Implementing a technology within a community in which one does not reside or originate requires a local support system to provide continuity. It is possible to maintain communication and engagement with communities beyond the intermediary, but this requires immersion in the community and established relationships that are not dependent on the intermediary.

In choosing an intermediary for a community project, researchers need to think of sustainability issues of the project after they have departed. Although external NGOs may have vested interest in the outcome of a community project and have a lot of insight into

community and users' characteristics, they eventually leave. We recommend selecting an intermediary from an institution that forms part of the community structure. In the eventuality of an individual leaving, the collaboration remains with the institution and so the partnership endures.

5.3 Issues of Reciprocity

There is a debate on acceptable ways of compensating study participants for their input. Actively engaging with participants in workshops means that they have to prioritize their time and participate. In a resource-constrained situation this has consequences for their livelihoods. Considering the ethics of reciprocity, we collaborated with our participants and created a useful artefact as a direct consequence of our research. This is considered a mutually beneficial relationship (Blake et al., 2014). However, we acknowledge that our participants, while motivated by the need to solve their problems, require compensation for participating in the research. We also acknowledge that we as researchers might gain more from this research than other participants.

Learning from the experiences of Rodil et al. (2012) with regards to conflicts arising from misunderstood local protocols, we relied on our intermediary for advice. With different cultures having different forms of appropriate rewarding mechanisms, we depended on our intermediary for guidance on acceptable and sustainable mechanism that would not create a dependency on monetary incentives. In many African communities, sharing a meal is considered a form of showing gratitude. We therefore compensated the participants with a transport refund (USD 10) per day and had meals together.

The water managers also received project phones for use beyond the purpose of the study. Leaving these phones with the participants created continuity and revealed layers of participant gains. For example, a community treasurer was helped by her son to use the smartphone and in return, the son used the device for personal communication. These devices became shared resources among family members and community members who previously had no access to mobile phones. These benefits are considered a form of compensation.

The mobile phones also created some form of respect for the participants within the communities as some participants remarked: *"we even use these phones to pose [show off] because they are good phones compared to the other ones [the basic feature phones]"*; *"People are getting to feel proud of themselves now"*; "*I am a farmer and carpenter and the LC 1 so it has helped me communicate with people. In fact when I am holding it, people think I am a very important person"*.

These forms of compensation may be considered exorbitant and possibly with potential to reaffirm existing social-economic inequalities (Scheyvens, 2014, p.176). Our choice of rewards was informed by our intermediary and was in recognition of our participants' commitment to the study. Scheyvens (Scheyvens, 2014) suggests that providing feedback to research participants can be a form of reciprocity. Through our research approach, we were able to provide feedback to participants and allowed them to share their feedback.

5.4 Supporting Technology Appropriation

Participants used PM4W and the phones in ways we had not anticipated. For example; to report broken pipes, assess repairs and record completed tasks. The DWO used information generated by PM4W to identify water sources that had too many users in order to inform the district budget and lobby for funding to construct new water sources. We also observed how the devices facilitated family relationships as forms of communication. For participants from Buheesi, when the water supply was cut off rendering the PM4W system unusable, new activities were created.

We recognize that the ability of people to use technology in ways that seem valuable to them is in itself a capability because they have the freedom to interact with the technology anyhow. These un-intended interactions are considered indicators of acceptance (Ferreira, 2015). Dix (2007) argues that when people use technology differently or make their own improvisations with the tools given to them, it is not a sign of failure but an indication that they are comfortable enough with the technology to use it in their own way. In allowing users to explore the technology for themselves and defining their own ways of using the technology, we were able to learn more about them and the factors within their environment that influence or motivate technology use.

5.5 Considering values

Community water management structures are sustained through voluntarism and easily break down if trust and respect are lost. Transparency and accountability of communal water funds was important and key in motivating payment of water fees. The implementation of PM4W sought to explicitly account for trust, accountability and transparency.

Although we did not directly ask participants to articulate their values, these were adequately expressed as expectations from water managers. This was in form of the need for feedback on collections or expenditures and concerns of the perceived reputation of water managers within the communities (since their work was a source of livelihood). Participants believed that the implementation of PM4W to provide information on financial records would gradually reduce mistrust, as accountability and transparency were now possible.

For the water users, the improved transparency by the water source caretakers and treasures has in turn contributed to improved trust within the community. A number of community members who received the SMS notifications expressed confidence in their water managers because of the feedback they were able to receive.

6 Conclusion

We have presented a case study in which we applied co-design in a rural context in a developing country. We attached great importance to sustainability and were therefore not only interested in having a usable system but also in its integration into community water management practices. We sought to make a meaningful impact on the lives of community members and rural water services in the long run. In so doing, we remained sensitive to local values, available technological resources and recognising constraints.

Community-Based Co-Design meant a commitment to a long-term collaboration with communities beyond the initial design. This allowed us to develop a practical intervention and study how participants could engage in design. We have explored the role and contribution of intermediaries in community-based research and how reciprocity can be achieved. Therefore, communities can be engaged successfully through knowledgeable and stable intermediaries that are able to provide clear perspectives on user capabilities and thus narrow the gap between community participants and external researchers. By so doing, we are better placed to capitalize on our interactions with communities and create technologies that are flexible and usable.

Participatory practices are normal and deeply anchored in the rural lives of many African communities, which suggests that we can generalise our lessons more broadly. Therefore, the emphasis of developers should be actively intervention-driven introduction of technology. This should be geared towards building up communities' technological sophistication and thus enable their active participation in design. Concerns about excessive 'rewards' must not stand in the way of giving our design partners access to appropriate technology. It is a truism of mobile development that 'advanced' devices rapidly

diffuse and reach most communities. This is especially true of projects with a long anticipated life.

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