Proceedings of the 6th International Conference on M4D Mobile Communication Technology for Development

M4D 2018, 15-16 November 2018, Kampala, Uganda

Rehema Baguma & John Sören Pettersson (eds.)

Faculty of Arts and Social Sciences

Karlstad University Studies | 2018:47

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Information Systems

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REPORT

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Foreword

The M4D conference series is this year returning to Kampala in Uganda. It is a pleasure for Makerere University to once again act as the local host, and it is a pleasure for Karlstad University to see the continuous engagement of friends from all over the world. The last conference, held in Maputo at the Universidade Eduardo Mondlane, ended with a panel on *The Future of M4D*. Despite a market drive to push mobile communication towards the Internet, the participants at the conference recognised that there is still a need for ICT conferences that focus on affordable information and communication technologies, and then the material means will be in focus. The mobile phone, whether conduit for voice, text, web pages or FM radio programmes, will be of special interest for under-served regions.

At the last conference we also noted the number of systematic literature reviews. This year too some papers draw on the academic databases as a source for deriving meta information about our field of study. While this method consolidates the research made, it also presents some problems for terse conference papers when the bibliography lists several pages of references. Possibly, it is time for a new category at M4D conferences, to make room for more extensive literature reviews. For it is not only academic databases that should be searched. There are many valuable reports from donor organisations as well as national and international bodies.

Interestingly, this year we have contributions making a point that they are outside the traditional or ordinary *e-* and *m-* fields, i.e. eGov, eLearning, eHealth, eBusiness, and their *m-* equivalents, to mention the most frequently recurring topics. Instead, the case for waste management and water supply as important areas is argued. Such utilities – and mobile-based services in connection to these – are present in many development schemes, but the literature reviews reveal a lack of such topics in the ICT4D/M4D literature. Perhaps a phone call to report leakage is not thought of as ICTish enough, but without the possibility to quickly report at all, damage will be so much greater. Moreover, some presentations at this conference show that many more additional services can be provided when the utility provider has recognised the availability of customers through the mobile network.

An often neglected area is *accessibility* in the sense of access to services by persons who do not have fully functional hearing, vision and motor functions. A workshop on mobile accessibility is offered to all participants at the conference by devoted people from universities in Pune, India. This is a very valuable contribution to the M4D 2018 program.

Finally, we would like to recognise the support from several sources for this year's event. At Makerere, several staff members have spent many hours preparing the conference and its web site. SPIDER (The Swedish Program for ICT in Developing Regions) supports the conference financially, and IPID (International Network for Post-graduate Students in the area of ICT4D) have organised the Post-graduate Workshop the day before the conference and awarded travel grants for some of the participants. Karlstad University and its Information Systems group at the Karlstad Business School has covered the cost of the conference proceedings.

Rehema Baguma
Makerere University

John Sören Pettersson
Karlstad University

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Keynote Speeches Abstracts

Open API and Mobile Money – a view from MTN-Uganda

Elsa MUZZOLINI
General Manager, Mobile Financial Services, MTN Uganda
www.mtn.co.ug

I intend to talk about open-API and how Mobile Money can further drive digital payment in Uganda. MTN believes that an open API infrastructure is key to fostering innovation for a financial inclusive economy. By exposing the MTN Mobile Money API, we hope to encourage monetization of innovations, stimulate new use cases of Mobile Money APIs and most of all build value for Innovators.

*

MTN Uganda is the largest telecom company in Uganda, with over 11 million subscribers, and holding a market share of more than 50% in this country. In 2009, the company introduced Mobile Money, a banking service based on mobile phone access, and is since several years back the major player in this field in Uganda.

Elsa Muzzolini has joined MTN Uganda in 2017 as General Manager, Mobile Financial Services. Elsa has had an elaborate career in the telecommunications industry in West&Central Africa. Her previous work engagement was most recently with McKinsey & Company (Canada&USA) where she was an Engagement Manager and drove major digital&lean business transformations, mostly in banking industry. Previous to that she worked as the Chief Marketing and Communication Officer at Orange Centrafrique (Bangui, Central African Republic) and Orange Money Project Manager at Orange Cameroun. Elsa holds an MSc in Business Administration and Management from HEC School of Management (Paris, France), a MSc in Project Innovation and Conception from Ecole Polytechnique (Palaiseau, France) and an undergraduate degree from HEC Montreal (Canada). She is highly skilled in mobile financial services, business planning and development strategy, product management and marketing and she is a Lean expert.

The Supporting Life Research Project – Lessons Learned from the field

Bo ANDERSSON
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In this keynote, I will address lessons learned from the *Supporting Life* research on e-health and future issues related to sustainable solutions in low- and middle-income countries, based on a Business Technology perspective.

The overarching perspective of this research is how to improve business operations with Business Technology, as well as in private organization as in the public sector. It seems that successful organizations that master the digital transformation have a common denominator – they perceive that business and ICT are in total fusion. They no longer divide business and ICT; instead, they see it as Business Technology. Business Technology is now a key component to success or failure within the modern business landscape. Hence, the digital transformation and utilization of its promises are becoming increasingly important for the public sector, with mounting pressure on cutting cost and simultaneously improving services.

Research Track

Reflections on the Maturity of the Mobile Communication Technology for Development (M4D) Landscape: 2008-2016

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ABSTRACT The 2018 M4D conference marks a decade of dynamic growth in the Mobile Communication Technology for Development (M4D) discipline. This paper reflects on the developments and maturity of the field based on a systematic literature review of the research papers published in the biennial M4D conference series (2008-2016). The findings offer a comprehensive overview of *what* was studied (application domains), *where* the research took place (geographic locations), by *whom* (the researchers affiliations), how the research was carried out (methodologies) and how the research *contributed* to the maturity of the M4D field. We conclude by summarising the insights gained from our investigation, with the goal of enriching discussions on how M4D research has evolved, where research gaps may exist and what can be gained by retaining a M4D theoretical corpus.

Keywords: M4D maturity, M4D theorization

1. Introduction

M4D is a relatively new field, which evolved due to the unprecedented growth and adoption of mobile technology by individuals and organisations, especially so in the Global South (Niang & Scharff, 2014, p.4). Larsson (2016, p.4) attributes the emergence of M4D as an offshoot of the ICT4D field to the recognition of the explosive uptake and distribution of mobile devices in developing contexts, their supposed ease of use, reach and potential to bridge social, economic and technical differences. The community of M4D scholars and practitioners confronted a swiftly-moving target over the past decade as handset costs dropped and functionality increased (Donner, 2010, p.2). Inexpensive devices, usage-based data pricing, wireless connections, personal/portable/intimate devices, universal appeal, and task-supportive design were all factors stimulating the uptake and use of the mobile internet (Donner, 2015, p.178). At the same time, the constellation of services and applications accessible via the world's mobile networks is broader and more diverse in ways that blur the boundaries between computers and telephony (Donner, 2010, p.2). This leads to particular challenges for ICT4D and M4D practitioners.

At the first Mobile Communication Technology for Development (M4D) conference, held in Sweden, Richard Heeks (Heeks, 2008, p.5) asked whether the conceptual foundations of M4D research had received enough attention and what M4D research was still relevant. The M4D

discourse has evolved since 2008, driven by the evolution of mobile devices, communication platforms, and usage patterns (Larsson, 2016, p.4). Ten years, and five conferences, later it is appropriate to consider how the field has evolved and responded to the challenge of developing the conceptual foundations of M4D research. This was the rationale for our study, which employs a systematic literature review of the research publications in the biennial M4D conference series (2008-2016), primarily to answer Heeks' questions. We provide an overview of previous literature reviews in Section 2 then present our methodology in Section 3, where we also discuss and motivate the foci of the analysis. The findings from literature, the contextualisation and synthesis thereof are discussed in Section 4. We reflect on these findings and limitations of this study in Section 5, before concluding in Section 6.

2. Disciplinary context of M4D

2.1 – M4D research in disciplinary context

The disciplinary foundations are useful in understanding the ontological and epistemological similarities and differences between the disciplines, which, in turn, inform the methodological differences. For example, HCI and HCI4D have some distinct differences. HCI4D research has a strong focus on practicality and places greater emphasis on *in-situ* prototyping and development than does the HCI field (Toyama, 2010, p.25). M4D discussions have been locked within development discourses, primarily because the least developed regions (also referred to as "the Global South") account for the majority of new mobile telephony subscriptions and rapid uptake (Larsson, 2016, p.4). Mobile technology has an unequalled potential to give developing country communities access to information. Such information is a key ingredient in supporting and enabling sustainable human development. There are different views on positioning M4D as a research field. Despite the theoretical and practical continuities between mobiles and other ICTs in "4D" processes, Donner (2010:11) maintains that mobile use does not require an entirely new theoretical corpus and can be mainstreamed into ICT4D research.

Heeks (2018:30) visualised the disciplinary foundations of all branches of development informatics research. His visualisation includes Development Studies; Development Informatics and Technology & Development as being M4D related entities, but excludes HCI, HCI4D and M4D. Abdelnour-Nocera & Densmore (2017:1), however, consider human–computer interaction for development (HCI4D) and participatory design for development (PD4D) to be sub-fields of ICT4D. Some may see PD4D as a methodology rather than a field but M4D is undeniably tightly linked to HCI4D, in the sense that mobile technology is the most widely-used technology in HCI4D research (Dell & Kumar, 2016, p. 2223). We will discuss the relevance of M4D as a research field in Sections 5 and 6 but, based on this discussion, we conclude that findings in the fields of HCI4D and ICT4D are relevant, applicable and pertinent to discussions of the M4D research field in terms of maturity considerations.

2.2 – Previous overviews of M4D research

Van Belle & Mudavanhu (2016, 150) reviewed research on mobile phones and development published in the Information Technologies & International Development (ITID) journal, the Information Technology for Development (ITD) journal and the Electronic Journal of Information Systems in Developing Countries (EJISDC) (2011-2015). They investigated two aspects: (1) the dominant characteristics of research on mobile phones, and (2) the future possible directions for M4D research. According to their study, the top application domains

included: Micro- and small-enterprises and entrepreneurship; Finance; Agriculture/farming; Migration; Health; Fishing; Education (van Belle & Mudavanhu, 2016, p.154).

In a study to identify the traditional development-related areas of research and practice in HCI4D, Dell & Kumar (2016, p. 2224) identified Education, Access and Health, but also observed diversification into areas such as entertainment and sustainability. The review of the M4D biennial conference proceedings (Wamala-Larsson & Svensson, 2015, p.10) recognised mHealth, mLivelihood, mGovernance and mLearning as recurring sectors that have benefitted from the application of mobile technologies in development.

Van Belle & Mudavanhu (2016, p.157) concluded that most of the research on mobile phones and development tends to be empirical. Few studies reflected on the mobile phone for development literature as a whole. The authors advocate for more a reflective theoretical approach into topics such as the meaning of mobile development and its impact. This resonates with a review of the M4D biennial conference proceedings carried out by (Wamala-Larsson & Svensson, 2015, p.10), who argue that we still need to work on developing our understanding of the methods and theories informing the concept of M4D. The findings from these three literature reviews support the rationale of this paper, i.e. to explore how M4D research has evolved and to delineate areas where more research is needed.

3. Methodology

The systematic literature review method generally has three functions: (i) identifying, summarizing and critiquing current theory and methods; (ii) identifying ontological, epistemological and methodological problems and gaps; and (iii) providing evidence for decision-makers when identifying and supporting priority issues (Pickering, Grignon, Steven, Guitart and Byrne, 2014, 1757). This is useful in pinpointing the areas covered by existing research, and also in revealing the gaps, since it approaches the literature from different perspectives and facilitates delivery of new insights (Pickering, et al., 2014, 1761). Grant and Booth (2009) published a typology for distinguishing the connection between the type of literature review and the outcome. Based on their topology of 14 review types, we selected the *systematic review* as a method to systematically search for, appraise and synthesise evidence from literature (Grant & Booth, 2009, p. 95), as most appropriate for our study. In this paper, we also include the results of a qualitative analysis to help make sense of the quantitative findings

3.1 – Themes for analysing the maturity of the M4D field

Previous literature reviews (Section 2.2) informed the structure of our quantitative data capture, in terms of identifying *where* the research was done, *what* the application domains were, *and how* the research was carried out. We thus commenced with the regular, quantitative literature review analysis of the M4D conference proceedings' papers, in terms of the country of study, author affiliations, the application domains and the Google Scholar citations. This affords triangulation with the previous findings and profiles. However, to gain a deeper understanding of the *maturity* of the field, we looked for alternative approaches and themes to support our analysis. We finally fixed on the findings and a set of meta-themes adapted from Bødker's HCI wave classification (Bødker, 2015), as detailed below. Before arriving at these themes, we considered a number of ways of analysing the developments in the M4D field that would serve to reflect its maturity.

Other researchers have carried out studies to gauge their field's maturity levels. Cheong and Shehab argue that the nature of the research published in a field can provide a sense of its progress and maturation (Cheong & Shehab, 2003). Renaud and Flowerday use an analysis of a snapshot of papers published in peer-reviewed human-centred security conferences to serve as an indicator of how that field is maturing (Renaud & Flowerday, 2017, p. 77).

In contemplating the maturity of M4D's closely related ICT4D field, Heeks (2014:24) proposes four *waves* of development informatics research: ***first***: Readiness (1960 - mid 1980) dealing with Policy, Infrastructure and the Digital Divide; ***second***: Availability (mid 1980 - mid 1990) dealing with Implementation and Design; ***third*****:** Uptake (mid 1990 – mid 2000) dealing with Demand, Usage, Use Divide and ***fourth*****:** Impact (mid-2000s to mid-2010s) dealing with Micro-Outputs, Outcomes and Development Contribution. We cannot simply appropriate this classification to structure our analysis of the research because, although readiness, availability, uptake and impact are relevant to M4D, these particular categories do not necessarily demonstrate the maturity of the M4D research field as a whole because the focus on mobile devices entail specific assumptions and constraints.

We considered an HCI-related classification, to benefit from M4D's disciplinary connections to HCI. Bødker (2015) suggests that the field of Human-Computer Interaction (HCI) has matured in a succession of waves. The first wave, she explains, focused on the individual. Individual perceptions, cognition and behaviours were tested and modelled. The second wave moved from studying the individual to contemplating social behaviours, agency and interactions within workplaces and with other humans via technology. The focus moved to groups working with applications, adding a social element to the focus of the studies. Context and situational analysis became important. The third wave then broadened the focus even more to address studies of the integration of technology into people's everyday lives. During the third wave, publications are characterised by papers dealing with user experience and meaning making. During this wave studies report on participatory prototyping, experiments and in-the-wild studies.

Renaud and van Biljon (2017) used an adaptation of Bødker's classification (Bødker, 2015) to categorise *mobile phone design guidelines* in terms of waves, in order to reflect the maturity of this HCI field offshoot. Their ***first*** wave was made up of individual, small-scale studies, which laid down foundational principles, the ***second*** wave reported larger-scale studies, with a broader focus. The focus on the individual no longer dominates. Social aspects started to merit inclusion, and initial results were used in further studies – building on the foundations laid during the inception of the new field. The ***third*** wave explicitly built on the extant M4D literature; questioned unwritten assumptions and made recommendations about the way forward.

We needed to identify meta-themes to inform our analysis of the M4D research. We did not search for waves, *per se*, as performed by the aforementioned studies, for a number of reasons. The *first* was that the M4D field is much younger than the other fields, where a wave-like analysis is feasible. The *second* was that the M4D field builds on foundations laid down in other fields and so does not need to do as much groundwork to establish the boundaries as other fields have had to do. This led us to focus on cross-cutting ***meta-themes*** to reflect the maturation of the M4D field. The three meta-themes used to inform our qualitative analysis of the M4D conference papers were:

Theme 1 (*Foundation*): papers that sought to understand the M4D user's needs, context and use of technology. These could be considered *foundational papers*, e.g. Eilu, Baguma & Petterson (2014).

Theme 2 (*Design*): papers that describe the design, implementation and evaluation of applications, benefiting from the findings of Theme 1 papers but also adding to them. These are considered *design papers*, e.g. Atnafu, Workneh and Getachew (2010).

Theme 3 (*Abstraction*): papers that apply existing knowledge to implement mobile technology, replicate that in a new context, or extend existing research. That is, they analyse, synthesise and refine existing research to *abstract* new knowledge. An example is the research carried out by Donner, Verclas, and Toyama (2008)

3.2 – Analysing the Landscape: Proceedings of the M4D Conference series

Table 1 provides an overview of the venues and number of papers in the Research track (short papers excluded). The study was conducted in two phases. During the first phase (*paper selection*), all full research papers from the 2008, 2010, 2012, 2014 and 2016 M4D Proceedings were included, which resulted in 123 papers. Notably, nine of the 2012 papers analyses were based on the abstracts', since the full papers were not included in the proceedings. Two of the 2016 papers were in Portuguese and were excluded from analysis. During the second phase (*coding*), the following information was recorded: title of the paper, name of author(s), research methodology, Google scholar citations, domain and meta-themes. Previous studies classified the papers in terms of quantitative, qualitative or mixed-methods research. To allow finer grained analysis, the conceptual model proposed for ICT4D research by Van Biljon and Alexander (2015, p.94) was used to categorise the methodologies used. The analysis is available from https://goo.gl/DcEZbM.

Table 1: Research papers extracted from M4D Conferences

Year	Location	Papers	Year	Location	Papers
2008	Karlstad, Sweden	*10*	2014	Dakar, Senegal	*16*
2010	Kampala, Uganda	*15*	2016	Maputo, Mozambique	*20*
2012	New Delhi, India	*62*			

4. Findings

4.1 – Quantitative analysis of the M4D Conference Proceedings

Guided by the research questions posed namely, whether the conceptual foundations of M4D research has received enough attention and what M4D research should be done we proceeded to map the M4D landscape in terms of the (1) country of study, (2) the national affiliations of the authors, (3) application domains and (4) methodologies to outline the M4D field in terms of *where* the research was done, by whom, *what* the application domains were, *and how* the research was done. The geographic locations of the projects, and the authors' affiliations, are depicted in Fig. 1.

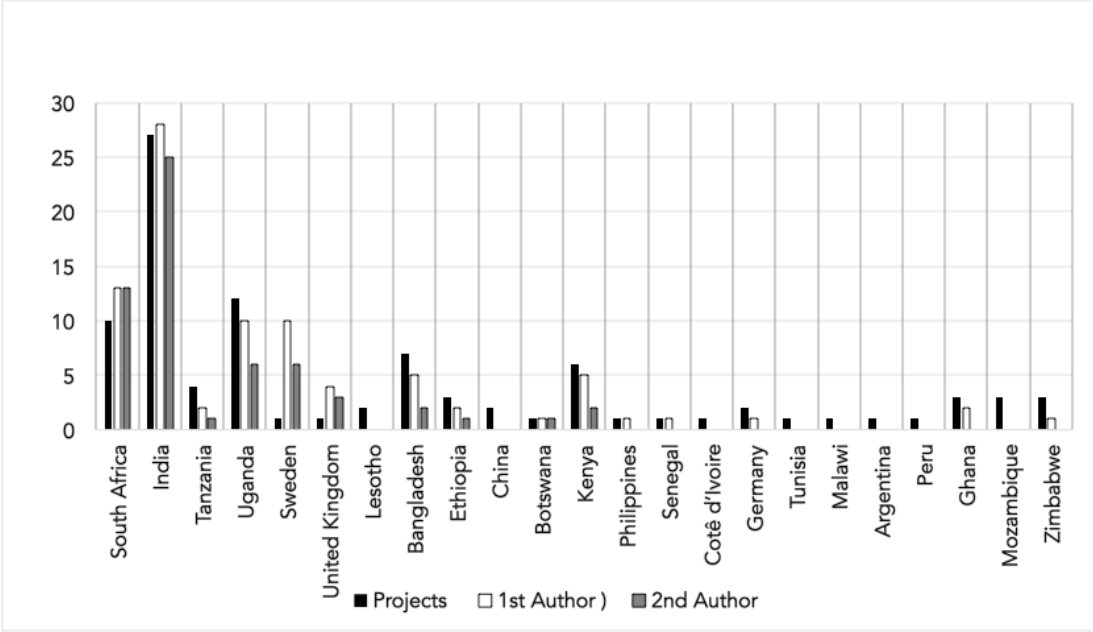

Fig. 1: Number of papers in terms of geographic locations of the projects and the authors' affiliations

Note that the following observations are based on the M4D data, and cannot be generalised without further investigation. From Fig. 1, we observe that India, South Africa, Uganda, Bangladesh and Kenya contributed most, in terms of where the research was conducted. The findings confirm the results of Van Belle & Mudavanhu, (2016, p.153), who also found that most of the M4D published research is being conducted in the Global South.

We noted that the papers produced in the UK and Sweden were mostly reviews or reflections i.e. not empirical studies. The inter-country collaboration explains why some countries have few projects but a high number of authors. Despite not having hosted an M4D conference, the following countries made notable contributions: Kenya, Bangladesh, Zimbabwe and South Africa. Fig. 2 depicts the Research Domains looking at the yearly differences, to reveal variations across time. It is interesting to note that interest in technical and innovation fields seems to be waning, while health remains a topic of interest. The interest in Education (learning) seems to be increasing, but one would have to take another look in a few years to see whether this is a temporary blip or a trend. Fig. 3 depicts the same information as Fig. 2, but also shows the distribution per domain. Health received the most attention, followed by Empowerment, which hosts all the papers that do not fit into any of the other categories.

Fig. 4 depicts the Publications' Google Scholar Citation Counts, which gives us an indication of the extent to which researchers are building on each other's research in the area. Besides the four papers with more than 20 citations, the results do not provide compelling evidence of researchers using other researchers M4D papers. Making the M4D accessible by providing those in an open repository benefits developing country researchers who may not have access to expensive academic databases but the downside is that the papers are not picked-up by citation database of peer-reviewed literature like Scopus.

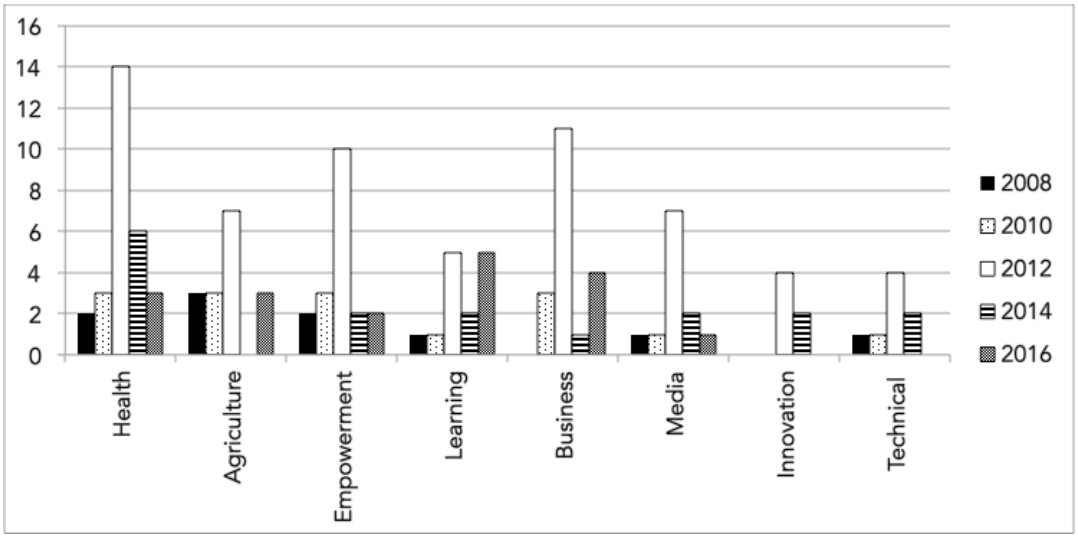

Fig. 2: Research Domains recorded in M4D Proceedings at M4D 2008 to 2016

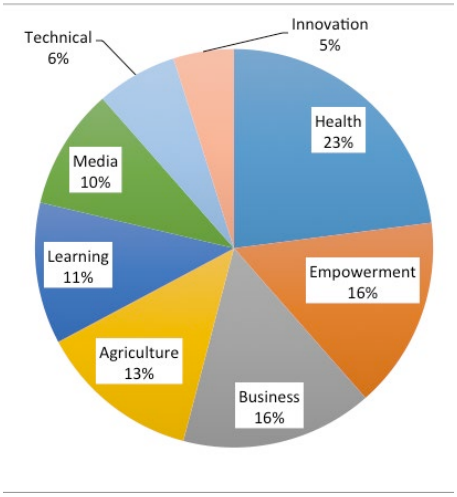

Fig. 3: Research Domains

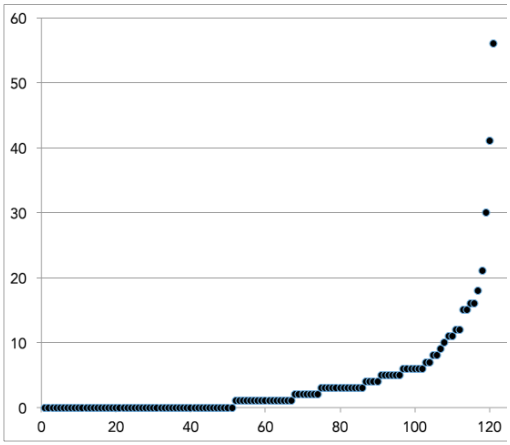

Fig. 4: Publications' Google Scholar Citation Count

Fig. 5 shows the number of citations of each year's proceedings' papers. The 2012 citations are fairly proportional to the number of papers whereas the papers in the first year, 2008, have been heavily cited. This could be expected from an inaugural conference where initial enthusiasm for the discipline is high. The low citations for the 2016 papers are understandable due to the time lapse between publication and getting cited and eventually being picked up as a citation, but the low citations of 2014 papers are surprising.

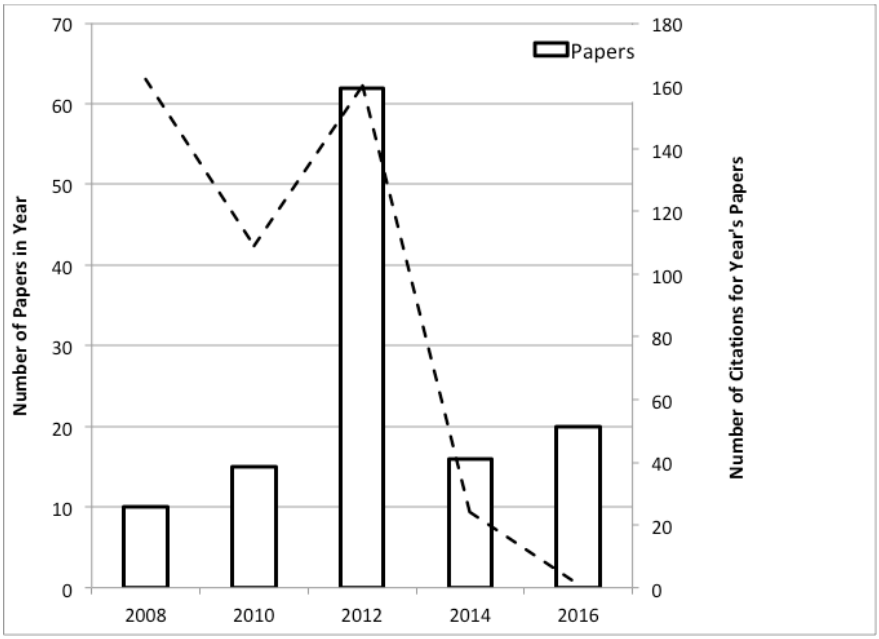

Fig. 5: Papers per Year and Numbers of Citations per Year

4.2 – Qualitative analysis of the M4D Conferences' Proceedings

The research reporting on the philosophical underpinnings and theoretical framing was *ad hoc* and limited, if at all present. This made rigorous capturing and analysing of these aspects impractical. However, the investigation into the use of models and frameworks provided a number of insights. Considering the 123 analysed papers, two proposed frameworks and eight proposed a model as part of their contribution. The methodologies include: Systematic Literature reviews; Design Science Research; Case Study Research; Ethnography; Action Research and Grounded Theory. The data capturing methods included: Surveys; Interviews; Focus groups; Observations; Literature and Document analysis; Prototype development and evaluation. This provides evidence of the scope (sophisticated and diversified methodological development) but no confirmation of depth or contribution to theory building.

The frameworks included the mobile user experience for voice services (Botha, Calteaux, Herselman, Grover and Barnard, 2012) and a framework on supporting the construction of programs on a mobile device (Chao, Blake and Suleman, 2014). This means that a relatively small number of papers (10 of the 123) proposed a theoretical model or framework, and those were all domain specific. Our findings support the argument made by Van Belle and Mudavanhu (2016, p.153) that papers that reflect on key concepts in the M4D field, such as the meanings of development and the impact of mobile phones to the overall development goal, are limited. The findings also seem to resonate with those from HCI4D (Dell & Kumar, 2016, p. 2224) which revealed a focus on action rather than on knowledge creation and theorisation. Taking cognisance of the disciplinary positioning of M4D research, the diversity in related disciplines, such as Development Informatics, ICT4D, HCI4D and HCI (which has a Computer Science base), undoubtedly influence perceptions of how research contributions should be presented. Therefore a lack of models and frameworks may not necessarily imply a lack of theorisation but rather an alternative levels and formats of the contribution e.g. specifications, standards and guidelines.

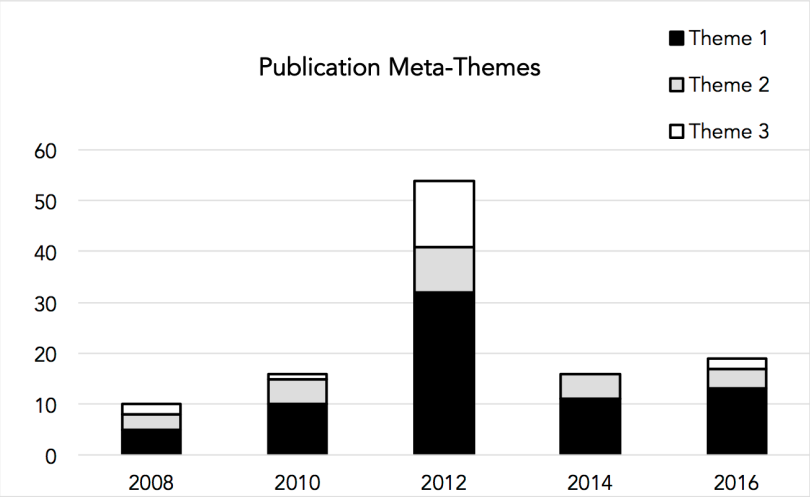

Fig. 6: Publications according to Meta-Themes

The categorisation of papers into themes reveals an interesting profile. It is perhaps to be expected that a relatively new field, such as this one, will see the majority of their papers addressing foundational issues, and indeed this is what we see from Fig. 6. There was a fairly stable number of Theme 2 papers, building (implementing) and evaluating prototypes. The third theme does not seem to have enjoyed much attention, with the exception of the 2012 conference. This, too, might be understandable for such a young field, which needs a critical mass of papers before abstraction and synthesis papers can start to appear.

5. Discussion

We considered the papers published in the M4D conference series as a proxy for Mobile Communication Technology for Development (M4D) publications, and publications themselves as a proxy for research activity. This analysis of the M4D publications in terms of the geographies (*where*), research domains (*why*) and the research methods (*how*) provides a point of departure for discourses on the connections between ICT4D and other related development domains. Our findings confirm and extend earlier studies in terms of the geographic dispersion of M4D research. Much is located in the Global South, the *foci* of research domains is delineated, and we shed new light on the range of research methodologies used. To gain a deeper understanding of the maturity of the field we applied meta-themes adapted from Bødker's HCI wave classification. The findings indicate that researchers have focused on addressing the user's needs, in terms of the specific developmental challenge, i.e. understanding user needs and contexts (Theme 1) and implementing mobile ICT applications to address these needs (Theme 2) but in many cases the findings and insights have not been abstracted and synthesized towards models, frameworks and theories that strengthen the conceptual foundations of the discipline. That explains the small number of Theme 3 papers. This resonates with Toyama's observation that HCI4D research tends to be pragmatic, and focuses on practicality and the potential for genuine impact (Toyama, 2010:24). Having identified some basic characteristics on the development and maturity of M4D, and triangulated those with previous findings, we have to conclude that the conceptual foundations of M4D, as a dynamic and ever diversifying discipline, still has not received enough attention.

This supports the argument of Wamala-Larsson & Svensson (2015, p.22) that more work is needed to conceptualise the notion of mobile participation, its features, its demands and its shortcomings as well as its flexibility.

Donner (2010, p.10) argues that "*The sooner and more forcefully M4D research is connected to the broader conversations on ICT4D (and on technologies and societies), the stronger it is likely to be*". However, that connection should not be at the expense of valuing, preserving and sharing the knowledge embedded in the M4D literature. We argue that the diversification in the M4D field increases the need to maintain a shared knowledge base. Therefore publication opportunities, events and interactions should support cross-dissemination to ensure that findings of common interest is shared and researchers have the opportunity to build on the extant M4D knowledge and best practices across M4D research domains and application areas.

More research is necessary to inform the structure of the collective M4D knowledge base, identify the unarticulated philosophical and theoretical underpinnings, and demonstrate how those can be presented. This paper provides a point of departure in providing the current domains, meta-themes and methodologies. Furthermore, a comprehensive review of M4D literature is needed to include the publications outside the M4D Conference series and triangulate the findings with the insights presented here.

6. Conclusion

We asked whether the conceptual foundations of M4D research had received enough attention. Our investigation concluded that the conceptual foundations seem to have been developed within each application domain, rather than for M4D as a consolidated field. There are relatively few general studies of the M4D research domain and the models and frameworks that *have* been developed are application domain specific e.g. Health or Education.

Returning to the guiding questions, and what M4D research still needs to be carried out, we conclude that the M4D field has grown and engaged with an extensive range of geographies, technologies, and application domains. Despite the diversification, and perhaps as a consequence thereof, the M4D field has not yet matured in terms of researchers building on other researchers' work.

Furthermore, the focus of M4D (similar to HCI4D) has been to make a genuine (which is often viewed as a practical) development contribution and this might explain why theory building has not manifested as a priority. The philosophical and theoretical underpinnings were under-reported and the methodologies were not always clearly articulated but this pertains to *how* the research was done rather than *what* should be done.

We realised that it would be inappropriate to apply maturity models from other fields to M4D and found the derived meta-themes more useful. Highlighting concurrent theory building (without neglecting the focus on practical relevance) as the next step in the research process could address the longstanding issues of re-inventing the wheel or creating small, unconnected projects of limited impact ('*pilotitis'*).

The distinctions between M4D and ICT4D projects continue to blur, and that may cause the priorities of M4D to align with those of ICT4D. However, the unprecedented ubiquity and reach of mobile technology has created unique opportunities that warrant evidence-based

research attention in order to navigate the challenges and optimise the benefits of mobile technology in supporting development.

Despite the noted challenges to growing and maturing M4D, the continued value of M4D as a research field which provides a framework for linking and aligning multi-, inter- and trans-disciplinary research should not be underestimated.

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Uncharted Academic Waters: A Case for mUtilities (Energy, Water and Sanitation)

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ABSTRACT This paper aims to explore the academic literature in Information and Communication Technology for Development (ICT4D). It seeks to find out how Information and Communication Technology (ICT) and mobile technologies have been used to enhance the provision of utility services (energy, water and sanitation). We systematically searched through 1263 academic research papers from five top ICT4D journals and one Mobile Communication for Development conference series over the last decade (2008-2017). Only six papers were found to have discussed the use of ICTs in the provision of utility services in a broad way. This dearth of academic research moved us to further explore how practitioners have handled research in the same field. The literature from practitioners shows a lot of potential in the use of mobile technology in supporting the infrastructure used to provide utility services, because most of the people lacking these services are connected to the mobile infrastructure. Their access to the mobile network presents an opportunity to innovate and leverage on the mobile technology and infrastructure to efficiently provide these utility services. Companies leveraging mobile technologies to provide utility services have also attracted significant funding in the recent past, demonstrating investor confidence in this sector. We therefore present a case for the inclusion of mUtilities as a viable empirical testbed within the M4D and ICT4D academic literature.

Keywords: M4D, ICT4D, mUtilities, Energy, Water, Sanitation, PAYG Solar

1. Introduction

From the global Millennium Development Goals (MDGs) to the United Nations' Sustainable Development Goals (SDGs), alleviating poverty in all its forms and dimensions, including extreme poverty, remains the cross-cutting aim (United Nations, 2015; Heeks, 2014)

At the moment, major groupings have already been made within the academic literature on ICT4D and its subset, Mobile Communication for Development (M4D). The groupings have revolved around health, education/learning, agriculture, commerce and governance. These groupings have given rise to the ePhenomenon and mPhenomenon for example eHealth, eLearning, eAgriculture, eCommerce and eGovernance, plus their equivalents in mobile technology. Other additional groupings have also emerged within ICT4D academic literature, albeit at less frequency for example mInclusion, mEmpowerment, mInnovation, mLivelihood and others.

On closer examination, the major groupings are in line with specific SDGs and MDGs. Table 1 shows the groupings and their corresponding SDG and MDG.

Table 1: ICT4D/M4D groupings and their corresponding MDGs and SDGs. Source: Authors' Conceptualization

	ICT4D/M4D Groupings	**Corresponding MDGs and SDGs**
1.	eHealth/ mHealth	MDG 4 - To reduce child mortality; MDG 5 - To improve maternal health; MDG 6 - To combat HIV/AIDS, malaria, and other diseases SDG 3 - Good Health and Well-Being for people
2.	eLearning/ mLearning	MDG 2 - To achieve universal primary education SDG 4 - Quality Education
3.	eAgriculture/ mAgriculture	MDG 1 - To eradicate extreme poverty and hunger SDG 2 - Zero Hunger
4.	eCommerce/ mCommerce	MDG 1 - To eradicate extreme poverty and hunger SDG 8 - Decent Work and Economic Growth
5.	eGovernance/ mGovernance	MDG 8 - To develop a global partnership for development SDG 16 - Peace, Justice and Strong Institutions; SDG 17 - Partnerships for the Goals

1.1 – Utility (Energy, Water and Sanitation)

The Oxford Dictionary defines Utility as "an organization supplying the community with electricity, gas, water, or sewerage". Utilities therefore, are key players towards the achievement of SDG 6 – Clean Water and Sanitation; and SDG 7 – Affordable and Clean Energy.

Achievement of SDG 6 and/ or SDG 7 will have a catalytic effect of enhancing the achievement of the other SDGs. On the contrary a lack of access to modern energy can confound a country's efforts to tackle its challenges, such as poverty (SDG 1); food production and security (SDG 2); air pollution, low levels of life expectancy and lack of access to essential healthcare services (SDG 3); delivering quality education (SDG 4); gender inequality (SDG 5); economic growth and employment (SDG 8); sustainable industrialisation (SDG 9); and adaptation and mitigation of climate change (SDG 11). This affirms the importance of access to modern energy services and the centrality of energy in achieving many of the other SDGs (United Nations, 2015; United Nations, 2016).

The United Nations (n.d. a) reported that 1.2 billion people globally do not have access to the electricity grid. This translates to one in every five people. About 95% of them live in sub-Saharan Africa (598 million) and South and East Asia (571 million) (BNEF & LG, 2016). It is also estimated that another 1 billion people globally are connected to the grid but suffer from unreliable service levels. Another 2.8 billon people globally rely on wood, charcoal and coal for cooking and heating, which results in over 4 million pre-mature deaths per year due to indoor pollution. Without electricity, women and girls spend hours fetching water, clinics cannot store vaccines for children, many school children cannot do homework at night, and people cannot run competitive businesses (ibid).

Even though access to water, sanitation and hygiene is a human right, billions of people globally are having problems accessing the most basic of these services. The United Nations (n.d. b) reported that about 1.8 billion people worldwide use a source of drinking water that is faecally contaminated. 2.4 billion people lack access to basic sanitation services such as toilets

and latrines. 40% of the world's population are affected by scarcity of water and this population is projected to rise.

Water and sanitation related diseases are reported to be a major cause of death in children under the age of five years. More than 800 children die daily from diarrhoeal related diseases. Two million people die every year from diarrhoeal diseases, of which 90% are as a result of poor hygiene and unsafe drinking water (ibid)

It is rather peculiar that, of the 1.2 billion people without access to the electricity grid, 855 million of them have access to 2G or 3G mobile networks (GSMA, 2018). Of the 848 million people without access to water, 373 million have access to 2G or 3G mobile networks. Similarly, of the 2.4 billion without access to basic sanitation, 1.97 billion have access to 2G or 3G mobile networks (WHO, 2017). This access to the mobile network presents an opportunity to innovate and leverage on the mobile technology and infrastructure.

Practitioners within the mobile network industry, utility service providers, impact investors, venture capitalists and international development organizations have partnered and created solutions to address the challenges and tap to the opportunities presented. There has been concerted efforts made by the different partners towards using mobile technology to increase access to energy, water and sanitation to the underserved. On the path to accomplishing this, considerable knowledge has been generated by the practitioners. In contrast, there is a dearth of knowledge around these utility services from academic literature within ICT4D or M4D.

2. Objectives

The goal of this paper is to systematically explore the academic literature in M4D and ICT4D to find out how ICT and mobile technology have been used to enhance the provision of utility services (energy, water and sanitation), in relation to development. We aim to present a case for inclusion of mUtilities as a viable empirical testbed within the M4D and ICT4D academic literature.

3. Methodology

For this paper, we employed Systematic Literature Review (SLR). SLR is a specific research methodology developed in order to gather and evaluate the available evidence pertaining to a focus topic (Biolchini et al, 2005) as reported by Touray et al (2013).

We limited the scope of our study to top ICT4D journals only, because they have a rich database of ICT studies that are related to development. We included the top 5 open access ICT4D journals according to Heeks' (2010) ranking that was based on citation rates. The included journals are: Information Technology for Development (IT4D), Electronic Journal of Information Systems in Developing Countries (EJISDC), Information Technologies & International Development (ITID), Asian Journal of Communication (AJC) and African Journal of Information & Communication (AJIC). In our study, we also included conference proceedings of the International Conference on M4D Mobile Communication for Development series.

Our inclusion criteria was: studies that are either research papers or articles that were published in the five journals or one conference between January 2008 to December 2017, and were addressing the use of ICTs in energy, water or sanitation sectors in a broad way. Only literature published in the last decade was considered for analysis because this ensures that the study

represents an up to date view of the current state of research (Johnston et al, 2015) in this case, ICT interventions related to energy, water and sanitation.

Consequently, we excluded the following studies that were present in the journals and conference proceedings: reports; editorials; thematic reports; tributes; notes from the field; practitioner tracks; view from practice; legislative reviews; institutional reviews; forums; panels; case notes and book reviews.

3.1 – Our Review Process

In order to allow for replicability of our study and to apply rigour in our methodology, we iteratively followed the steps below:

1. Accessed the online repositories of the included journals and conference series.
2. Applied the following search phrase "ENERGY" OR "WATER" OR "SANITATION" OR "ELECTRICITY" OR "SOLAR" OR "UTILIT*" in the digital archives of IT4D, EJISDC, ITID and AJC. The filter was case indiscriminate. We delimited the results to only include articles that were published between January 2008 and December 2017.
3. From the search results, we then looked at the title and skimmed through the abstracts of each of the results. If the information from the title and abstract was unsatisfactory in providing the empirical setting of the paper, we then skimmed through the full paper text to deduce this information. Based on the scanning and skimming, we decided whether or not the study qualified to be included for review.

We iterated through these steps until all the four journals were exhausted.

For the AJIC, there were a lot of search results from the university website that hosts the journal. This is because it was linked to the Google search engine. We decided to manually access all the online issues of the journal from the year 2008 to 2017 without using the search terms. We therefore moved straight to the third step of our iterative process, scanning and skimming through the title, abstract and full paper text if need arose.

For the M4D conference series, all the five conference proceedings were in Portable Document Format (PDF). Therefore, applying the search phrase in the second step of our iterative process proved futile. As a result, we also decided to manually scan and skim through all the titles, abstracts and full paper texts where need arose.

With this systematic search process resulting in only a handful of articles meeting the inclusion criteria (Six articles), we resorted to practitioner-based literature, to give inspiration to the future possibilities that academic literature in this sub field could take. These practitioner publications that are dedicated to utility services included GSMA M4D Utilities and Global Off-Grid Lighting Association (GOGLA).

4. Results and Analysis

Table 2 shows the number of research articles published by the top five journals and the M4D conference series from the year 2008 to 2017. Table 3 shows the total number of articles returned from our search queries and the articles that we considered for review in this study. Of the 1263 research articles that were published in the five top ICT4D journals and one conference series, only six articles addressed ICT usage in either energy, water or sanitation sectors in a broad way.

Joo and Kim (2016) examined the factors influencing the adoption and diffusion of the smart grid from the perspective of users and provided strategic guidelines for government and providers. They conducted in-depth interviews with users of the smart grid in the Jeju test bed in South Korea, the world's largest community with smart grid. They analysed data by applying grounded theory. They argue for smart grids as the next generation of intelligent electric power grids by incorporating ICT into existing power grids for optimisation of energy efficiency and utilization. Their study does not touch on the mobile technology.

Table 2: Research articles published by top 5 ICT4D journals and M4D conference proceedings between the year 2008 and 2017

Year of Publication/ Journal Name	**IT4D**	**EJISDC**	**ITID**	**AJC**	**AJIC**	**M4D CONFERENCE**
2017	28	51	13	38	6	
2016	36	50	15	33	20	20
2015	30	46	13	34	17	
2014	14	48	13	34	-	28
2013	15	26	16	35	8	
2012	17	43	23	32	8	62
2011	13	33	16	32	-	
2010	15	33	20	28	4	21
2009	15	33	18	25	4	
2008	15	20	8	23	5	10
Total Number of Research Articles Published	**198**	**383**	**155**	**314**	**72**	**141**

Table 3: Number of research articles that met the inclusion criteria against the search results and the research articles published

Journal Name	**IT4D**	**EJISDC**	**ITID**	**AJC**	**AJIC**	**M4D**	**TOTAL**
Research Articles Published Between 2008 - 2017	198	383	155	314	72	141	**1263**
Research Articles in the Search Results	117	157	78	57	*	*	
Articles addressing the energy, water or sanitation sectors.	**1**	**1**	**1**	**0**	**0**	**3**	**6**

Nganyanyuka et al (2017), focused on a mobile- phone based ICT platform. They proposed and tested an approach to monitor and repair rural water points in three villages in Tanzania, through a mobile based ICT platform. They carried out their research using in-depth interviews

in the local dialect (Swahili), participant observation and informal interactions in the markets (having lived there for eight months).

Dasuki and Abbott (2015) used Luke's concept of power and Sen's Capability Approach to create a framework to understand the social powers that inhibit or enable individuals from taking full advantage of ICT resources for furtherance of their lives. They illustrate the framework's utility with a case study based on empirical work in the Nigerian Electricity sector. They used in-depth semi-structured interviews, observations and document analysis to carry out a case study on a Computerised Electricity Management System that among other features, allowed customers to pay their electricity bills using their mobile phones. Their main focus however was not on the mobile component.

The M4D conference proceeding accounted for half of the academic research papers that met our inclusion criteria (three out of six papers). Hellstrom and Jacobson (2014) through an in-depth analysis of four cases, sought to understand the common benefits and challenges for increased and sustainable use of mobile applications in the provision of water services. They contended as a study limitation that use of ICT and mobile in the water sector was a relatively new phenomenon and many projects were still in an early stage of implementation. They conducted their studies in Kenya and Uganda. They however did not provide a specific theoretical underpinning to their study.

Herard and Richomme (2014) present a description of a complete low-cost open-source sensor network solution from the sensor to its associated framework. They describe two use cases where Sensonet has been deployed: in a water survey where a sensor network has been designed in order to automatically retrieve the level of the water sources in Sahel region in order to optimize the path of nomadic farmers. It has also been deployed on solar panel monitoring in schools in Niger. The maintenance is realised by a central entity located in the capital. The sensor network checks that the remote panels are still working and alert, it if is not the case. The paper is quite technical, describing the architecture and overview of the machine-to-machine solution. The paper however lacks the link of how the solution actually leads to development.

Lastly, Sundharam et al. (2012) present a mobile application that can calculate energy consumption and savings by a user in terms of monetary values and carbon footprints. It is also a technical, systems development paper that describes the functionalities and anticipated advantages of the application. The authors have however done less to argue about development or used any theories to explain their work.

Most of the other search results were excluded from this review because they only tackled energy, water or sanitation in passing, or as a requirement or challenge in the field. It is only the six papers that handled in a broad way, the link between ICTs and energy, water or sanitation.

Academic research in this area is still at its embryonic state (Etoundi et al., 2016). This is demonstrated by the handful research articles in the top ICT4D journals. It is also in line with a list of ICT research domains in Africa reported by IST Africa (2012). IST Africa reports that many African countries focus their research efforts in health sector, in technology enhanced learnings, in networks, in digital libraries and in agricultural sector. It seems ironical that as 13 countries are interested in network technology, only two consider the energy sector is an important issue that should be addressed. Less than 20% of African families are connected to

the electricity network and therefore, the energy sector should be one that researchers should address as a matter of priority (ibid).

This dearth of academic literature on ICTs transforming the energy, water and sanitation sectors, provides an opportunity to make a case for inclusion of mUtilities as a viable empirical testbed. The next section describes the status of the field in practice and what the academia can learn and borrow from practitioners, moving into the future.

5. Insights from Practice

The GSMA represents the interests of mobile operators worldwide, uniting nearly 800 operators with almost 300 companies in the broader mobile ecosystem, including handset and device makers, software companies, equipment providers and internet companies, as well as organisations in adjacent industry sectors. The Mobile for Development (M4D) utilities programme within GSMA works with any energy, water or sanitation service, provided to a community, which includes a mobile component (voice, Short Message Service (SMS), Unstructured Supplementary Service Data (USSD), Machine-to-Machine (M2M), Near Field Communications (NFC), a mobile operator's agent network, tower infrastructure). It aims to leverage mobile technology and infrastructure to enhance affordable and reliable energy, clean and safe water and sanitation services in underserved communities (GSMA, 2018).

Through the support that they have received from the government of the United Kingdom (UK) through the Department for International Development (DFID), Scaling off-grid Energy by USAID, Power Africa, Shell Foundation and The African Development Bank (AfDB), GSMA M4D Utilities has extended energy access to 20 million households across Sub Saharan Africa through off-grid household solar solutions.

One can own a mobile phone yet lack basic amenities such as reliable energy to light the house or power business, safe drinking water or household sanitation. These amenities are vital for any individual's well-being and socio-economic development, but universal access is far from reality. Widespread availability and the rapidly growing markets for mobiles has presented a key opportunity to address the gap.

Business models have 'matured' and they combine a variety of mobile channels to deliver essential utility services particularly mobile money, M2M communication and mobile services. It is appealing to the Mobile Network Operators (MNO) and utility service providers to help achieve a social goal (SDG 6 and 7) while also achieving a commercial purpose. The partnerships between MNOs and utility service providers helps improve the lives of the underserved customers; stimulates the markets; and empowers small businesses and saves lives.

Since the year 2012 when the M4D Utilities programme began, 43 organizations have been awarded grants from the Innovation Fund. 25 working on energy, 13 working on water and five working on sanitation. So far, there has been two phases of grants with another three on the way. In the first phase, GBP 2,589,784 was awarded. The second phase saw an increase in the award money to GBP 3,426,470. So far, GBP 1,600,000 has been committed for the phase three grants.

In addition to the grant awards, the grantees have attracted additional USD 275 million in investment from the private sector. This demonstrates the opportunity seen by private investors. The initial grant was towards early stage firms to demonstrate proof of concept for their models

in order to attract additional funding. Most of the investment went towards Pay-As-You-Go (PAYG) solar companies with Lumos leading with USD 90 million and M-KOPA following with USD 80 million. The grant projects have demonstrated that improving access to energy, water and sanitation also helps improve health, education, income generation and other areas that enhance the lives of underserved people.

The M4D Utilities programme has managed to publish 17 case studies. It has funded projects and studies in 27 countries: one Latin American, one Oceanic, eight Asian and 17 African. They have concluded market assessment studies for MNOs in nine countries and have approximately impacted 4,542,410 direct beneficiaries.

From evidence, it is reported that digitising utility companies can lead to improvements in the efficiency of water delivery, overcoming the challenges such as bill payment and collection, reliability and improving customer service. Mobile technology is seen as a platform for accelerating progress on the SDGs. In the developing countries, rapid growth of the mobile industry has outpaced the growth of infrastructure and services that are essential for economic growth.

5.1 – The Pay-As-You-Go Model

PAYG refers to a conglomeration of technologies, payment arrangements, ownership modes and financing structures that allow the end user to pay for a solar kit in instalments. The embedded M2M connectivity disables the system if a payment is overdue (GSMA, 2016; M-KOPA, 2016)

The customer typically makes an initial payment of around 30 USD from a sales location for a basic Solar Home System (SHS) that consists of a Photo Voltaic (PV) panel, a battery and a control unit, two or three Light Emitting Diode (LED) bulbs, a phone charger and sometimes other appliances. The customer then makes regular payments (daily top-ups/ credits) of 0.30 - 0.50 USD per day to access the services. They are also allowed to buy credits in any amount, from a single day to 30 days or more. After the customer pays 365 credits, the system automatically switches to free use, requiring no further top ups. The customer then owns the system (M-KOPA, 2015; BNEF & LG, 2016; GSMA, 2017).

The cost is normally calculated so that it is competitive with the daily expenditure on stop gap technologies, such as candles, allowing customers to save from day one. This however applies only to the most common types of SHSs. The payments are mostly made via mobile money although there are alternative ways, such as scratch cards, direct cash payments or using mobile phone credit. If the account is empty or in arrears, the SHS will not discharge power until a payment is made.

PAYG customers under a lease-to-own model may also make use of the PAYG activation technology to collateralise the asset once all payment is made. This will enable them to purchase additional solar capacity, more appliances on offer like smart phones or smart television sets or even non-electrical products like water tanks or energy saving cook stoves. If another product is purchased, the system is closed and top-ups are re-introduced until the full payment is made once again (BNEF & LG, 2016; M-KOPA, 2016; M-KOPA, 2015).

Proliferation of mobile phones in low income economies has been a major driver behind PAYG model. The number of people who own mobile phones far out strips those with access to other services such as grid power and banking (M-KOPA, 2015). The addressable market for PAYG

solar solutions remains largely untapped. GSMA (2017) estimates that two thirds of the 1.2 billion off grid population are covered by mobile connectivity. This presents an exciting opportunity to redesign solutions for people who are invisible to traditional service providers.

The PAYG solar sector allows lower income customers to buy solar products on credit and pay small fees for continuous use. By mid-2017, over 1.6 million PAYG solar units had been sold, having been an increase from 800,000 units that had been sold by 2016. Table 4 shows the distribution of the cumulative sales of PAYG units in 2016 and 2017.

Table 4: Distribution of cumulative sales of PAYG solar units in 2016 and 2017. Source: GSMA 2018 Annual Report (GSMA, 2018)

Year	PAYG Solar Units	East Africa	West Africa	South Asia	Latin America
2016	800,000	92%	4%	3%	1%
2017	1.6 Million	83%	11%	3%	4%

There has been impressive scale in the sales, with the West African market improving at a faster rate followed by Latin America. As a result, 8.5 million individuals had benefited from clean and reliable energy in their homes.

The PAYG solar sector is advancing as displayed by the large amount of private capital invested recently to several key players. The PAYG model relies on debt financing to offer SHS on credit. In the early stages, raising capital from risk-averse lenders proved to be difficult. However, in 2016 and 2017, the positive performance by PAYG companies has begun to reverse the trend.

Bloomberg New Energy Finance (BNEF) reported that USD 380 million had been invested in PAYG solar companies in 2016 in debt, equity and grant capital and in 2017 brought additional investments of up to USD 100 million. This attraction of huge capital by companies demonstrates that investors are recognising the commercial promise by the sector. There is now a large community of international funders (17 foundations, 21 impact investors and a number of venture capitalists).

The PAYG market is most advanced in sub-Saharan Africa. The offerings are most common in Kenya, Tanzania, Rwanda and Uganda where market leaders such as M-KOPA, Mobisol, Off-Grid Electric, Fenix International and BBOXX operate (GSMA, 2015; GSMA, 2016). In West Africa, Nova Lumos, PEG Ghana (an M-KOPA franchisee) and Oolu Solar are preparing for growth in Nigeria, Ghana and Senegal respectively (BNEF & LG, 2016; GSMA, 2017).

The success stories in the sector are still being confined to East Africa, with providers looking at the emerging West African market. The Asian markets have important differences and challenges. They have high levels of competition from commodification of the market and a mobile money ecosystem that is either nascent or based on Over the Counter (OTC), in which customers make payments through agents rather than through their own mobile wallets. This presents an opportunity for academicians to help understand the underlying reasons behind this.

5.2 – Emerging Trends in the PAYG solar sector

PAYG companies offer follow-on financing schemes and new products for customers after paying up for the SHS. These new products include televisions, radios, larger appliances, water filters, better cookstoves. This arrangement also reinforces the sales made by the PAYG providers. Financial services, including loans and insurance are also provided to the customers.

Based on customer data and payment histories, credit scoring is enabled. Fenis offers customers access to financing for school loans while PEG offers health insurance.

There is growth of MNO-led business models for PAYG solar and grid mini power. With over 1.6 million mobile money transactions recorded per month on top up PAYG products in September 2016 (GSMA, 2018), the direct benefits to MNOs are clear. MNOs around the world are showing interest in launching their own PAYG solar models as well as smart metering and pre-paid energy platforms for centralised urban grids and mini-grids.

Orange has a mobile enabled grid management system in Tunisia and wants to replicate it in Burkina Faso. Dialog Sri Lanka is working with the national energy utility, Lanka Electricity Company (LECO), to develop a pre-paid metering solution. There is potential to test the potential of MNOs embracing the opportunity to become the driving business entity for launching and scaling these models. There is need to better understand the true commercial value of these services for the MNOs. There is also need to test whether MNOs' brands and vast customer networks can scale these services at rapid rates.

All these emerging trends in the mobile and utilities sector present vast opportunities for research in related academic spheres.

6. Conclusion, Limitations and Future Directions

This paper reveals a dearth of academic research into the area of ICT use in provision of utilities (energy, water and sanitation services). It presents the academic research landscape within this area over the past 10 years (2008 - 2017), with the intention of proposing ways to fill the gap. Of the 1263 academic articles that were the subject of this study, only six discussed ICT usage in the energy, water or sanitation sectors, in a core manner. This demonstrates that very little academic research exists in this area. However, on a positive note, it provides a great opportunity for future research.

We are in agreement with Strand (2016) that since this is an emerging field with low level of maturity, the review process was further complicated. It could be argued that a less formalistic review design may have resulted in a larger body of academic research to analyse. Future research analysis should include other publication platforms including but not limited to database searches, influential reports from the development community, conference papers, sector-relevant edited books and chapters.

Moving into the future, academic research in this area can borrow a leaf from the practice in the same field, which is evidently more advanced. The practitioner research in this field points to gaps and opportunities which can be addressed by academic research. There is also potential for academic research to inform policy in this area.

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Framing M4D in the Water Sector: Examining Effects of Mobile Technology Initiatives

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ABSTRACT While Mobiles for Development (M4D) research examines subjects describing the effect of mobile phone technologies on the development of multiple sectors; there is a lack of studies related to the influence of mobile apps on the development of the water sector in Sub-Saharan Africa (SSA). This paper draws on a systematic literature review process and Walsham's framework for ICT-based development initiatives to illustrate how mobile apps have an impact on the continual growth and development of the water sector. We adopt two framework categories – *better lives for the poor* and *improved government services* to explain that mobile app-enabled development in the water sector is an ongoing process that is having substantial effects on water service delivery, dissemination of information, the interaction of all stakeholders and establishment of socio-economic opportunities. The literature on findings of apps mentioned provide for an interpretive understanding of their consequences towards development, and continual app implementations speak to their progressive contributions. However, limited academic literature related to app initiatives in the water sector was a substantial challenge.

1. Introduction

As an indicator of ICT infusion, mobile phones have permeated SSA because of nationwide access to telecommunication networks, low costs and their provision of speedy communication mechanisms (Ekeng-Itua, 2018; Etzo & Collender, 2010; Uwizeyimana, 2015). Mobile phones are now considered convenient tools that have augmented opportunities for countries in SSA to improve service delivery provision (Champanis & Rivett, 2012a; Hellström & Jacobson, 2014; Kumpel et al., 2015). Mobile-based interventions have now been implemented through e-government policies and private sector interventions to improve accountability, management, transparency and provide for critical evaluation of citizenry access to services (Johnston et al., 2015; Rashid & Elder, 2009; Ssozi-Mugarura et al., 2017; Uwizeyimana, 2015)

Mobile phone applications in SSA countries follow two classic approaches for app service implementation. The first approach uses mobile phone generic features provided by the telecom network such as mobile money and M-Pesa; while the second approach entails the use of apps that can be downloaded onto the mobile phone (Loudon, 2016; Perrier et al., 2015; Uwamariya

et al., 2016). Loudon (2016) states that the short message service (SMS) is a prevalent platform for mobiles for development (M4D) applications and services. Due to the diffusion of mobile technologies, the M4D field manifested to relate the effects of mobile phones on to development (Donner, 2010; Perrier et al., 2015; Rashid & Elder, 2009). M4D advocates for an understanding of the significance of mobile technologies towards service delivery access and socioeconomic development (Perrier et al., 2015; Uwizeyimana, 2015). Mobile-based influence on development has resulted into sector-specific synonyms like m-Health, mWASH, m-government and m-education; and several specific mobile phone applications in SSA have been implemented across multiple domains of health, agriculture, education, water sanitation and hygiene (WASH), e-commerce, business and finance (Aker, 2010; Hutchings et al., 2012; Mayende et al., 2006; Murugesan, 2013; Ndaw, 2015; Rashid & Elder, 2009; Wesselink et al., 2015; Wolff-Piggott et al., 2017; Wolff-Piggott & Rivett, 2016).

The water sector has experienced increased implementation of mobile related apps to improve service delivery, functionality of water sources, transparency, data management and accountability (Champanis & Rivett, 2012a; Hellström & Jacobson, 2014; Kumpel et al., 2015; Nel et al., 2014; Rein, Champanis, & Rivett, 2013). For example, in East and Southern Africa, several mobile applications such as Mobile for Water (M4W), Pay Me For Water (PM4W), Water Point Mapper (WPM), Field Level Operations Watch (FLOW), MajiVoice, M-Maji, DropDrop and e-water payment system in National Water & Sewerage Corporation (NWSC) have been implemented to improve service provision for citizens (Chemisto & Rivett, 2015; Ndaw, 2015; Ssozi-Mugarura et al., 2017). In Ethiopia, sensors and smartphone technologies have been implemented to track water collection in rural communities (Chaudhri et al., 2012).

Using a technology-based perspective, this paper provides a systematic literature analysis showing how mobile applications are affecting service delivery access and broader development of the water sector. The study uses specific categories adapted from a framework for ICT-based development initiatives proposed by Walsham (2010) to provide an understanding of the consequences of app implementation. Using a systematic literature review process (SLR) for analysis, the paper examines literature describing the significance of selected mobile applications and their interpretive influence on water service delivery. The main research question for this study is: *How have mobile phone apps influenced development in the water sector*? Thus, the specific objectives of this study were to assess the influence of mobile applications on development based on perspectives from the literature on service delivery, and mechanisms to support accountability and transparency.

2. Study Context

Over the last decades, the access to mobile phone platforms has multiplied exponentially in SSA, and mobile-based tools are now the fastest and cheapest form of communication mechanisms that governments and private entities are utilising to provide specific services to citizens (International Telecommunication Union, 2016; Loudon, 2016). SSA is mainly responsible for the exponential growth in access to mobile platforms, and multiple scholars have described mobile phone use as an influence that is cultivating economic development (Ekeng-Itua, 2018; Loudon, 2016; Muto & Yamano, 2009; UNDP, 2016; Wesselink et al., 2015). Mobile platforms have made it possible to quickly disseminate service delivery information towards rural and urban communities (Jack & Suri, 2014; Muto & Yamano, 2009).

The extent to which citizens in SSA are using mobile phone applications has become an essential factor in determining mobile based developmental contributions (Donner, 2010; Ekeng-Itua, 2018; Hellström & Jacobson, 2014). Interaction with mobile phones and the ability to acquire new innovative ways of interacting with the device have improved personal developments or capabilities of individuals. Benefits like learning new ways to use mobile phones, access to the internet, social media and other mobile payment services improve personal capabilities. Mobile-based interventions in SSA are now being implemented to tackle developmental challenges across numerous sectors such as education, agriculture and the water sector (Chemisto & Rivett, 2015; Hellström & Jacobson, 2014; Rein et al., 2013; Ssozi-Mugarura et al., 2016; Uwizeyimana, 2015).

Whereas research categorising effects of mobile technologies is still ongoing, substantial apps have changed ways in which some sectors operate (Loudon, 2016; Uwizeyimana, 2015). For example, the success of M-Pesa in Kenya and mobile money in Uganda has influenced operational changes in several transactions based organisations such as banks and businesses in the water, health, education and agricultural sector (Chemisto & Rivett, 2015; Donner, 2010; Jack & Suri, 2014; Ndaw, 2015). The success of these mobile-based payment mechanisms have led to an increase in systems that integrate these payment methods on to their processes. The ability to directly or indirectly impact service delivery access and quality of service for finance and economic processes of citizens have significantly led to focus on mobile-based developments (Loudon, 2016; Rashid & Elder, 2009).

Within the water sector, which is the focus of this paper, mobile based applications in SSA such as MajiVoice, M4W, DropDrop, WPM, FLOW and PM4W have demonstrated service delivery provision, communication improvement, efficiency, transparency and accountability benefits to citizens. For example, MajiVoice was implemented in Kenya by the Water Sector and Regulatory Board (WASREB) to support communication between citizens and the Nairobi City Water and Sewerage Company (NCWSC) and is now used by water service operations (Ndaw, 2015). DropDrop is used by citizens in South Africa to manage their water usage in Cape Town city which is experiencing water scarcity (Rein et al., 2013). M4W and PM4W have been functional in rural Ugandan towns to manage access and functionality of water sources successfully; with M4W being integrated to existing systems by Uganda's Ministry of Water and Environment (MWE) (Ndaw, 2015; Ssozi-Mugarura et al., 2017; Triple-S, 2013). All these mobile apps were developed using different methodologies but have provided substantial success and ubiquitous benefits to communities.

However, there is still limited evidence to support development based contributions of mobile applications (Loudon, 2016; Mthoko & Khene, 2018; Uwizeyimana, 2015). Most articles document extensive spread use of mobile devices and their contributory properties, but there are no significant measures for development. Several studies have documented individual capabilities adapted, and direct or indirect employment opportunities attained due to applications such as M-Pesa and mobile money (Kleine, 2010; Mthoko & Khene, 2018; Ndaw, 2015). Copious research has been or is presently being undertaken to identify practical perspectives that link influence of mobile-based services to the development of citizens and countries at large (Duncombe, 2014; Ekeng-Itua, 2018; Haji et al., 2016; Hellström & Jacobson, 2014; Katule et al., 2016; Katule et al., 2016b; Salim & Wangusi, 2014; Uwizeyimana, 2015).

3. Methodology and Analysis Framework

Two distinct methodological approaches were adapted to recognise findings in this paper. One approach was used for article selection during the literature review process, and the second approach was undertaken to analyse findings from the literature. The method of article selection follows a systematic qualitative literature review process adapted and modified from related studies by Dybå & Dingsøyr (2008); Grant & Booth (2009) & Hauge et al. (2010). Evaluating information from literature is based on a framework for ICT based development initiatives proposed by Walsham (2010). Due to literature being the primary source of empirical data, the underlying philosophy of this investigative research is interpretivist because we provide a constructive understanding of meanings from contextual themes. The next sub-sections discuss the two approaches.

3.1 – The Process of Systematic Literature Review (SLR)

We adopted an SLR approach from Grant & Booth (2009), but is also similar to other related literature review studies by Dybå & Dingsøyr (2008); Hauge et al., (2010) & Johnston et al. (2015). According to Grant & Booth (2009), SLR studies can lead to an interpretive explanation of a specific phenomenon and broader development of a new theory. The reasons for choosing SLR was because we wanted to discover themes or categories from understanding meanings or interpreting perspectives specified in the articles.

Thus, our first step to finding articles related to the influence of mobile phone applications on the development of the water sector was to search electronic databases for journals, conference proceedings and reports. We limited ourselves to these three article types to reduce search results. Our search string included keywords relevant the study objectives. Dieste & Padua (2007); Dybå & Dingsøyr (2008) & Hauge et al. (2010) endorse searching through abstracts and titles as a suitable strategy while using keywords selected for the study. The search string comprised: ***mobile phones AND mobile Apps AND water AND sub-Saharan Africa AND m4d AND development***. We also interchanged search string elements to refine the search process. Figure 1 shows the adapted search process.

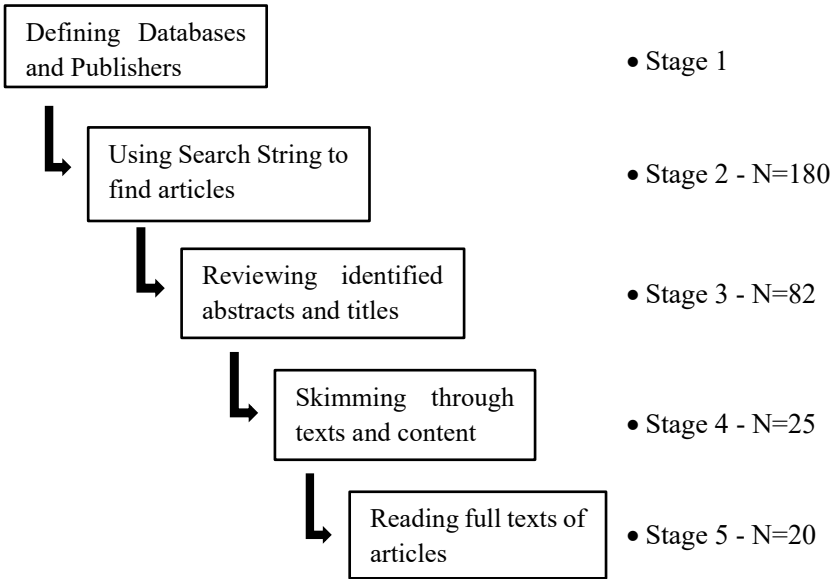

Figure 1: Article search and selection process

Generally, articles with mobile app initiatives were mostly considered while other specific articles with M4D related themes that matched the keywords were also selected. The resultant article search and selection process yielded 20 specific articles of interest. Only these few articles were considered to ensure parsimony towards the research. Nevertheless, we also found a limited number of articles because not much M4D research has been conducted for specifically the water sector. Articles over the last decade were mostly considered, but the articles had to either be relevant towards the water sector or be based on related mobile technology applications.

Table 1: Showing article sources, keywords and total search results

Databases	Link	Total	Keywords
Google Scholar	https://scholar.google.co.za	102	Mobile Phones
Springer	http://www.springer.com/gp/	46	Mobile Apps
IEEE	https://ieeeplore.ieee.org/Xplore/home.jsp	25	Water
ACM	https://dl.acm.org	5	Africa
AIS	http://aisel.aisnet.org	2	M4D
			Development

All the articles identified were added to Mendeley and read by the authors. Using Nvivo software, a thematic analysis was undertaken to highlight core themes identified from article interpretations which pinpoint developmental contributions.

3.2 – Exploiting the Analysis Framework

Once all the required literature had been identified, we commenced analysis of data using a published framework. I selected a framework for analysis of ICT based development initiatives that was proposed by Walsham (2010) because we could not find an appropriate M4D based analysis framework. The framework was derived from five categories of development freedoms described by Sen (1999), particularly categories related to economic, social and transparency. The framework is composed of four development based categories, that is: *Better lives for the poor*, *Improved government services*, *Enhanced economic activity* and *Improved civil society* (Walsham, 2010).

In using the framework, we chose two categories to link development effects of mobile applications and the water sector. These categories were *better lives for the poor* and *improved government services*. The categories were associated with quotations from articles to examine the influence of mobile applications on water sector development.

Table 2: Showing framework categories adapted from Walsham (2010)

No	Development Category	ICT-Based Initiatives	Specific Development Goal
1	Better Lives for the poor	- Mobile payments apps for water such as M-Pesa and mobile money - Adoption of apps for water management - Improved communications and water service access	- Improved economic and social activities due financial services - improved access to services for water service delivery or water sources - Better financial services to citizens and businesses
2	Improved government services	- Mobile apps for information and services - Computerized back-end administrative systems - E-government direct services - Use of GIS and Water Management Information System (WMIS)	- Access to information and decision making - More efficient services to citizens - Better planning and implementation of infrastructure - Transparency and accountability

The sub-sections below describe how the categories were exploited.

3.2.1 – Better Lives for the poor

This category is related to Goal 6 of the United Nation's (UN) Sustainable Development Goals (SDGs), which focuses on enabling safe water access for all (United Nations, 2016). Our analysis of this development category digests how mobile applications in the water sector are linked to better lives for the poor. The potential of mobile apps in supporting service delivery through data collection, storage and reporting are crucial to improving the welfare and livelihoods of communities. Mobile applications support reporting, water quality management, water accessibility, community engagement, storage, accounting, transparency, billing and revenue management (Brown, Marsden, & Rivett, 2012; Champanis & Rivett, 2012a; Chaudhri et al., 2012; Duncombe, 2014; Murugesan, 2013). Use of mobile phones has enabled development of Apps which are now providing flexible support to improve access to water services for communities (Brown et al., 2012; Hellström & Jacobson, 2014; Murugesan, 2013).

3.2.2 – Improved Government Services

This development category entails the use of apps to manage government services. The government are responsible for delivery of services to citizens, and there has been an increased use of mobile apps for the provision of efficient services to citizens (Chemisto & Rivett, 2015; Mirembe, 2014; Salim & Wangusi, 2014). Mobile applications in the water sector have been implemented under e-Government services for effective management of water supplies (Champanis & Rivett, 2012b; Hellström & Jacobson, 2014; Ndaw, 2015). Mobile apps and mobile money payment systems, especially in East Africa, have supported public and private sector water utilities to manage payments and delivery of water services to communities (Hellström & Jacobson, 2014; Hutchings et al., 2012; SNV & IRC/Triple-S, 2012).

4. Findings and Discussion

This section explains the literature findings of mobile apps and then relates the meanings to the framework categories. We describe each category by referencing how a specific mobile app has supported development through analysis of their influence towards communities. The findings are realised using two questions associated with the development category from the framework.

4.1 – Have mobile apps contributed to better lives for the poor?

Mobile phone implementations or mobile money applications such as Mobile for Water (M4W), Pay Me For Water (PM4W), Water Point Mapper (WPM), Field Level Operations Watch (FLOW), MajiVoice, M-Maji and DropDrop have had contributions in the water communities using them to manage their water services. Table 3 details the literature findings.

Table 3: Literature findings related to better lives for the poor

Themes Under Better Lives for the Poor	**Article Citation**
Better functionality of water points	The Water Point Mapper (WPM) system in Ethiopia assists to "*plan for rehabilitation and extension of water supply services*" (Breslin, 2013, p. 12). Pay Me for Water (PM4W) system was used "*to report broken pipes, assess repairs and record completed tasks" and use 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*" (Ssozi-mugarura et al., 2017, p.122) Using MajiVoice system in the management of water service provision, "*Number of reported leakages has doubled since the introduction of MajiVoice*" (Breslin, 2013) In Uganda, mobile phones aided "*efforts to improve the functionality of water sources and the reduction of response time in cases of breakdown*" (AfDB, 2013) ICTs like "*MajiVoice are levelling the playing field between water consumers and providers by enabling access to information on rights and responsibilities*" (Hellström & Jacobson, 2014, p. 55)
Empowerment and Social opportunities	Through DropDrop, users "*appreciated the chance to learn and to understand their water usage and the water meter*" (Rein et al., 2013) PM4W improved transparency, "*community members who received the SMS notifications, expressed confidence in their water managers because of the feedback*" (Ssozi-Mugarura et al., 2017) Through M4W, "*HPMs role is now more formalised, and they have more authority to help the community*" (Hellström & Jacobson, 2014, p. 55) PM4W improved "*personal communication and other services such as, accessing mobile (money) payment services that allow rural dwellers to receive money from relatives living in the towns*" (Ssozi-Mugarura et al., 2017)

	PM4W aided participants to find "*new ways of using mobile phones and articulating their needs and experiences*" (Ssozi-mugarura et al., 2017, p.127)

4.2 – Have mobile apps contributed to improved government services?

To answer this question, we related improved government services to water governance using mobile apps implemented by public and private institutions. Mobile apps such as M4W, MajiVoice, FLOW and WPM were implemented with strong support from government agencies. Mobile apps are providing support for improved data collection, which in turn supports better decision making by government agencies responsible for service delivery towards communities. Several studies assert that the use of mobile apps in the water sector is changing the way water is governed, and mobile apps are supporting improved service delivery challenges (Brown et al., 2012; Champanis & Rivett, 2012b; Hellström & Jacobson, 2014; Ssozi-Mugarura et al., 2017).

Table 4: Literature findings related to improved government services

Themes Under Improved Government Services	**Article Citation**
Improved Services delivery	MajiVoice system implemented by NWSC, it was able to "*Strengthen management and regulator through better data (because it provides customer service data)*" (Breslin, 2013) M4W has "*supported the updating of District and National Information Systems like the WATSUP (Water Atlas Update Project) database which has real-time information on the status of water sources*" (SNV & IRC/Triple-S, 2012) The WPM in Ethiopia "*support government-led collection, analysis, use and updating of water infrastructure data*" (Breslin, 2013). Using FLOW system, "*District Local Governments can also use the data to plan for future investments, and assess service and sustainability levels*" (Hutchings et al., 2012, p. 51); and "*The government of Liberia uses FLOW for its water and sanitation program to plan future interventions and rethink poorly functioning technologies*" (Hutchings et al., 2012, p. 85) In Uganda, NWSC customer "*has the choice to pay using mobile money Pay Bill service, or to go to the nearest bank which has NWSC e-Water interface to pay, in which case a short message service (SMS) alert will be delivered to the paying customer's mobile handset when the transaction is done*" (Waiswa & Okello-Obura, 2014, p. 5)
Better decision making	For MajiVoice "*Number of reported leakages has doubled since the introduction of MajiVoice*" (Breslin, 2013) M4W "*has enabled the collection of up-to-date data and access to real-time information on water problems in the community"* (Hellström & Jacobson, 2014)

	MajiVoice "*allows service providers to broadcast information to its customers by SMS such as service interruptions*" (Hellström & Jacobson, 2014, p.53) The WPM in Tanzania, "*contains extensive information on water point location, technologies, history, and populations served*" (Wesselink, Hoppe, & Lemmens, 2015, p. 61) Through WPM in Ethiopia, "*Decision makers are informed on where to spend funds in the coming year based on the functionality of water points*" (Schouten, 2013, P.13). MajiVoice "*Helping customers voice critical service issues more easily… Enabling staff to process and resolve complaints faster*" (Breslin, 2013)

5. Limitations of the Study

The main limitation of this study is that it relies on secondary data from literature about the significance of the mobile apps initiatives. We use SLR to search and find articles related to the influence of mobile apps in the water sector. It was surprising to find a few articles related to M4D in the water sector. Thus, more research needs to be conducted on the impact of mobile apps on the water sector of SSA countries. More limitations included: no literature on theories or theoretical frameworks evaluating mobile app influence in the water sector, limited literature on theoretical contributions, limited academic articles on mobile apps in the water sector and most of the literature does not strengthen mobile based theoretical approaches to development. Finally, the assessment in the paper may be biased by the authors' optimistic world-view of technological contributions.

6. Conclusion

This article examines literature related to the effect of mobile phone applications on service delivery improvements and developments in the water sector. Through SLR and conceptual categories from an ICT based developmental framework proposed by Walsham (2010), the paper examines how mobile applications are described in the literature. The study draws evidence from literature statements detailing how increased use of mobile phone apps such as M4W, PM4W and MajiVoice are changing what ways in which the water sector operates. We cited literature about mobile technology descriptions, consequences and effects on services or welfare of communities (Ball et al., 2013; Champanis & Rivett, 2012b; Hellström & Jacobson, 2014; Kumpel et al., 2015; Ssozi-Mugarura et al., 2017). Mobile technologies have added to new mechanisms used by governments and development partners to facilitate development in the water sector because of mobile phone saturation in SSA (Ndaw, 2015).

Findings suggest that mobile applications are having both direct and indirect effects on water service access to citizens; and the general growth of the water sector. The significance of apps is mostly observed in the provision of information about water services, storage of data, decision making using the information and matters regarding transparency, accountability and reporting. Apps such as M4W, MajiVoice, PM4W, DropDrop, FLOW and WPM are influencing service delivery decisions and policy. Information from M4W and MajiVoice has been used by authorities (Uganda's Ministry of Water and Environment (MWE) and Nairobi City Water and Sewerage Company (NCWSC)) to make decisions about infrastructure management and water service access for people.

The mobile technology initiatives stated in this paper were reportedly developed and implemented to bring change onto the welfare of citizens requiring water services. In addition to developmental effects, we similarly identified literature highlighting several challenges related to usage and implementation. These included: sustainability due to infrastructure issues, funding difficulties, app proprietorship by governments, telecommunication network issues in many SSA countries, internet and bandwidth costs, app reliability and poverty. These challenges had significant effects on app usage and affected service delivery.

Finally, SLR and the framework adapted allowed this study to have a deductive investigation on the effects of water sector app initiatives. Although I could not find any article that had a direct measure of app influence, we were still able to make an interpretive contribution based on the literature descriptions just as is reported in most the cited articles. The framework supported generated themes from literature to be related to developmental categories better lives for the poor and improved government services. We conclude by stating that proper measures for analysis of M4D effects should be developed and our future studies will undertake to develop a framework for the analysis of mobile technology-based development initiatives. We invite more M4D researchers to pursue framework or theory building undertakings that explain how pragmatic or applied research from mobile technology initiatives influence human development in Sub-Saharan Africa.

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Role of Mobile Phones in Encouraging Public Participation in Municipal Solid Waste Management

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ABSTRACT Global municipal solid waste management (MSWM) challenges call for integrated sustainable waste management (ISWM) in order to attain sustainable waste management systems. However, the potential of ISWM has been hindered by limited public participation in MSWM processes. There is need to explore different ways in which public participation in MSWM can be enhanced. The increased penetration of mobile phones in both urban and rural communities has a potential to increase public participation in MSWM. However, the use of mobile phones in public participation in MSWM has not been widely researched. The aim of this paper, therefore, is to present insights on the extent to which mobile phones can encourage public participation in MSWM in Uganda. We conducted an exploratory study in Uganda's central region with key stakeholders to understand MSWM and how mobile phones can be used to support process of MSWM. The results were analysed using thematic analysis and findings show that mobile phones have a potential to support MSWM activities. From the findings, voice calls, SMS, and WhatsApp are the mostly used mobile phone services. There is a need for further investigations on how mobile phone applications and mobile platforms can be adapted to support public involvement in specific waste management processes (such as recycling and waste prevention) and to educate or increase public awareness on proper waste management practices.

1. Introduction

The global economic developments have not left sub-Saharan African countries unaffected. The sub-Saharan region of East Africa registered the highest growth estimated at 5.3% (ADB, 2018). Uganda's growth was at 4.8% in 2017 and is projected to reach 5.9% in 2018 (ADB, 2018b). Despite the numerous positive effects of massive economic growth such as increased urbanization, improved living standards, increased population growth, and increased

industrialization, there are environmental challenges associated with huge quantities of municipal solid waste as a result of increased economic development (Sjöström & Östblom, 2010; Hoornweg et al., 2013). The global municipal solid waste generation are estimated at 1.3 billion metric tons annually, and the quantities are expected to rise to approximately 2.2 billion metric tons by 2025 (World Bank, 2015). In Sub-Saharan Africa, per capita waste generation ranges from 0.09 to 2.98 kilograms and approximately 62 million tons are generated per year (Kawai & Tasaki, 2016; World Bank, 2015). ISWA (2018) noted that every household on average generates one ton per year in least developed countries. In Uganda for example, it is estimated that the per capita generation of garbage in Kampala is one kilogram per day (Kampala capital city authority, 2015).With a population of about 1.5 million, Kampala generates approximately 1500 tons of waste daily

Solid waste refers to materials or objects "which are disposed of or are intended to be disposed of or required to be disposed of" (Basel Convention, 2011). Solid waste is collected and disposed of by normal municipal solid waste collection services (Khatib, 2011). With the increase in the amount of waste generated, MSWM becomes an essential service that every municipality should offer to its inhabitants (Rajendran et al., 2013; Khan & Faizal, 2008). However, many least developed countries are grappling with the challenge poor MSWM mechanisms (Guerrero et al., 2013; Henry et al., 2005). In many of these countries, their waste management system is characterized by limited coverage of collection services; poor infrastructure, limited resources, weak legal frameworks (Mukama et al., 2016; Okum & Nyenje, 2011) yet public participation in MSWM can help to provide sound solutions (Garnett et al., 2017).

Public participation entails the distribution of information to citizens, the collection of ideas, opinions and knowledge from the citizens and the involvement of the public in the public administration decision-making process (Floreddu et al., 2011. Public participation is part of the broader ISWM strategy that seeks to reuse, reduce and recycle waste ((Van de Klundert et al., 2001). Advance in ICTs have not left Public participation unaffected (Gouveia & Fonseca, 2008). Public participation supported by ICTs is referred as e-participation (Islam, 2008). E-participation is enabled by tools such as: Participatory Geographical Information Systems (PPGIS) (Sieber, 2006), Volunteered Geographical information systems (VGI) (Wang et al., 2015), social media platforms such as WhatsApp, Twitter and Facebook (Peirson-Smith, 2012). However, the potential of mobile phones to support public participation has not been widely researched (Wambui, 2016). The aim of this paper, therefore, is to explore the extent to which mobile phones facilitate public participation in MSWM and MSWM processes supported by mobile phones. The remainder of the paper is organised as follows: In section 2 we present literature on MSWM, public participation and the role of mobile phones in public participation. In Section 3 we explain how semi-structured interviews were conducted in Uganda and the method of analysis. In section we present study findings and in section we present the study discussion, conclusions and future work.

2. Literature review

2.1 – Municipal solid waste management

MSWM is associated with control of generation, storage, collection, transport or transfer, processing and disposal of solid waste materials in a way that best addresses the range of public

health, conservation, economics, aesthetic, engineering and other environmental considerations (EPA, 2015). In order to attain sustainable waste systems, IMSWM was introduced as an extension of MSWM (Van de Klundert et al., 2001). However, in least developed countries the goals of MSWM and ISMSWM have not been fully realised (Guerrero et al., 2013). MSWM in least developed countries is challenged by limited coverage of waste collection services, illegal dumping and open burning of waste, limited space for waste disposal, minimal sorting of waste at the source and inadequate infrastructure to recycle waste (Guerrero et al., 2013). As a result of poor waste management systems, uncollected waste is illegally and indiscriminately dumped in open spaces along roadsides and streets, water bodies, and drainage channels that are eventually blocked, leading to a filthy environment (Kinobe, 2015).

Poor waste management systems are a serious environmental concern globally because of the resultant environmental, economic and health effects to the community (Giovannini et al., 2014; Felice et al., 2012; Glanville & Chang, 2015). Ejaz et al (2010) noted that negative environmental impacts from illegal dumping of waste can be easily observed everywhere in the developing world and some of the evident environmental problems include groundwater contamination, emissions of toxic fumes and greenhouse gases, land contamination, and increases in pest and disease vector populations (e.g., rodents, flies, mosquitoes) (EPA, 2014). The decomposition of organic waste produces a mixture of methane and carbon dioxide. This can be dangerous if allowed to build up in the body of the waste, as it may cause explosions in the heaps of illegally dumped waste. It can also seep out through subterranean fissures and collect in nearby buildings, causing a risk of explosion (NEMA, 2018). A study by Critto et al (2003) found that harmful pollutants from an illegal dump site in Venice, Italy, penetrated through the top soil and contaminated subsurface soil and nearby aquifers hence putting humans and wildlife at high-risk of direct inhalation of volatile contaminants.

Poor waste systems are also associated with health issues. Felice, et al., (2012), found that Campagna residents were continuously exposed to harmful chemicals from illegally dumped waste through polluted soil and water, burned wastes, and consumption of foods farmed on contaminated soil. In their study Senior and Mazza (2004) also noted that the high level of cancer mortality in the area can be linked to the level of pollution caused by inadequate waste-control methods such as illegal dumping. They further noted that 77 percent of cancer mortalities are found in contaminated sites of national concern. Zhang et al (2013) also evidenced that telomere (protein that cap eukaryotic chromosomes) length may be affected by toxins and gas emissions from illegally dumped hazardous waste that has frequently been associated with chronic diseases.

Poor waste management systems also results in huge economic loses because heaps of illegally dumped waste lower real estate values, limit tourism and the entire community becomes unattractive to prospective commercial and residential developers (Matos et al., 2012; Onifade & Nwabotu 2014). In addition, clearing illegally dumped waste presents a huge financial burden to municipal authorities. For example, Mahlokwane (2014) reported that it costs the city of Johannesburg approximately R170 million per annum to clean up street littering and illegal dump sites. In addition, Illegal dumping site rehabilitation charges can consume as much as 30% of municipal government budgets in the United States (Glanville & Chang, 2015).

2.2 – Public Participation in MSWM

Public participation is a process where concerned citizens, government agencies, industry, academia, community groups and local institutions collaborate to monitor, track and respond to issues of common concern (Gouveia & Fonseca, 2008). Public involvement in waste strategy and facility planning helps to transform traditional consultation techniques to incorporate deliberative and participatory activities that involve lay communities at an early stage of decision-making, where there is still a chance to talk about alternatives, potential sites and community benefits (Cotton, 2013). Effective MSWM systems need the involvement of stakeholders as well as social, economic and psychological components on top of technical innovation (Hipel, 2016). Public participation is beneficial because: 1) all the interests and issues at stake are considered, 2) it reduces outrage and develops good working relations and 3) it helps stakeholders to reach a compromise and long-lasting solutions which are satisfactory to all parties (Wiedemann & Fermers, 1993). However, public participation in waste management has received less attention in most developing countries much as it is critical to the success of any waste management system (Afroz et al., 2011). Buntaine and Nielson (2016) also noted that Uganda still finds it difficult to engage the public in actionable ways to improve waste management irrespective of the immense support received from donors.

2.3 – The role of Mobile phones in public participation

Public participation has benefited from developments in Information and communication technologies (ICTs) (Gouveia & Fonseca, 2008). Public participation enabled by ICTs is referred to as e-participation. ICT tools act proactively and change the spheres of public involvement, increase access to information and adversely broaden participation (Tambouries et al., 2007). ICTs have a potential to motivate citizens to participate and also ensure real-time access to information (Islam, 2008). With respect to environmental planning and decision making processes such as waste management, public participatory GIS (PPGIS) and Volunteered Geographic Information (VGI) are dominant e-participation tools (Clark, 2014. Mobile participation is an emerging research area (Ertio, 2015) and has not been fully explored in MSWM (Anthouli, N.d). The proliferation of mobile technologies enables both novel forms of participation; however, Governments have been unable to fully exploit the capabilities of mobile phones to realise the benefits of mobile democracy such as receiving feedback from citizens about services delivery (Hermanns, 2008). Mobile phones have a potential to increase public participation (Heeks and Bailur, 2007) in environmental matters such as waste management and increase effectiveness of waste management systems. According to Anthouli (N.d) mobile social platforms provide to public an opportunity to comment MSWM serves and communication to waste management authorities. In another study by Wambui (2016) citizens/ public can be used as a "sensor" to inform the relevant authorities about illegal waste dumping through mobile channels. Matsumoto and Takeuchi (2011) also noted that mobile surveillance and reporting systems in cooperation with the local residents contribute to a significant reduction of illegal dumping. The Increased penetration of mobile phones in both urban and rural communities has widely extended the potential of the citizens' observatories (Havlik & Schimak, 2014). In Uganda, at least more than 52.3% of the populations (19.5 million) have access to mobile phones. Mobile phone accessibility in Uganda has been on a trajectory growth, increasing to over 20 percent in 2008 and 46 percent before growing to above 52 percent in 2014 (Nakaweesi, 2015). However, the use of mobile phones in citizen's observatory of illegal dumping has not been widely researched (Wambui, 2016).

3. Methodology

In this section, we present a set of methods that were used to study the Municipal solid waste system in Uganda and how mobile phones are used in municipal solid waste management. We describe the study setting, the target audience, data collection and analysis procedures.

3.1 – Study Area

The study was conducted in the districts of Kampala, Mukono, and Wakiso. These districts constitute the Kampala Metropolitan region—the fast-growing urban region in Uganda. The regions' rate of industrialization and urbanization is estimated at 5.1% with a population of 1,507,080 based on 2014 national census (UBOS, 2014). Kampala's population is rapidly increasing, with an estimated growth rate of 3.0% per annum (UBOS, 2014). Kampala city has five divisions, namely, Central, Nakawa, Makindye, Rubaga, and Kawempe. Wakiso is the second largest urban region after Kampala city. It is divided into four municipalities and has a population of 2,007,700 people as per 2014 national census (2014). In this study, Entebbe and Nansana municipalities were selected to provide an understanding of municipal solid waste management challenges experienced in well-established municipalities and new up-coming municipalities in Wakiso District. Kampala and Wakiso are the only urban areas with an engineered landfill—Kitezi. Kitezi landfill is located in Wakiso district and was opened to its works in 1996. Mukono is also one of the large urban areas in Uganda. Mukono Municipality has two divisions—Goma and central housing a population of 161996 people (UBOS, 2014). Mukono municipality is also a home to the Kampala metropolitan's' new landfill site—Dundu. Secondary data was obtained from academic journal articles, waste ordinances, consultancy reports, and books in order to understand the magnitude of illegal dumping and municipal solid waste collection and disposal challenges in Uganda.

3.2 – Data Collection

Primary data were obtained using semi-structured interviews. Semi-structured interviews were used because they help to builds a holistic snapshot, analyses words, reports detailed views of informants. They also enable interviewees to "speak in their own voice and express their own thoughts and feelings" (Berg, 2007). Interviews were carried out to gather different views regarding MSWM challenges and the extent to which mobile phones are used. A semi-structured interview guide was prepared before the survey that was later be administered in a face to face interview session. Interviews were recorded and the interviewees were required to answer all questions in the guide. Interviews lasted between 40minutes to 1 hour. A total of 22 interviews were conducted as follows: (1) 5 Solid waste officers (2) 1 landfill officer, (3) 3 Environment officers (4) 1 compost site officer, (5) 5 Physical planning officers (one of each division), (6) 4 directors of waste collection agencies and 3 health officers (one of each division). The participants were purposively selected because they have knowledge on waste management practices; they have participated in planning for MSWM and have supervised waste collection and disposal services. The selection helped to gather different views regarding challenges to municipal solid waste management that are often reported by the public and the mobile phone communication functionalities that are used.

3.3 – Data Analysis

In this study, we listened to the recorded interview and transcribe the data on papers. Transcripts were used for analysis by applying thematic method of qualitative data analysis

advanced by Braun and Clarke (2006). The thematic method of data analysis by Braun and Clarke (2006) includes six steps that the researcher iterates through. Thematic analysis provides a flexible and useful research tool, which can potentially provide a rich and detailed, yet complex account of data. The approach has been adopted by other qualitative researchers (e.g. Maguire and Delahunt, 2017; Nowell et al, 2017). Nowell et al (2017) noted that Braun and Clarke's (2006) phases of thematic analysis are an iterative and reflective process that develops over time and involves the researcher constantly moving back and forward between phases. In this study, interviews were recorded, transcribed and the transcripts were coded to create initial codes in addition to codes that were generated during data collection.

In this study thematic analysis was done through reading the transcripts and generating the initial codes that were later integrated derive final codes. The initial round of data analysis aimed at identifying expressions of municipal solid waste issues commonly reported with mobile phones. Having carefully read through the transcripts to gain a thorough understanding of the material, themes were identified that were later characterized to form municipal solid waste challenges often reported using mobile phones as follows: collection points, littering and illegal dumping and collection schedules and leachate flow. The themes that were later characterized were prefaced by statements like, "when skips are full" and "when there is free public space". Following these statements, we were able to characterize municipal solid waste management issues along which results were reported.

In another round of analysis, we concentrated on identifying mobile phone technologies used in municipal solid waste management in the transcripts. This resulted in a characterization of the mobile phone technologies important for municipal solid waste management. These statements were often prefaced by, for example, "they normally call when they identify an idle public space", "they send SMS" and "we normally receive phone calls". Following these statements, we got an understanding of the functionalities of mobile phones crucial for municipal solid waste management.

4. Results

4.1 – Municipal solid waste management issues reported using mobile phones

We began this study by exploring the kind of municipal solid waste management issues that have so far been reported using mobile phone technologies. From the thematic analysis, four major municipal solid waste management issues reported using mobile phone technologies emerged, namely: inadequate collection centers/points, failure to collect waste as per the schedules, illegal dumping and littering, and leachate flow. Details of the findings are presented in Table 1.

Table 1: Challenges in municipal solid waste management

Challenges	No. of respondents	Percentage
Inadequate collection points	4	18%
Illegal dumping and littering	12	55%
Leachate flow	1	4.5%
Failure to collect waste as per the schedules	15	68%

The study findings in Table 1 show that failure to collect waste on agreed upon schedules is a waste management challenge commonly reported using mobile technologies. 15 participants (68%) admitted that whereas they receive complaints on uncollected waste through their mobile phones, municipal authorities and waste collection companies at times fail to adhere to waste collection schedules and waste is left uncollected for some time. One of the division health officers said that

> "*Sometimes when our vehicles break down or we don't have funds to buy fuel, we fail to collect waste on scheduled days and area representatives call us*".

Another respondent, a solid waste officer said that

> "*We have a toll free number where the public informs us about uncollected waste especially on road reserves when we take long to collect it".*

The second most reported issue is littering and illegal dumping accounting for 55% (12 respondents). Municipal authorities are phasing out skips and collection points except in inaccessible areas. However, citizens/residents still dump in earlier condoned and other open public places. It is also not uncommon to find posters "illegal dumping is prohibited" in some public places. One of the managers of a waste collection agency said that

> "*Some residents refuse to pay for collection services and illegally dump their waste in front of peoples' gates and we receive complaints*".

Another respondent, a solid waste officer, said

> "*We have a big problem with illegal dumping especially in slum areas and the area representatives have tried their best to report. But these days we have enforcement officers and we carry out sensitization campaign to curb the problem".*

Inadequate collection points/centers accounted for 18.18%. In inaccessible areas and commercial areas, it is important to have waste collection points/ centers. However, due to limited public space, some areas do not have waste collection points. One of the respondents admitted that

> *"We lack collection points and space to place skips".*

In some areas, residents mobilize themselves and create temporary collection points and they call us to go and place a skip or verify if the space can be used as a collection point".

Leachate flow is the least reported problem, mentioned by 1 respondent. A landfill officer said that

> *"On rare occasions, leachate flows to gardens of residents near the landfill and they complain".*

The landfill officer, however, maintained that

> "*They work hard to control leachate from flowing to other places and they have a leachate treatment area".*

After establishing the kind of municipal solid waste management issues that are reported using mobile phone technologies, there was a need to determine the kind of mobile phone

technologies used for reporting municipal solid waste management issues. Details of this study are reported in the next section.

4.2 – Mobile phone technologies Used in municipal solid waste management

The study sought to investigate the role of mobile phone technologies namely voice calls, video calls, short messages (SMS), WhatsApp, Facebook, Twitter and others that might have been used in municipal solid waste management. Results from thematic analysis showed four mobile phone technologies as the most widely used namely: voice calls, short messages (SMS), WhatsApp, and Facebook. The results of the study are summarized in Table 2.

Table 2: Mobile phone technologies used in municipal solid waste management

Mobile Technology used	No. of Participants	Percentage
WhatsApp	3	14%
Voice Call	11	50 %
SMS	7	32%
Facebook	1	4.5%

As shown in Table 2, Voice calls were the most widely used. Eleven (50%) participants reported to have received phone calls regarding municipal solid waste management issues. One of the solid waste officers commented that

> "*We mostly receive phone calls on municipal solid waste management issues, particularly collection schedules, community sensitization campaigns, waste dumping in prohibited areas".*

Another respondent, a landfill officer, concurred and said that

> *"We receive and make many phone calls to resolve issues concerning waste collection, transportation".*

Short messages were the second most used mobile phone technology to report municipal solid waste management issues. Use of mobile phones was mentioned by 7 (32%) participants. One of the respondents, a manager of a waste collection company, said that

> *"Short messages are very important to us because they help us to communicate amongst ourselves, to our clients, community-based associations and they are cheaper than phone calls".*

One of the environmental officers is quoted to have said that

> *"We also use SMS to communicate amongst ourselves, council representatives and community-based associations".*

WhatsApp is another mobile phone technology used in municipal solid waste management. 3 (14%) participants reported to have received WhatsApp messages. One of the directors of a waste collection contracted agency said:

> *"We receive WhatsApp messages from the field officers and clients sometimes confirming that waste has been collected".*

Facebook was the least used for reporting municipal solid waste management. Only one participant agreed to have used Facebook to advertise their waste management services to different clients. Advertisement of waste management services is an important aspect of MSWM as it increases public awareness of the municipal waste management practices.

5. Discussion of Results

The study sought to investigate the municipal solid waste management challenges reported using mobile phones and the mobile phone technologies management. From the study findings, Voice calls, SMS, WhatsApp, and Facebook are the major technologies currently used in municipal solid waste management. Voice calls and SMS were the commonly used technologies representing 50% and 31.81% respectively. The results are in line with those of Thinyane et al (2015) from South Africa. In their study, voice calls and SMS were ranked as the most important mobile phone functionalities used by the public to participate in governance issues. Another study by Small (2015) found that phone calls and text messages were the most preferred channel of communication used by Ghana citizens to air out their grievances.

In line with this study finding, Mavropoulos et al. (2015) also noted that SMS is a useful channel for the public to communicate with waste authorities and ask for information, comment on waste management services offered and show their dissatisfaction with waste management services. In addition, illegal activities may be reported from citizens to relevant authorities through SMS. Thus, SMS have a potential to improve on the waste management challenges because they support collaboration with between municipal authorities and citizens.

WhatsApp and Facebook were also used according to 3 and 1 of our respondents, respectively. Mobile based social platforms can provide to public an opportunity to learn more about the waste management issues, share their opinions with other members of the public, and interact actively with their local and waste management authorities, provide valuable feedback waste management services (Anthouli, N.d). Peirson-Smith (2012) noted that social media has a potential to improve public participation without necessarily replacing face to face conversations. In his study, over eight million messages were sent using WhatsApp SMS service to report a crisis in Hong Kong. Kamwaria et al (2015) concluded that governments should engage important issues through Facebook, Twitter, WhatsApp and other means of social media platforms to get citizen feedback. Therefore, exploiting the potential Mobile social platforms can enhance stakeholder engagements in MSWM.

The challenges of municipal solid waste management reported by citizens through mobile included: 1) inadequate collection centers, leachate flow, littering and illegal dumping and failure to follow the waste collection schedules. Similar challenges are reported in the literature, for example, Guerrero et al (2013) noted that achieving waste-collecting schedules that fit the service users' needs is hindered by inadequate waste transportation facilities and the poor quality of the road; transportation challenges associated poor road conditions, mechanical issues of vehicles and insufficient funds compromise waste collection schedules. Guerrero et al (2013) further noted that few of the cities have transfer stations and collection centers where waste can be collected temporarily before it is transported to a landfill.

Challenges of failure to follow waste collection schedules and illegal dumping of waste were also noted by Henry et al (2006). In their study, they found that illegal dumping of waste is a common phenomenon and their respondents attributed illegal dumping MSW in paths,

riversides, road reserves on the failure of local authorities to provide prompt collection services. They further noted that dumpsites in most areas do not meet the basic requirements in protecting the environment from pollution by leachate flowing.

Based on the study findings, we conclude that mobile phone technologies namely voice calls, SMS, WhatsApp and Facebook have a potential to support public participation in municipal solid waste management. The capabilities of mobile phones need to be fully exploited because like other ICTs, mobile phones can widen the participation spectrum and also help to collect real time information on waste management from the public.

6. Conclusion and Future Work

The study was carried out in the central region of Uganda in order to identify MSWM challenges reported using mobile phones and the extent to which mobile phone support public participation in MSWM. The findings show that SMS, voice call, WhatsApp and Facebook are the used mobile phone technologies. MSWM challenges commonly reported include: failure to collect waste on schedule, leachate flow, lack of collection points and illegal dumping.

We conclude that the potential of mobile phones can be further exploited so as make them enablers for a more sustainable waste management system. There is a need to develop and adapt mobile applications that can support real-time communication and deliberation between waste authorities and the public. In addition, mobile applications can be developed to handle specific waste management issues such as waste recycling, waste collection and transportation, waste disposal and public education and awareness.

The potential of Mobile social platforms such as: WhatsApp, Facebook and Twitter need to be fully exploited in order to increase citizen participation in waste management. Mobile social platforms enable citizens and authorities to freely changes views and ideas and also get information from a wide range audience.

The study was conducted in the central region of Uganda only. Therefore, the municipal waste management practices and the subsequent use of mobile phones may be different from other regions. The study also lacks the general publics' view on the use of mobile phones. Since citizens are key stakeholders in any waste management plan, another study needs to be conducted to incorporate the opinions of the public.

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Use of mobile technologies in monitoring delivery of public health services in Uganda

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ABSTRACT Information and Communication Technology (ICT), especially mobile technologies, are considered to have a big potential to improve the effectiveness and efficiency of anti-corruption measures in public service delivery through facilitating easier reporting of incidents of corruption, automated audits of transaction records to uncover occurrence of fraudulent payments or service automation to replace discretionary decision making by public officials with rule-based automated decision-making, among others. Focusing on public health service delivery in Uganda as a case study, this paper examines what mobile technologies are being used to fight corruption in delivery of public health services, how these technologies are being used; achievements made, challenges faced and existing gaps; as well as recommendations for improvement. The study indicates that: a number of mobile technologies are being used to monitor delivery of public health services; some of these technologies have registered considerable successes but implementation of others has been faced with considerable challenges. These challenges/gaps need to be addressed in order for current and future mobile technologies to be more beneficial in the fight against graft in the health sector especially in developing countries.

Keywords: Corruption; forms of corruption; mobile technologies; public service delivery; public health service delivery

1. Introduction

Public services are services that are mainly or completely funded by money from taxes for a given government (Humphreys, 1998). Common public services include: health, education, security services, electricity, emergency services (like firefighting, law enforcement, search and rescue), environmental protection, public broadcasting, public transportation and water supply network. The process through which these public services are brought to communities is known as delivery of public services (Egberi & Madumelu, 2014). Delivery of public services in in the right quantity and quality and, in the right place and time is the primary responsibility of any government (Egberi & Madumelu, 2014). However, this responsibility is often not fulfilled by many governments due to corruption.

Delivery of public services world over continues to be undermined by rampant and pervasive corruption, among other challenges (Nagavarapu & Sekhri, 2012; Asiimwe, Wakabi &

Grönlund, 2013; Davis, 2004; Rose-Ackerman & Palifka, 2016). In public service delivery, corruption (both grand- abuse of high-level power and petty- abuse at administrative level) can also be classified as political, administrative and systemic (Andvig et al., 2000; Rose-Ackerman & Palifka, 2016). Political corruption is the kind of corruption that involves lawmakers. On the other hand, administrative corruption includes the use of bribery and favoritism to allow certain individual businesses to lower their taxes, escape regulations, or win low-level procurement contracts (Rose-Ackerman & Palifka, 2016). Systemic corruption is where bribery is routine in dealings between the public and individuals (Andvig et al., 2000; Rose-Ackerman & Palifka, 2016). This type of corruption affects service delivery at all levels of society (Andvig et al., 2000; Rose-Ackerman & Palifka, 2016).

In most African countries, corrupt practices have become erosive and a common occurrence in public service delivery (Joel & Crowhers, 2012; Ige, 2017). AfriMAP (2016) reported that over 50 billion US Dollars is lost annually through graft and illicit practices in Africa. Countries like Libya, Tunisia, and Egypt have faced a number of uprisings due to corruption in public service delivery (Joel & Crowhers, 2012).

Like other African regions, East Africa has also had its share of corruption in public service delivery. Corruption in public service delivery in the three East African countries (Uganda, Kenya and Tanzania) remains endemic regardless of the anti-corruption laws and institutions put in place (AfriMAP, 2016).

Uganda is one of the East African countries that has registered a considerable increase in the number of corruption cases in both petty and grand corruption (AfriMAP, 2016). Most of these corruption cases manifest in form of bribery, absenteeism, extortion, diversion of public resources, influence peddling, conflict of interest, abuse of office, loss of public property, sectarianism, nepotism and embezzlement (IG Report, 2014). Others include causing financial loss, false assumption of authority, fraudulent disposal of trust property, false accounting, false claims, uttering of false certificates by public officers and illicit enrichment (IG Report, 2014). Globally, Uganda was at position 142 out of 174 countries in 2014 and 139 out 168 in 2015 (Transparency International, 2014 & 2015). Additionally, it is estimated that the Government of Uganda lost more than 300 million US Dollars due to corruption between 2011 and 2013 (Lowenstein, 2013). The funds were lost through creation of "ghost" projects and "ghost" public servants diverting foreign aid and local government funds to private bank accounts, bidding and selling government assets at lower costs, diverting logistics for public servants' welfare, and poorly monitored revenue sources and programs (Asiimwe, Wakabi & Grönlund, 2013; IG Report, 2011).

In Uganda, corruption is mainly facilitated by low economic development, a large divide between the rich and poor and lack of transparency and accountability in all governmental and social service delivery institutions (Asiimwe et al., 2013). Other factors facilitating corruption in Uganda include public beliefs and attitudes, lack of political leadership, moral decay in public service, limited capacity of anti-corruption agencies and the judicial system, and delays in the legislative framework (Asiimwe et al., 2013).

In order to fight corruption in public service delivery, both direct and indirect measures are used. The direct measures aim at exact manifestations of corruption while the indirect measures aim at removing or weakening conditions that favor corruption (World Bank, 2008).

Direct measures include: establishing anticorruption commissions, investigation and prosecution of corrupt officials, establishing code of conduct for public officials, requirements for public officials to disclose their assets, recovery of stolen assets, and investigation and prosecution of officials with unaccounted for wealth (World Bank, 2008).

Other direct measures include: strengthening internal control systems such as auditing to detect corrupt activity staff rotation to reduce the propensity for individuals to establish themselves in entrenched corruption (Mills, 2012) and enforcing repressive measures where harsher penalties for corrupt practice are needed (Mills, 2012).

Despite the use of these anti-corruption measures, corruption in public service delivery including in the health sector has remained a big challenge. Proponents of using Information and Communication Technology (ICT) in enhancing service delivery like Gaventa (2010) and Basu (2004) consider ICTs especially mobile technologies to have a big potential in improving the effectiveness and efficiency of anti-corruption measures. ICTs/Mobile technologies can aid the fight against corruption through facilitating easier reporting of incidents of corruption, automated audits of transaction records to uncover occurrence of fraudulent payments or service automation to replace discretionary decision making by public officials, among others (Holeman, Cookson & Pagliari, 2016).

Focusing on public health service delivery in Uganda as a case study, this paper examines what mobile technologies are being used to fight corruption in delivery of public health services, achievements realized, challenges faced and existing gaps as well as recommendations for improvement.

The rest of the paper is structured as follows: section 2 covers the methodology; section 3 presents the findings; and section 4 provides a discussion of the findings and conclusion.

2. Methodology

Using purposive sampling, six case studies among institutions responsible for monitoring health service delivery in Uganda were selected. The selection was based on the Ministry of Health's Management structure, location and accessibility. The location of selected institutions was distributed in urban, peri-urban and rural areas of four districts in Uganda, namely Tororo in the Eastern region, Mitooma in western Uganda, and Wakiso and Kampala in central region. In addition, the selected institutions covered central government agencies, local government agencies and one NGO. The six institutions are: Ministry of Health (MoH), Uganda National Health Consumers Organization (UNHCO), Office of the Prime Minister-Delivery Unit (OPMDU), Tororo District Local Government, Mitooma District Local Government, and Wakiso District Local Government.

Seventeen participants were purposively selected from the six institutions to participate in interviews. The basis for the selection was involvement in monitoring health service delivery. An unstructured interview guide was used to collect information from the chosen respondents about mobile technologies being used to fight corruption in delivery of public health services, achievements realized, challenges faced and existing gaps as well as recommendations for improvement.

Descriptive statistics and content analysis were used to present general results on what mobile technologies are being used to fight corruption in delivery of public health services in Uganda, successes so far realized and existing gaps and suggestions for improvement.

3. Findings and Discussion

3.1 – Demographic Information

Tables 1-3 show the demographic information of the study participants: 59 percent of the participants were from Central region, 17 percent from Eastern region and 24 percent from Western region. On the education level, diploma holders were 24 percent, graduates 18 percent and post graduates at 58 percent. In addition, it can be mentioned that 71 percent were males while females were 29 percent. For designation, 18 percent were bio-statisticians followed by district health officers at 12 percent and the others categories were 6 percent (=1 person) each.

Table 1: Description of the sample

Region	**District**	**Organization**	**Total**	**Percentage**
Central	Kampala	Ministry of Health	3	17%
		Office of Prime Minister Delivery Unit	2	12%
		Uganda National Health Consumers Organization	1	6%
		Sub total	**6**	**35%**
	Wakiso	Wakiso District Local Government	4	24%
Central Sub Total			**10**	**59%**
Eastern	Tororo	Tororo District Local Government	3	17%
Western	Mitooma	Mitooma District Local Government	4	24%
Total			**17**	**100%**

Table 2: Educational level

Education	**Frequency**	**Total**
Diploma	4	24%
Graduate	3	18%
Post graduate	10	59%
Total	17	100%

Table 3: Designation of the 17 particpants

Designation	**Frequency**	**Designation**	**Frequency**
District Medical officer	1	Health educator	1
Bio-statistician	3	Nursing Officer	1
Data Assistant	1	Programme Officer	1

Data Expert	1	Senior Clinical Officer	1
District Drug Inspector	1	Senior engineer	1
District Health Officer	2	Senior Pharmacist	1
Expert Health	1	Statistician	1

3.2 – Mobile Technologies Used in Monitoring Delivery Public Health Services

Participants were asked if they have ever used mobile technology tools in collection, analysis and transmission of data related to monitoring of public health services. Results showed that the majority (65 percent) of the participants had used mobile technologies for data collection, 18 percent for analysis and 41 percent for dissemination. However, it was noted that mobile technology tools are used mainly at district and Ministry of Health levels. Use of mobile technologies at lower levels like health centre II was low especially for data collection. The commonly used mobile technologies/tools/systems are mobile Tracking (mTrac), AKVO flow, Bespoke and Open Data Kit (ODK).

Mobile Tracking (mTrac) works on the mobile phone already in the hands of Ugandan health professionals and the community members to collect data. Open Data Kit (ODK) is used by Uganda National Health Consumers Organisation(UNHCO) to collect and analyse data about delivery of health services in the country. AKVO-flow is used by Village Health Teams (VHTs) to collect data of HIV patients to establish their satisfaction with given services. Using a smartphone and an online workspace, AKVO flow enables simple and reliable gathering of geographically referenced data that can be used straight away. Bespoke captures data for real time response to the identified problems, decision making and monitoring progress of health projects. These sytems are used with both smart and feature phones.

Mobile Tracking (mTrac) is a Ministry of Health led innovation, designed to work on the mobile phone already in the hands of Ugandan health professionals and the community members. The objective of mTrac is to introduce more transparency and accountability into the health system and empowering district health officials and their central government managers with real-time and actionable information. There are four main sources of data within mTrac, covering both official government data channels as well as crowd-sourcing community data for verification. The first data source comes from health care workers who report on notifiable diseases, malaria case management and stock quantities of Artemisinin-based combination therapies (ACTs) on a weekly basis. ACTs is a combination of two or more drugs with different modes of action for malaria treatment. The data submitted by health facilities is based on the existing Health Management Information System (HMIS) paper based form (033B Form 1 and 033B Form 2). The information from the paper form is coded based on keywords by health workers. All District Health Teams (DHTs) and selected national stakeholders are able to view and approve all data submitted by health workers in their district before being submitted to the Ministry of Health in Kampala. The approved information is then aggregated, tabulated and graphed on an online dashboard, available to the District Health Teams (DHTs). Once data is approved, it is automatically forwarded to the Ministry of Health's District Health Information System 2 (DHIS2) database, which serves as the national repository for HMIS data

The second source of data is from the Village Health Teams (VHTs). VHTs are volunteer community health workers providing first line health care service to households. VHTs submit

weekly aggregate data through SMS based on their existing HMIS form 095 (quarterly reports). The data submitted includes the number of identified cases of malaria, severe malnutrition and cases referred to the nearest health facility during the week, as well as Artemisinin-based Combination Therapy (ACT) and Amoxycillin stock.

The third source of data is community reports through an anonymous SMS Health Service Delivery Complaints hotline 8200. Through this toll-free SMS short code, community members are able to report on service issues impacting their communities ranging from health worker absenteeism, drug stock-outs to a great service at the health facility. A national call centre reviews these reports, and those with sufficiently actionable information are made immediately available to the DHTs in a "ticket tracker" format on their online dashboards for review and follow-up. DHTs have a two-week period where they are required to indicate on the dashboard what action they have taken. If the reports are not acted upon within this time frame, they are forwarded to national government stakeholders like State House's Medicines Monitoring Unit, to investigate.

The fourth and last source of data is called U-Report. Information from both U-report and the complaint hotline 8200 is triangulated between official HMIS data and community reports for generation of more comprehensive reports. These reports inform action against incidents of corruption in public health service delivery.

Open Data Kit (ODK) is another mobile technology used in collection, analysis and compilation of data on public health services in Uganda including monitoring delivery. ODK is used by Uganda National Health Consumers Organisation(UNHCO) to collect and analyse data about delivery of health services in the country. The ODK platform has two main modules namely: which are ODK collect and ODK aggregate. ODK collect is the client side module, which can run in any Android device such as smartphones, netbooks, notebooks and tablet computers. On the other hand, ODK aggregate is the server side module, which gathers all data collected from ODK collect module. ODK aggregate can be hosted either on a local server or in a cloud server to enable multi location data collection (Jeffrey-Coker, 2010). ODK aggregate offers other services of manipulating data such as visualization of data in various forms and mapping the data with locations. ODK supports data of all types including text, video, images, audio, GPS data and barcode data. Use of ODK enables timely collection, processing and reporting of data on incidents of corruption in delivery of public health services.

Another mobile technology tool used in data management in the selected organizations is AKVO flow. Using a smartphone and an online workspace, AKVO flow enables simple and reliable gathering and transmission of geographically referenced data that can be used straight away. It is used by Village Health Teams (VHTs) to collect data of patients to establish their satisfaction with given services. With direct feedback from public health services consumers, possible corrupt behaviors are reported.

The ordinary mobile phones were also used by Ministry of health to collect data from community members who respond to SMS questions using U-REPORT. U-Report is a free SMS social network that was designed by UNICEF to provide Ugandans with a platform to voice their opinions on issues that affect them. Any community member can report any issue related to health services, such as health centre closures during working hours and stock-outs of essential medicines at hospitals. This information is used to fight corruption in health service delivery.

Bespoke is another mobile technology used by Office of the Prime minister Delivery unit to collect data on specific areas of service delivery which includes reports on incidents of corruption. The collected data is used to identify gaps in the service delivery for immediate action by the prime minister's office.

Table 5 summarizes the mobile technologies used in monitoring delivery of public health services in the six cases covered. All participants agreed that use of mobile technology can improve the process of collection, analysis and reporting of information about monitoring the delivery of public health services.

Table 4: Mobile technologies used in monitoring public health service delivery

District	**Organization**	**Technology**	**Purpose**
Kampala	MOH	mTrac	• Data collection and dissemination, • Epidemiological surveillance reporting, • Report order and supply of drugs and other supplies, • Use collected data to determine national stock status and informing re-distribution plan.
		Ordinary phones	• Get feedback from the community members
	OPMDU	Bespoke	Captures data for: • Real time response to the identified problems, • decision making and monitoring progress of health projects
	UNHCO	AKVO Flow	• Used for evidence based advocacy, • Data collection on client safety to inform policy and engaging policy makers.
		ODK	• Data collection and analysis
Tororo	Tororo District Local Government	mTrack	• Collection and transmission of data
			• Collection of data from the communities on progress and coverage of health projects
		Mobile phones	• Get feedback from the community
Wakiso	Wakiso District Local Government	mTrac	• Collection of information from the community, • Reporting to the district and MoH
		Mobile phones	Data collection for sport on supervision
Mitooma	Mitooma District Local Government	mTrac	• Sending general reports to the district and MoH • Collection of data on some specific diseases • Monitoring disease prevalence, supplies and healthcare • Information dissemination

3.3 – Benefits of Using Mobile Technology

The study participants were asked to indicate the benefits of using mobile technologies in monitoring delivery public health services. A number of benefits to have been registered as a result of using mobile technologies in monitoring delivery of public health services.

Easy and timely access to information by health workers and other stakeholders: One of the key benefits that has so been registered is easy and timely access to information by health workers and other stakeholders. For example a commissioner in the MoH said:

"I can tell you now when the minister asks for information, the people from the resource center just say give me 2 minutes, and they give you live information".

Increased volume of data reporting in real-time: Use of mobile technologies has also increased the volume of data reporting in real-time and the accuracy of such data which is supporting easier and quicker decision making. For example, an officer in charge of Kashenshero health III noted that:

"……using mTrac is less tedious and handy because we send coded data and therefore one can sent a lot of data in near real-time…".

Reduced costs for reporting: Use of mobile technologies has also helped health workers using simple, non-expensive mobile phones to collect and submit needed information electronically, which has helped reduce costs compared to the previous paper based reporting method. For example, it was noted that mTrac has reduced costs for papers and transport. Most participants confirmed using mobile technology tools to collect and disseminate information has made the process much cheaper than before.

Reduction in data falsification: Some participants noted that using the web-based interface and the real-time monitoring has helped reduce/completely deter data fabrication instances that were common with paper based reporting. This benefit is a big achievement in the fight against corruption in the delivery of public health services since data falsification is one of the methods used to commit corruption.

Other benefits that have been realized include: reduced manpower requirements as use of mobile technologies reduces the volume of work, easy tracking of work progress, easy communication, reduction in data errors and automated data validation.

3.4 – Challenges of Using Mobile Technology

The study participants were also asked to indicate the challenges of using mobile technologies in monitoring delivery public health services.

Lack of power for charging mobile devices: Most study participants identified lack of power for charging mobile devices as a major challenge to the effective use of mobile technologies in monitoring delivery of public health services especially in rural areas. One participant from a a district said the following in response to this question:

"Power for charging mobile phones is a big challenge as most rural areas like ours are often not connected to the main power grid".

This is a big problem given that majority of the health facilities in Uganda are located in rural areas where there is limited and unreliable power supply. Thus charging mobile devices raises

maintenance costs as it involves sending them to nearby trading centers for charging which attracts both transport and charging costs.

Limited content and coverage of data captured by mobile technologies: Study participants also identified limited content and coverage of data captured by mobile technologies as a big challenge. The used mobile technologies are mostly SMS based and SMS has limitations on data capturing capabilities. This limitation affects the quality of data submitted such as level of completeness which in turn reduces the value of such data for effective monitoring of public health service delivery. For example, mTrac- main tool used by Ministry Health does not capture some variables of interest such as staff attendance records. Also, like other SMS based mobile applications, mTrac has limited flexibility of its user interface and is only practical with simple text information and short forms. Data that requires large forms and a variety of data types like GPS and photos cannot be easily handled by mTrac.

Limited knowledge and skills of using mobile technologies for monitoring delivery of public health services:

Furthermore, most of the participants interviewed identified limited knowledge and skills as a major challenge of using mobile technologies. This problem was confirmed by the senior clinical officer from Mitooma district local government as follows

"*Most workers here are not willing to assist in compilation of reports because it requires commitment, knowledge and skills which they do not have*".

Similarly, another participant responded:

"*Some staff do not have the necessary skills and expertise to collect and send data using mobile phones. Therefore, when you are absent no one is able to stand in for you".*

The skill and knowledge requirements also extend to maintenance and repair of mobile devices. For example, according to the Programme Officer with Uganda National Health Consumers Organisation, while using ODK, only project engineers could repair and maintain the used mobile phones and when project ended there was no one to take on the role of these engineers.

Limited man power: Another major challenge affecting use of mobile technologies in health facilities and monitoring delivery of public health services is limited man power. Most of health facilities do not have designated staff for managing data collection, analysis and dissemination. The understaffed health workers who provide health care services are also supposed to handle data which they sometimes do not prioritise because of a lot of workload.

For example a participant commented:

"*The process is hectic, without a records assistant, health workers are the ones responsible for compiling data. The health workers already have a heavy load attending to patients, at times they have activities outside the health facility, attending meetings and workshops, and time becomes really limited. Therefore, there is little time for them to capture all the data and then compile reports for sending using mobile phones. You have to work during the night to compile such reports".*

Poor attitude of health workers: In addition to limited manpower, some health workers have negative attitude about data collection, poor information use culture, and commitment, all of which affect the use of mobile technologies for in data collection, analysis and reporting about health service delivery. **General nature of some mobile technologies**: Furthermore, some

mobile technologies are not selective in data capture and also require sending information on all items including those for services which are not offered at the health facility which wastes a lot of time. A case in point is mTrac which takes in anything that is typed and also requires you to fill for services not at your centre.

Language barrier also affects the use of mobile technologies in monitoring delivery of public health services. All identified mobile technologies are programmed in English and yet not all potential users such as VHTs and general members of the public know English. A senior Pharmacist from ministry of health in charge of monitoring medicine and other health supplies countrywide noted that:

Poor connectivity and reliability of mobile and internet networks: The poor connectivity and reliability of mobile phone and internet networks is also another challenge for many mobile technology users. For example, SMS messages in Uganda that run through third party aggregators generally get reprioritized against person-to-person messages and advertisements run by the telecoms themselves. This leads to long message queues and delays of up to a day. This was reported a major issue with mTrac as it scales nationally.

Lack of sustainability: The mode of project implementation under which some mobile technologies in health care service delivery is implemented are sometimes unsustainable. Most use of mobile technologies in health care service delivery is mainly donor funded. Mobile technologies used are normally abandoned at the end of the project due to lack of funding and institutional support. According to the Programme Officer with UNHCO:

"ODK and Text to Change were being implemented under a project mode and projects have a life span, so the life span for those projects expired". "The project under which we were using smartphones with supervisor (apd) ended and the application was proprietary and therefore we no longer access it".

Insufficient supplies of health data collection and processing tools in health facilities: Insufficient supplies of health data collection and processing tools in health facilities also limit the use of mobile technologies. Mobile technologies are mainly used to transmit health data from communities and lower level health facilities to higher levels. However, the primary data capture is majorly done with hard paper forms which are supplied by Ministry of Health and other implementing partners. Failure to capture this data means, there will not be any data to use with the mobile technologies.

3.5 – Recommendations for Increasing the Use of Mobile Technology

Participants were also asked to suggest how the use of mobile technologies in monitoring delivery of public health services could be increased. A number of participants observed that mobile technologies should:

Adapt them to Local languages: Cater for local languages as some potential users do not know English. A senior Pharmacist from ministry of health in charge of monitoring medicines and other health supplies countrywide noted that:

"*....the biggest challenge now is that our country Uganda does not have a common language like other East African countries where Kiswahili is used by all nationals. Therefore, a good tool should take care of the different local languages in the country or the most predominantly spoken ones in each of the four regions of the country...*"

Provide support services to end users: Initiatives that provide mobile devices to end users should provide additional training support, repair and maintenance of devices and availability of power for charging them.

Develop/acquire custom made mobile technologies for different sources of corruption in the health sector: Government should develop/acquire custom tailored mobile technologies for monitoring delivery of public health services or specifically aligned to specific forms of corruption to improve their performance. For example a medical officer in charge Heath centre IV commented:

"…*If government would introduce automatic staff attendance registers, staff absenteeism from duty would greatly reduce…*"

Other recommendations given include: introducing primary data capture technologies, provision of computers and power back-ups and internet to health facilities, deploying IT support staff and M&E professionals to all health facilities, creation of awareness on the importance of data/ information collection among health workers and on job training of health workers in computer literacy.

4. Discussion and Conclusion

The main aim of this study was to establish what mobile technologies are being used to fight corruption in delivery of public health services, how these technologies are being used; achievements realized, challenges faced and existing gaps; as well as recommendations for improvement.

The study findings indicate that a number of mobile technologies are being used to monitor delivery of public health services; some of these technologies have registered considerable successes but successful implementation of others has been faced with considerable challenges.

Results from the study indicate mobile Tracking, AKVO flow, Bespoke and Open Data Kit as the commonly used mobile technologies/tools/systems in fight against corruption public health services. Among these mTrac is the most commonly used tool because it is government policy for public health facilitities to use it. This is in agreement with WHO report which indicated that in Uganda, mTrac is a Ministry of Health led service innovation for monitoring delivery of public health services (WHO, 2014).

Furthermore, results indicate that all these identified mobile technologies are mainly used for data/information collection, processing and dissemination. Hence these technologies have enabled easy reporting of corruption incidents in delivery of public health services. The findings concur with the findings of Bhatnagar (2014), who also found out that ICT can be used to accelerate information dissemination, improve efficiency of public services and increase the transparency and accountability of government administration to reduce corruption. However, it should also be noted that ICT can support anti-corruption measures in many different ways like service automation to replace discretionary making and automated audits all of which are not catered for by the existing mobile technologies (Holeman, Cookson, & Pagliari, 2016).

The findings also revealed a number of benefits that have been registered as a result of using mobile technologies in monitoring delivery of public health services. These include easy and timely access to information by health workers and other stakeholders, increased volume of

data reporting in real-time, reduced costs for reporting and reduction in data falsification. Other benefits that have been realized include: reduced manpower requirements as use of mobile technologies reduces the volume of work, easy tracking of work progress, easy communication, reduction in data errors and automated data validation. This is in agreement with Kiberu (2014) and Otto et al. (2015) whose findings indicate timely access health information, reduced costs and data errors as some benefits of using mobile technologies.

The study findings also established a number the challenges of using mobile technologies in monitoring delivery public health services. Most study participants identified lack of power for charging mobile devices, limited content and coverage of data captured by mobile technologies, limited man power, knowledge and skills of using mobile technologies and poor attitude of health workers. Other challenges included general nature of some mobile technologies, language barrier, poor connectivity and reliability of mobile and internet networks, lack of sustainability, insufficient supplies of health data collection and processing tools in health facilities which are source data for these technologies. The findings corroborate that of Hellström (2010) who noted that ICT capacity in East Africa is low and there is a lack of training and skills development.

Also, the findings concur with Ebo, Amosa, & Adenusi (2012) who found out that majority of health facilities in developing countries are located in rural areas. The rural areas are usually not connected to the power grid and when connected, such power is usually extremely unreliable that recharging the mobile devices becomes a serious challenge as it raises maintenance costs. Similarly, these results are corroborated by Bexelius *et al*. (2009) who noted that most of the existing mobile services are mostly SMS-based and SMS has limitations on data capturing capabilities.

These challenges need to be addressed in order for current and future mobile technologies to be more beneficial in the fight against graft in the health sector especially in developing countries. In order to address some of these identified challenges for improved performance of mobile technologies in monitoring delivery of public health services, participants observed that mobile technologies should, cater for local languages, provide support services to end users and acquire custom made mobile technologies. Other recommendations given include: introducing primary data capture technologies, provision of computers and power back-ups and internet to health facilities, deploying IT support staff and M&E professionals to all health facilities, creation of awareness on the importance of data/ information collection among health workers and on job training of health workers in computer literacy.

In conclusion, the study revealed that many mobile technologies are being used in monitoring delivery of public health services. However, much as there some benefits gained in using these technologies, there are still many challenges encountered. These challenges affect performance of mobile technologies in fighting against corruption. It is anticipated that adoption and use of the proposed recommendations can greatly improve the performance of these technologies.

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Mobile Money at the Intersection of mInclusion and mLivelihoods: The Rural User Experience in Kasese Uganda

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ABSTRACT In Uganda, mobile money is big business where adoption and financial throughput is high. According to the Bank of Uganda, the value of mobile money transactions in June 2017 was Shs.52 Trillion ($14.5 Billion USD) implying a high rate of financial inclusion provided by the service. While many of the gains in mobile money adoption are evident in urban areas, the rate of participation and impact of use in rural regions is less evident. Based on qualitative research with rural users in Kasese in Western Uganda this research demonstrates that while access to mobile money as a financial service is high, barriers to participation in using the service persist. Low participation rates are seen where there is a lack of access to agents, high transaction costs, and limited income earning opportunity from the service.

Yet while a rural-urban divide remains in the uptake and impact of mobile money, a lesser understood phenomenon of mobile money as a livelihood facilitator emerges. This paper points out the patent need for deeper understanding of rural mobile money use where remittance and money transfer is utilised in ways that extend families' financial practices across rural, peri-urban and urban settings. By reframing the rural-urban divide in terms of rural families undergoing a complex multi-locational shift, this research suggests that mobile money for livelihoods research offers deeper insight into the rural-urban relationship than does extant research on mobile money alone.

1. Introduction

Mobile money has been touted as the most dynamic shift in enabling financial inclusion among the poor in Africa. This is because mobile money, piggybacking on mobile phone services, has facilitated a dramatic increase in digitally delivered financial inclusion to millions of excluded people all over Africa including Uganda. The recent decade-long surge in phone and mobile money ownership has contributed to a situation in which mobile money transactions now account for the equivalent of half of Uganda's annual GDP ($14.5 Billion USD) (Kasekende, 2017). World Bank data for Uganda shows that by 2017, 59% of the adult population (aged 15 and over) had an account with a financial institution or a mobile-money service provider (World Bank, 2017). This figure represents a 34% increase in financial inclusion in Uganda since 2014. Because of these dramatic figures, mobile money is a technological solution that has the capacity to address the longstanding problem of financial exclusion in Uganda. This emergent technology has made deep inroads to the achievement of financial inclusion goals for

Uganda's Central Bank, and the larger international project of meeting the World Bank's 2020 goals.

While the numbers are significant and growth rates are impressive, however, the service use and application is varied and inconsistent among users in Uganda. Evidence of a lack of uptake of financial services and of a digital divide for rural Ugandan's suggests a hidden problem, partly at least occluded by contestable official reports. Official figures, published in The Global Findex Database (World Bank, 2017) suggests that the difference in financial account ownership between the rural and the overall population is low. The same source indicates that much of the recent growth in the inclusion dataset assumes high rural and urban account ownership where the 2017 data indicates a difference of 1% point between the whole of the population (59%) and the rural population (58%). Likewise, the data indicates that the difference between these groups on ownership of a mobile money account is also minimal. The overall population figures suggest 51% mobile money account ownership, with the rural population being 50% (World Bank, 2017). Unfortunately, however, the data does not provide an equivalent category for urban dwellers and as such, apparent differences between the rural and the urban contexts are difficult to assess.

The Intermedia organisation has been collecting data on financial inclusion in Uganda over several years. Their data collection provides details for the category of *active use* which they define as activity within the last 90 days. Also, they provide further aggregation to differentiate users that are rural and urban. The Intermedia (2016) report notes that while 38% of the total population (aged +15) has a mobile money account, 59% of urban dwellers are registered, compared with only 31% of rural dwellers. The Intermedia data provides insight into some of the differences between urban and rural populations in Uganda that does not correlate with the World Bank data. Of note, while the World Bank draws its figures from data provided to them by the Uganda Bureau of Statistics, Intermedia derive theirs from data they collected from a population sample of 3000 people. But the contrast in figures is stark and deserves further consideration.

Other researchers too, in mobile-led financial inclusion and the rural-urban contexts in East Africa have noticed similar inconsistencies. Assessments made on the ground, so to speak, draw a different conclusion than those of the official figures. Mulwa and Ndati (Mulwa & Ndati, 2014) look to understand the barriers to uptake of mobile banking services in Kenya. They highlight a number of access and participation challenges the poor experience in using specific banking programs. Munyegera and Masumoto (2016) undertake in-depth research of mobile money in Uganda centred on rural users' practices. They note there is evidence to assume inequality in financial sector services access between urban and rural users and they find available data tends to group rural and urban together (2016). As such, they tailor their research toward rural Ugandan household use of mobile money as an alternative financial service to highlight the particularity of rural use. The analysis of both Mulwa and Ndati (2014) and of Munyegera and Masumoto (2016) complements this research, acknowledging a rural-urban divide in digital and financial inclusion in Kenya and Uganda respectively, which counters official data, and that seeks to bring the unique concerns of mobile money use in the rural context to the fore.

2. Method

This research aims to highlight that access to mobile money does not equal participatory inclusion in the way that so many formal developmental institutions attest. By looking at data collected from interviews with rural and town dwellers in the west Uganda district of Kasese, this research aims to inform the utility of mobile money that goes beyond statistical representation of adoption rates. Instead the research adopts a qualitative approach that nuances the experience of rural users and their use of mobile money in their own setting. For this reason, the Kasese District provides a good example of a typical rural Ugandan region. It features a predominantly rural population but with a district centre that provides the majority of institutional, economic and political administration in the region. The Uganda Bureau of Statistics (UBOS) indicates that the Kasese District is comprised of a population of about 700,000. According to the latest UBOS population report, Kasese Central is the only urban centre in the district, having a population of 102,000 (Uganda Bureau of Statistics, 2016). The Kasese District features a mix of rural and urban populations, and thus lends itself well to this kind of analysis.

This study used data collected from, predominantly, rural users of mobile money. Data collection consisted of qualitative interviews. Interviews were also conducted with a number of community leaders in various roles of governmental, educational, and business and entrepreneurial positions in the urban centre. Participants, other than the community leaders, were selected from users of mobile money services in each of the locations visited. Purposive sampling was utilised, drawing on typical case and opportunistic sampling techniques (Teddlie & Yu, 2007). In total, 38 interviews were conducted in 9 villages as well as in Kasese Central. Interviews were semi-structured, utilising four categories of questions for each participant. These categories covered questions of mobile money adoption, usage, use of other financial services, and perceived impact on family and income. Using questions as a guide, interviews were conducted to enable the conversation to range across multiple areas of interest between the interviewer and interviewee. A research assistant fluent in the local languages was used for those interviews conducted in the villages where English language competency was expected to be limited. The majority of interviews not conducted in English were in Luhkonzo.

3. Rural Kasese in Context

Rural dwellers in Kasese exist in an economy oriented toward production of cash-crops and a variety of other farming practices that generate a diversity of income from agriculture. On the fertile slopes of the Rwenzori Mountains are Bakonzo tribe farmers whose production activities are a mix of cash-cropping of Arabica coffee and other produce that support family and local market consumption. Below the Rwenzori, in the Rift Valley, plots of cash-crop production of maize, cotton, and cassava are present as well as other lesser intensively produced crops that support families and local consumption. Importantly, there is evidence of a disparity of income potential between the more prosperous coffee farmers whose coffee retrieves a relatively higher value per acre in comparison with the less prosperous farmers of other kinds of foodstuffs and agricultural production in the lower elevations. Cotton, for instance, is a popular cash-crop in the valley, but it's per acre yield of income remains lower than coffee. Despite these overall differences, rural dwellers in this region of significant geographic and agricultural diversity are highly reliant on agricultural production as the primary means of income generation.

4. Mobile Money versus Cash

While rural Kasese is highly dependent on the agricultural production economy, this research finds the core components of the agriculture value-chain continue to resist mobile money usage. The research frames the problem as three key, but persistent constraints to the utility of mobile money for rural users. In brief, the reasons are: the limited access to the availability of agents which limits the inter-functionality of cash and mobile money, the high transaction costs associated with using the service that include transport needs to access agents and the fees that accompany its use, and the subsequent challenges to earning mobile money income.

4.1 – Access

One of the primary limiting factors to broader mobile money usage in the livelihood practice of rural users is the problem of proximity to, or availability of servicing agents. Like the problem of access to banks in rural regions, mobile money agents themselves have a propensity to set up shops in higher density population areas like the larger trading centres and towns. This concentration of service points in urban and peri-urban areas means fewer agents in rural areas. MTN is the dominant telecoms network and mobile money service provider in the district. The company is actively trying to promote new agents to setup their shops in more remote areas, but they find this is a difficult proposition for agents who are seeking high volume turnover of mobile services. Moreover, these agents themselves experience the challenges and costs of distance from formal banking services on whom they depend to secure and supply their own daily operation of cash float and safe storage. The situating of cash agents in proximity to the larger trading centres creates a problem of access for rural dwellers. Limited access to locally operating mobile money agents—acting as service points for cash-in-cash-out (CICO) actions—limits the fungibility of mobile money with cash for rural users.

4.2 – Transaction Costs

Evidence from the research also notes the prevalence of responses concerning a *price sensitivity* to the many costs associated with mobile money usage. This is actually a two-fold problem: consideration to the cost of both transportation and time, and consideration for the fees incurred while making transactions. First, the rural user must consider whether the transaction will incur a transportation expense; whether they will incur a charge for the hire of a motorcycle taxi (boda-boda) to get back and forth to an agent, as well as consideration to whether the time lost in transport is worth the imposition. Secondly, the transaction cost of mobile money itself—with the charges incurred for each transaction—further increases the overall transaction cost of the service. One rural labourer explains this conundrum:

> *"If I was paid for my labour in mobile money today, my boss would receive a charge to transfer money to me [1000Shs], I would have to take a boda-boda to the village to the MTN agent for 800Shs, and I would get charged 700Shs to do cash-out."*

For a day's wage of 6000Shs, the cost to use mobile money between the employer and the labourer would be 2500Shs—a 42% overall charge to conduct a complete transaction. For many rural users these kinds of high transaction fees are prohibitive and severely limit mobile money's utility as an alternative to cash.

4.3 – Earning Opportunity

Opportunities for mobile money as a mode of earning income do exist in rural areas especially in the labour work of maintenance and harvest of cash crops, but this research finds farmers and farm workers continue to indicate a preference for cash. Because of these previously mentioned factors of access to services and transaction costs, even rural users of a higher cash income status show a reluctance to employ mobile money in their livelihood activities. This is notable even when they are part of a production value-chain where mobile money can be readily employed. For instance, mobile money is recognised by local coffee buying companies as a preferred form of exchange due to the many benefits that mobile money potentially provides: increased security, electronic record of payments, receipt of payment, and the suitability to transfer large payments over distances. Benefits of mobile money use to the agricultural buyer are clearly evident.

However, the research finds a reluctance among the labourers, coffee producers, lead-farmers, and middle-men's embrace of the service demonstrating a resistance to mobile money use in the *last mile* of the agricultural value-chain. Interviews with rural coffee farmers indicate an ongoing preference for cash payments despite the recognised security benefits that mobile money offers them when selling their crops. One farmer explains:

> *"If I have a number of workers who want to get paid for their day's work, I prefer to use cash. Whether I get paid in mobile money or not, if I have to pay 5 workers 800Shs each, I will get charged maybe 250Shs in fees for each. This is too expensive. It is better, I change my mobile money to cash, get the fee only once, and then pay the workers with cash".*

For rural users, low-value transactions are the most frequent kinds of exchange they undertake—daily wages to labourers, purchases of small consumption items from local merchants, and transportation expenses. Due to the fee-structure of the service, the farmer is dissuaded from using mobile money when wanting to undertake these multiple, low-value transactions. In light of the limited access to mobile money agents, rural farmers prefer to hold cash to serve these multiple purposes, and the zero-fee status that cash use engenders.

Interviews with lead-farmers assert a similar disposition. One lead-farmer acknowledged there were a few farmers who do receive mobile money, and for him, he uses it in his buying activities for a regional ginnery. The ginnery in Kasese Central credits him mobile money in order to aggregate locally produced cotton into his storehouse. But despite his income of mobile money from the ginnery, the majority of the farmers he buys from insist on cash. Those few that do take mobile money are local farmers who have easy accesses to the several MTN agents in the trading centre where he operates.

Mobile money continues to face limitations in the rural areas due to a complex problem of integrated factors. Limited access to agents is a significant constraint, whereby, the lower income potential on the part of mobile money agents keeps them away from the rural villages where they preference higher traffic locations. This, in part, increases the costs incurred by locals to access agents, limiting the overall utility of mobile money to rural users. This is a challenge of costs associated with distance for rural users. Moreover, the high fees that accompany each mobile money transaction challenge the user to revert to cash exchange practices where the transaction cost is near zero. Mobile money comes at a higher price than cash. The opportunities for mobile money to be employed into the village economy through

the agricultural value chains remains a challenge where cash is favoured as the preferred mode of exchange.

5. Multi-Local Families

Interestingly, this research provides evidence of another form of value-chain activity within the rural regions that livelihoods research recognises, and which needs to be brought to light within the mobile money economy. From the perspective of this research, it demonstrates where mobile money for inclusion and for livelihoods intersects in a meaningful way in a money transfer economy. Of the changing dynamics of rural integration is the acknowledgement of multi-sited, and multi-local livelihoods approaches of rural families (de Haan & Zoomers, 2005). Evidence suggests that globally, families are being *stretched* over increasing geographical distances in order to maintain or gain advantage for improving income and reducing risk (de Haan, 2017; Murray, 2002). The reasons for this are numerous: population pressures from increasingly overburdened agricultural lands; the potential for cash generating activities in towns and cities; and the promise of improved access to services and information in urban areas are notable factors (Andersson Djurfeldt, 2012; Duncombe, 2014; Tacoli, 2007). What is increasingly evident in this shift from rural to urban living, however, is not only the migration of individuals from country to town, but also, the underpinning substructure of the individual's kinship network. These networks expand with them in varying forms of physical ties, transfer of goods and services, social obligations, and importantly for this research, the technological capabilities that facilitate expansion (Porter, 2016; Sheller & Urry, 2006).

Livelihoods research considers this phenomenon in terms of the multi-locality of livelihood activity for the family. This entails the positioning of its members into increasingly intensifying urban environments to gain a foothold in urban areas and the accompanying income generating opportunities that these settings may provide. Research considers the developing market of remittances that sees primarily the youth, moving to the urban centres to look for work and to provide remittances back home (Bah et al., 2003; de Haan & Zoomers, 2005; Munyegera & Matsumoto, 2016). But these transactions do not need to be at such a great distance or presume a complete separation of the individual from the home village or the region (Satterthwaite & Tacoli, 2003). Rather, this research in Kasese suggests the multi-local family is evident within the local district where highly developed kinship networks involve family members in various degrees of proximity to the regional centre.

A number of rural interviewees demonstrate this pattern of multi-local families spread across the region. A two or three generation family can be *stretched* across the district from home village, to peri-urban trading centre, to the urban centre in Kasese Central. Along these family care-chains are lines of communication, child and elderly care, flows of goods and produce, and money transfers in the form of mobile money and cash. One interviewee describes a typical family situation:

> *"The grandparents are the primary care-givers to young children at the family home in the rural village. The children and grandparents maintain the family land and are engaged in varying levels of agricultural production. One parent (the mother) takes residence for the working week in a larger village at a distance from the village, positioned along the main road where there is an active fruit and vegetable market. The daily cost of transport is too high to undertake a commute—the mother is a produce vendor at the highway-side market. She sells some of the home village's surplus produce as well as dry goods at her stall. She*

takes low-cost lodging during the week there and returns home for the weekend on Saturdays. The father, a tailor, lives in a larger trading centre performing his trade in a shop where he has found a higher demand for his skills. The father too, takes similar lodging during the week while ensuring a regular remittance of income is returned to the wife and grandparents as needs arise such as for the payment of school fees. He also returns home some weekends or when circumstances demand, but due to the distance from home, he does not regularly go home".

While the transfer of goods across a family network between the rural to the urban settings has been well documented in the livelihoods literature, the adoption of mobile money helps facilitate this arrangement with greater ease. In reverse, the above mentioned parents' cost of living expenses may be offset by the regular supply of garden produce from the home that is sent to them, or gathered at each visit to the home, or provided by way of neighbour networks in similar situations. The scenario demonstrates how families undertake to spread across a region, positioning their skill set and capacity in order to maximise their earning potential. They then utilise their familial as well as village networks to leverage diverse livelihoods of agricultural and non-agricultural production between rural and urban locations.

A number of the research participants indicated that they themselves made a living, at least part-time in a village or town setting, and then undertook to send money home to the family in the village for the maintenance of parents, and/or spouse, and children. Some indicated this remittance was a regular and expected practice, others indicated that payments were only made upon request of family members. Mobile money transfer for the purposes of paying school fees was the most common reason cited. School fees are a large, regular impost of expense for many families in the district. The ease of mobile money transfer is noted amongst interviewees in the making of the transfer for these kind of large payments. Participants indicated that money sent usually exceeded 20,000Shs ($5.25 USD), as the imposition of a sending tariff and the cash-out fee to send less than this was too expensive to warrant a transfer. Smaller payments to family members are avoided due to the acknowledged barriers of use highlighted earlier in this study.

However, there is a degree of variation in attitude to the obligation to assist in meeting the cost of school fees or other expenses by those interviewed. Here further clarification into what constitutes a remittance versus a money transfer in a local but multi-situated household is perhaps important. Is a remittance an obligation, a gift, or both? Moreover, are these remittances actually strategic, intentional behaviours, or are they unplanned, and unintentional?

De Hann and Zoomers (2005) highlight that these patterns of behaviour may indicate divergent objectives for individual and household goals. This research provides evidence of an asymmetry of intent amongst family members livelihoods behaviours (de Haan & Zoomers, 2005), which raises an interesting question for the application of mobile money remittances in livelihoods research in future. It is indicative of increasing complexity of livelihoods in multi-spatial, multi-generational families across rural–urban settings and the assistance that mobile money affords them.

6. Conclusion

Despite official statistics, rural users continue to experience the digital divide and limitations to receiving the benefits of mobile money and financial inclusion. Findings suggest cash

preference extends across all income strata in rural areas from those in extreme poverty even to others who are relatively prosperous—the rural non-poor. While many users have access to the service and show a degree of financial and technological inclusion, active participation with the service is hampered by a number of constraining factors. Key to understanding the barriers to rural uptake of the service is the problem of access to mobile money agents and its attendant problem of fungibility, the transaction costs of using the service, the limited earning options in rural settings in a predominately cash economy. Users employ mobile money, however, in the instances of larger once-off transfers such as the payment of school fees, or the receipt of larger value remittances or other money transfers between family members for their maintenance. But smaller transfers incur too high a cost for rural users who demonstrate significant price sensitivity to the service, and therefore mobile money is avoided in the day-to-day exchange of goods and services at the rural village level.

But in assessing the mobile money economy of Kasese, the consideration to these barriers to use and the notions of a rural-urban divide, mobile money research provides insight into the deeper functioning of livelihood practices among the region's residents. Evidence suggests families are spread across a complex interrelated web of geographical, economic and social linkages that mirror those of production value-chains. As such, they demonstrate a complex chain of productive capacity that promotes the utility of mobile money as a livelihood technology despite the service's constraints as a tool toward overall rural economy transformation. While cash use is firmly entrenched in exchange practices, mobile money employed as a money transfer technology in livelihoods practices is highly effective.

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Diminished parallels: Avoiding peripheralization in ICT4D settings

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ABSTRACT Information and Communication Technology for Development (ICT4D) initiatives focus on the appropriation of technologies to formulate solutions to recurrent problems in less developed contexts. More often, technologies prevalent elsewhere are diminished in functionality and galvanized against the challenges that hinder their adoption and use in these regions. These appropriated technologies however retain connections and modalities that lead to their perception as inferior or peripheral versions of standard technologies. This in turn leads to a perception of their users as peripheral. In this paper we advocate for the emergence of independent and parallel conceptions of ecosystems that allow for freer interaction of distanced communities with technology.

Keywords: Social Technology, ICT4D, Distanced Communities

1. Introduction

Communities may be distanced geographically due to physical distance or barriers that prevent them from interacting with other communities. Besides physical distance, communities may also manifest economic, social, religious and technological demographics that are distant from the norm of the collective to which they belong.

In this paper, we use the term *distanced communities* to refer to these communities. While this distance can be towards better or worse, our focus on ICT4D inherently is selective towards only communities that are distant in a worse sense.

This paper will begin by exploring the hindrances to technology use and adoption, which in part necessitate ICT4D initiatives. We will then, in section 4, examine select examples to understand why certain deployments have not had the impact that was envisaged and identify consonance with research into the sub-currents causing ICT4D projects to drift from their intended results. Section 5 then discusses ICT4Ds as peripheral to the mainstream. Finally, in section 6, we develop a notion of "parallel" rather than "peripheral" ecosystems. This conceptualisation, we argue, is fruitful for avoiding peripheralization in ICT4D settings.

2. The Origins and Distributions of ICTs

White's earlier conceptualization of development as the ability to harness and use energy [1] is still relevant today. Given the strong correlation between energy use and indicators of human development such as GDP per capita [2], development is inherently the ability to achieve mundane tasks through energy-driven mechanization. The nascence of computing devices has

resulted in the proliferation of computing in all spheres of human life and therefore one way of measuring development is by gauging the ease with which tasks can be achieved with the aid of computing in a given community.

Information and Communication Technologies (ICTs) have origins in regions that are now considered developed – where their use is prevalent and contribution to easing lifestyle is evident. Cellular telephony in its first digital generation (2G) for example was constituted by solutions by American, European and Japanese entities and has enjoyed wide usage and demand in these regions [3], which in turn has driven research into newer iterations (3G, 4G, 5G) [4] that push the capabilities of cellular telephony networks to new limits.

As another example, the Internet whose development was largely contributed to by the US government enjoys large utilization and while the global average stands at 43%, the developed world averages at slightly more than 80% [5]. The success of the Internet as an ICT has been phenomenal, and it is fast establishing itself as the de facto information dissemination channel with other ICTs such as analog broadcast radio and television switching to digital variants that are transmitted through the Internet

In regions with a lower Human Development Index (HDI), the access to digital ICTs is relatively low [6] and even in cases where access is possible, the use of these technologies is still low [7]. This goes to show that past making these technologies accessible, work needs to be done to make them usable, which in turn means that these technologies must make sense and add value to communities where they are deployed. The access and use of these technologies is impeded by infrastructural underdevelopment, reduced finances, low literacy levels and energy insufficiency – just to mention the most glaring challenges. ICT4D implementations are well aware of these challenges and their deployments make reasonable considerations to address them, which should result in them being usable and useful, but this has not always been the case as we see below.

3. The Space for ICT4Ds

The definition of ICT is complex, multifaceted and varies from sector to sector [8]. In routine use, ICT is almost always used in reference to digital communication media capable of interacting with the Internet. While other media that comply to some definitions of ICT such as FM radio and analog television were very specific in transmission model (broadcast), function (audio or video information access), top to bottom and centralized, the Internet on the other hand breaks away from these norms – it supports all forms of information dissemination (broadcast, unicast, multicast), is not built for any single function but facilitates all of them equally well, and allows for communication between all echelons of society. In fact, the Internet does support other ICTs such as audio radio from FM radio stations and video broadcast from analog television stations, albeit in digital forms. It is therefore little wonder that ICT4D is comprised majorly of initiatives that rely on the Internet or can interact with it, even though this interaction may be masked from the end users of these initiatives.

The term *development* in ICT4D is an overemphasis – any sanctioned use of ICT should lead to development, given the role that communication plays in development [9]. Even luxurious and leisurely use of ICTs has the potential to pivot into essential use, an example being social networks that are going from entertainment sites to crucial platforms for political mobilization and information dissemination. Every government however has areas that constitute the development agenda, and progress elsewhere may not be regarded as development. ICT4Ds

therefore are those designed to address the issues that lie in the development agenda of one community.

ICT4Ds are seen by some leaders as a shortcut to development [10], providing a route that circumvents the natural course that societies are otherwise to take. This has two sides to it: in a good sense, technology is fast evolving and some previously costly infrastructure developments, for example landline telephony networks, have been antiquated by new and cheaper technologies such as cellular telephony and the Internet. On a bad side though, this removes the design of the technologies from many communities that use them, given the previously discussed origin of ICTs. The alternative, the tortuous natural course, allows for – albeit at a slower pace – the application of indigenous knowledge and consideration of local peculiarities. The structures from these processes result in more appropriate technologies, a local skilled labour force and production systems that can be pivoted to different areas and sectors.

ICT4Ds can barely thrive without the kinds of infrastructure and government structures necessary for the standards on which they were designed – most solutions involve the use of electronic equipment which communicate over telecommunication networks that in turn necessitate electricity and transport infrastructure. In the developed world, ICT is icing on the cake – phone applications help citizens use a well-developed transport system and find their way in a city with complete addressing systems. The perception that ICT alone can make up for the void left by inefficient governments is misleading and should be avoided. ICT4D initiatives, as we will see later, are *rarely a nucleus* of development but *rather bring together* work from different spheres into technological products.

4. A Recap of the Challenges in ICT4D

The challenge in successfully implementing ICT4D is a convolution of factors that hamper the use of ICT in the first place and those that befall development initiatives in general. It also is possible that when these two challenges come together, novel challenges may arise whose manifestation is solely due to the combination of ICT and development work. Below we briefly recap well-documented challenges with reference to projects that are hampered by these challenges and/or recognize them as major design consideration.

4.1 – Literacy levels

A lot of development initiative is focused on areas that are rural, with poor communication, transport and energy infrastructure and diminished economies compared to the general demographic. This lack of infrastructure and finances affects education and thereby literacy levels. It is therefore no surprise that literacy levels are at their lowest in these communities [11]. Interactive ICT requires for messages to be exchanged and in many circumstances, these are textual. Initiatives such as SMS based health solutions for pregnant women [12] would take a big hit given that literacy levels are generally at their lowest in female populations in developing contexts [11].

Some projects have resorted to voice telephony in a bid to solve this challenge. Callers to a publicized number are taken through a menu of options by prompting them to press a number corresponding to the activity that they are interested in. Farm Radio International uses a similar approach [13] and this too was the setup of the Avaaj Otalo project in rural India [14]. While this works around the literacy issue, it has two downsides: this requires more time to interact

with, given that information retrieval and other activities have to be done sequentially. Another downside is that voice telephony is generally more expensive than SMS messages past the first few seconds and in the end, this becomes expensive to use. Two ways of going around the expense are the use of toll free lines – which is usually unsustainable given that the bill is picked by a development agency with limited funding – and tapping into the excess minutes that people buy in the form of voice bundles from telecom companies.

4.2 – Energy insufficiency

As mentioned before, many developing regions struggle with energy access. In sub-Saharan Africa, except for seven countries, the region has an average of 20% access to electricity [2]. There is a very strong correlation between electricity access and GDP per capita. ICTs by definition require access to electricity and therefore are constrained to regions where it is available. Operating outside this constraint means substantial investment in energy generation. Many ICT initiatives are saddled with the burden of installing and maintaining solar energy equipment.

In the case of the RootIO project in Northern Uganda [15], low-power FM radio stations costing roughly 3500 USD incurred a cost of roughly 1500 USD just for solar energy. The Kwiizya project [16] to deploy community telecommunication networks in rural Zambia demonstrated less than ideal quality in the energy that was sourced from the grid, as well as device outages caused by power fluctuations, indicating that even the 20% that has access may be using less than ideal quality of electricity.

In cases where an ICT4D setup does not involve communally used equipment that is centrally located, such as communal computing centres, but rather depends on individual devices such as mobile phones, this problem is distributed but not necessarily smaller. In many cases users will need to travel to trading centres to charge their phones and in many cases avoid use other than that which is critical. ICT4D initiatives that are not perceived as critical may therefore end up being ignored. The Polly project for example relied on a playful approach to introduce development messaging to users [17] – but the users were mostly using the platform for fun and this setup could fail in a context where energy access is scanty.

4.3 – Cost

Many ICT4D initiatives use technology that is facilitated by commercial entities. These entities have a profit interest and the cost of their services is, in many cases, high in comparison to per-capita income. As can be seen from [3], it does appear as there is a demand-supply mismatch – services are still considered expensive to use, while telecom companies are demonstrating reducing margins (EBIDTA) and the market is becoming characterized by exits and sell-offs in sub-Saharan Africa.

The cost cannot be detached from another factor – telecom companies suffer high operating costs to maintain networks in areas that are off the electricity grid and this makes for a hard business case especially in remote and sparsely populated areas. Attempts at breaking this impasse have included multi-structured universal service funds extended to telecom companies by entities including governments and international donors to facilitate access in hard-to-reach areas [18], monopolies handed to telecom companies [19] and tax waivers [20] to lure them to markets that are financially unattractive. In all this, the end users are usually the last to win –

even in light of all this, phone costs are high and usage is very low as can be seen from data supplied by the ITU [3].

4.4 – Development Factors

Besides the issues that affect the use of ICT, there are other issues that affect the implementation of ICT4D projects and hamper their adoption in areas where they are set up. To begin with, these projects advocate for a break from plain capitalism and as a first step require the employment of volunteers rather than paid staff, in a bid to stem capital requirements. This has the detrimental effect of a labour force not devoted to the project and that is highly itinerant. While capitalism has its criticisms, other models that have been suggested to replace or augment it, such as the sharing economy, are not without criticism [21] and in many cases gravitate towards plain capitalist practice. Many ICT4D projects by beginning with a volunteer model stifle planning around business continuity and socially appropriate financing, leaving these initiatives vulnerable to hijacking by financially able institutions at the expense of the communities for which they are designed.

Another common criticism is that initiatives are usually conceived outside the communities in which they are used, and the users are only brought in when the idea is concretized. This has the net effect of reducing users to mere participants rather than architects of solutions to their own problems, limiting them to predefined roles that they cannot alter. These initiatives eventually tend to steer and influence community interests rather than nurture and facilitate them.

5. ICT4Ds as Peripheral to the Mainstream

While designing ICT4Ds, it is critical to not look at them as tools that connect rural "grassroots" populations to the urbanites that are higher up the social, economic and other echelons. This turns out to be the case in many initiatives. Higher echelons of society typically have always had easier access to the input channels of broadcast media that was prevalent before the proliferation of unicast and multicast communication media. These channels were efficient at disseminating information but had no capability for dialogue or getting information back from communities.

ICT4D offers easy ways to hear back from the grassroots – communication channels are interactive and despite the usability hurdles, offer a much better option than was feasible with broadcast media. As such, many ICT4D initiatives are inadvertently "extractive" in nature. The U-Report initiative [22] for example allows for the dissemination of questions to target communities and the reception of answers from those communities. The people who answer these questions only get a statistical summary of the answers (usually "yes/no") but cannot use the system for example to ask their own questions to peers. Birth registration apps [23] allow for community-based users to send birth registration information to central repositories but cannot provide users any information about births within their community (surely, such apps are regarded as e-Government examples but e-Government features prominently on the development agendas of many countries).

ICT4Ds used in this way contribute to what we refer to as "peripheralization" in this paper. Distanced communities are viewed not as communities in their own right but as communities that are peripheral to whatever is regarded as the mainstream in a particular setting. Service

providers are stretched to reach these communities and set up representation rather than the encouragement of alternatives that are based within these communities.

The entities that are often built upon by ICT4D initiatives are big corporations, telecommunication companies being some of the most common ones. The resulting setup usually has small initiatives coupled with big entities that are usually not flexible to the demands of these initiatives. Some of the most successful technological ventures that have had lasting success were conceived deep inside of the companies whose technologies they rely on. M-Pesa for example, the mobile money flagship, was birthed inside Safaricom's parent company Vodafone in the UK [24]. Safaricom undertook tremendous reconfiguration of technologies and human resources and it is highly probable that this kind of rearrangement would not be possible for an initiative conceived without the telecom company.

MobileVRS, the initiative to digitize birth registration in Uganda using mobile telephony, was conceived by UNICEF working with Uganda Telecom (UTL) and Uganda Registration Services Bureau (URSB). This venture eventually did fly, but it is a use of ICT4D that is backed by entities that are very empowered financially, socially and politically that it is not possible to imagine that UTL and URSB would accord the time and accommodations to anyone substantially below the scale of UNICEF.

6. The case for parallel rather than peripheral ecosystems

We make an argument for arrangements that create, recognize and strengthens ecosystems that are parallel to the mainstream but interlink well with it, albeit being appropriately sized to the needs of the communities that they serve. This is because the introduction of community sized entities leads to peer initiatives that both depend on and reinforce each other. This way the entities based in a community are better adapted to the community than would be the case for representatives of bigger corporations.

We give as a first example the Internet: individual subscribers buy Internet service from service providers who are usually third tier and in the case of some big corporations, second tier. Third tier Internet service providers though work with and depend on first and second tiers of Internet service provision. This tiering results in service providers of different sizes running networks in parallel, as well as in tandem to deliver Internet service to communities of different sizes.

On the contrary, a small branch of a small bank and a small bureau of a telecom company may setup presence in a rural remote community. This though does not mean that these two entities can work together to tailor solutions for a community. First of all, the personnel in these bureaus will be customer service representatives with very little knowledge or influence on decision making for these entities. Secondly, if they were to open up, these corporations would have to look at potentially hundreds of applications unique to individual communities which would make this a laborious task. Lastly, this will more often be a low-income market and it may not make business sense to devote substantial time and money to their whims. The interactions between these two entities are negotiated at levels far removed from these communities and dictate the nature of service that these communities will be offered.

On the other hand, a community-based entity whose entire market space is the size of this community will be more willing to listen to the desires of other entities that are working at similar scale. We give as an example youth centres set up by initiatives from UNICEF and others in northern Uganda. These, rather than working directly with large ISPs, decided to work

with BOSCO Uganda as an ISP. As a result, their ISP offers traffic filtering in line with what is acceptable within the community. Whether this is fair or not is a debate on its own, but the point is that the ISP treats these small centres as substantial clients and provides service according to their desires.

In our field deployments of RootIO we witnessed how hard it was for small ventures to work with large corporations. For example, our request for IP telephony was heeded by one company because one of our engineers used to work there, understood the technology demands and had the trust of the company. This telecom company was also relatively small compared to the other companies. Our setting was however subsequently replicated for other clients who demanded the service. On the other hand, our request to another more popular telecom company after demanding a lot of technical and business information was turned down. The response we got was that the company was clearing a backlog and our request was therefore of less priority. Our interactions with community-based ISPs were also very promising and even though we never got to use their services, the discussions with them revealed that they were willing to make accommodations for RootIO stations that would make their operations more desirable.

7. Conclusion

In light of the examples given herein, we posit that the use of ICT4D in distanced communities needs to be loosely coupled with services from large corporations as this coupling can destabilize any possible community anchoring that ICT4D initiatives could potentially get from within communities. ICT4Ds that exist in communities merely by support from outside entities are not owned by the community and only achieve motives that serve the interests of entities at higher echelons that are introducing and sustaining these initiatives in these communities. What should be looked towards are small autonomous and co-dependent entities that work parallel to larger setups but are more responsive to the whims of the communities in which they are based and are financially viable within these communities.

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A mobile artefact for collecting and availing indigenous knowledge to farmers for food security enhancement

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ABSTRACT Food security is one of the priority targets of sustainable goals by 2030. This paper presents a practical mobile artefact for enhancing rural farmers' decisions on food security. The artefact provides intervention schemata for facilitating rural farmers to have improved and sustainable food security using indigenous knowledge. The artefact consists of different suites/components of services that work together to enhance farmers' decisions on food security. The artefact was evaluated by the intended farmers, community development workers and experts in the field of food security and information systems. Results indicated that the artefact provides useful mobile intervention schemata for facilitating farmers to enhance food security by exploiting indigenous knowledge.

Keywords: indigenous knowledge, mobile artefact, food security, decision enhancement

1. Introduction

Food security is defined by FAO (2014) as access by all people at all times to enough food for an active and healthy life. Food security is an essential aspect for minimum standards of living and every person has a right to be free from hunger and malnutrition. Nevertheless, food security remains one of the most challenging problems of rural communities in developing countries Uganda inclusive (USAID, 2016; WFP, 2015). Of the 795 million undernourished people globally, more than half are from Sub-Saharan Africa (FAO, 2014). Food insecurity is associated with poor health in both adults and children, poor cognitive and emotional development in children, and adult depression (UN, 2015).

While many parts of Uganda are relatively food secure, some parts especially rural areas experience chronic food insecurity. A study conducted by USAID (2016) in rural Uganda, indicates that levels of childhood malnutrition are quite high (40%), leading to high rates of child morbidity and mortality. Nine percent (9%) of households in rural areas of Uganda cannot afford more than one meal a day (UBOS, 2013, USAID, 2016; Tugume, 2017). Ending hunger and achieving sustainable food and nutrition security are very critical areas that need urgent attention in Uganda and other developing countries. In the United Nations' sustainable

development goals by 2030, ending hunger and food insecurity is target number two (UN, 2015). There is a dear need to ensure sustainable food production by rural farmers using resilient agricultural practices. This will not only increase productivity, but also help to maintain ecosystems and strengthen capacity for adaptation to climate change (FAO, 2017).

In a rural setting, indigenous knowledge is often the basis for local level decision making and an alternative means of promoting food security because of its cost-effectiveness and sustainability (Kamwendo & Kamwendo, 2014). Indigenous knowledge refers to what people know and have known and done for generations (UNESCO, 2016). To address the problem of food insecurity among the rural communities, it is important to build on their knowledge and experiences.

It is apparent that rural farmers have failed to adopt modern technologies due to high costs associated with modern technologies as a result of increasing levels of poverty (FAO, 2017). Given the rural context, indigenous knowledge would offer cost-effective solutions for achieving sustainable food security (FAO, 2014). Indigenous knowledge and innovations are core competences of rural farmers and, any interventions thought of, ought to build on farmers' knowledge and experiences. This study focused on finding out how rural farmers enhance their decisions on food security using indigenous knowledge. A decision enhancement approach of Keen and Sol (2008) was adopted. Decision enhancement is built on the fusion of people, processes and technology to enable an interactive and facilitative environment for decision-making.

The major question this study sought to address was "how can use of indigenous knowledge among rural farmers be leveraged to sustainable food security?" To address this question, we sought to design intervention schemata for enhancing rural framers' decisions on food security using indigenous knowledge. Specifically, the study was set to develop a mobile intervention schemata for establishing the status of food security among rural communities and to collect specific indigenous knowledge attributes that influence farmers' decisions in their efforts to enhance food security.

2. Related literature

In developing countries, agriculture is still dominated by peasant small holders using their indigenous practices and family members as source of labour (UN, 2015). It is vital to design interventions that complement local people's traditions for sustainability and inclusive development (Awuor, 2013). Interventions that build on the local practices (or those that integrate new technologies with local practices) enhance farmers' decision making capability (Kamwendo & Kamwendo, 2014; Awuor, 2013; Ranganathan, 2004).

In the East African region, there have been artefacts developed to address local communities' challenges in different sectors including poultry farming (Tumwebaze, 2016); mining start up enterprise (Habinka, 2012); water asset management (Katumba, 2016); agricultural produce marketing (Aregu, 2014); business process agility, (Amiyo, 2012); information needs for rural women start up enterprise (Komunte & Baguma, 2016). This development clearly demonstrates the potential of mobile artefact for handling complex decision-making challenges among rural farmers.

3. Methodology

Design science Research (DSR) approach within an engaged scholarship research framework approach was used in this research. DSR is an approach in which a designer answers questions relevant to human problems through creation of innovative artefacts (Hevner et al, 2004). In DSR, a researcher is required to look ahead to new possibilities as opposed to looking back to understand (Hevner, 2007). Engaged scholarship research is a participative form of research for obtaining the advice and perspectives of key stakeholders in the problem domain; (researchers, research users, clients, sponsors and practitioners) to understand and solve a complex social problem (Van de Ven, 2007; Costello & Donellan, 2012). In this study, key stakeholders were involved to have their different perspectives on how to tackle the problem of food security. The rigorous interactions and collaboration of stakeholders turned this study into "action research" with design science principles. Farmers as domain practitioners, extension workers and local leaders were engaged in dialogue to brainstorm on how indigenous knowledge could contribute to food security and also in the evaluation of the proposed solution.

A strategy of "Singerian inquiry" – that is, a practical approach for changing the status quo – in a pragmatic abductive reasoning framework was followed to get real issues from key stakeholders (Costello & Donellan, 2012; Churchman, 1971). Abductive reasoning (Pierce, 1857-1914) was preferred because it yields the kind of daily decision-making practice that does its best with the information at hand. The major aim was to contribute to both practical concerns of people and to the goals of social science by joint collaboration within a mutually acceptable social framework. Based on the ideas of Singer (Churchman, 1971), farmers and stakeholders were engaged in the process of identifying possible solutions to the problems of food security and evaluating the effectiveness of the solutions. An exploratory study with rural farmers and stakeholders was carried out to get real issues affecting their decision-making processes to improve food security. Farmer group discussions were instrumental in gaining a deeper understanding of how indigenous knowledge was used by rural farmers to improve on household food security and also to identify areas that needed to be enhanced.

Our focus on food security was mainly on three areas where critical decisions on food security take place and also to scope our research namely: seed selection, food storage and food processing. Seeds planted have a significant effect on the crop yield and crop yield in turn determines storage methods so as to avoid post-harvest losses and inadequate food in the household. Similarly, processing of food is critical to rural households as it has direct bearing on the form and quality of food to be consumed. This requires one to decide whether to use indigenous or modern methods of food processing or a combination of both depending on resources available (Gueye et al., 2013; Awuor, 2013; Kamwendo & Kamwendo 2014).

The exploratory study and discussions with farmer groups provided insights on how rural farmers engage in making decisions on food security. These insights were used to design the Food Security Decision Enhancement Artefact (FSDEA) following the DSR methodology. FSDEA was then evaluated with CDWs that are also farmers and food security experts for usefulness, usability and usage. In human centred design, usefulness addresses the value addition of a tool/system/technology. Usability on the other hand, covers the extent to which the tool/system/technology is easy to learn and use by the target audience while the usage attribute focuses on the actual application of the tool/system/technology by target users. Keen & Sol (2008) noted that usefulness, usability and usage are key aspects of effective decision enhancement. Artefact evaluation is an essential component of design science research (DSR)

and a crucial contribution to science and society (Pries-Heje et al., 2012; Peffers et al. 2008; Hevner et al., 2004). DSR comprises of two primary activities: "build and evaluate" implying that the utility, quality and efficacy of the design artefact must be rigorously evaluated (March and Smith, 1995; Venable, 2012). Purposeful artefacts are built to address unsolved human problems and evaluated with respect to the utility provided in addressing society problems (Hevner, 2007). Evaluation provides evidence that a new solution/tool/technology "works" or achieves the purpose for which it was designed (Veneble et al., 2012: Sonnenberg & Brocke, 2012).

4. Requirements for food security decision enhancement

From the exploratory study and farmer groups' discussions, insights on how rural farmers engage in making decisions on food security were gained. It was established that farmers' decision-making processes require coordination between farmers and across all stakeholders for effective collaboration and innovative solutions. It was further observed that rural farmers prefer working in groups that support each other in difficult circumstances. Additionally, great importance is attached to knowledge and experience sharing, despite the challenges faced in the rural context. It was established that farmers may not always make optimal and satisficing decisions due to various limitations (Simon, 1995). Key of these limitations include: limited resources, lack of knowledge, time constraints and effective communication channels.

These insights informed us of the need for a Food Security Decision Enhancement Artefact (FSDEA) for supporting interventions aimed at enhancing rural farmers' decisions on food security. Rural farmers need to be helped to collaborate and effectively communicate with each other and key stakeholders like experts in order to make more effective decisions about food security. Best indigenous agricultural practices that promote food security need to be appreciated and shared among farmers for sustainable use. We realized that our starting point of collecting indigenous knowledge alone is not enough. There is need to provide intervention schemata to Community Development Workers (CDWs). The intervention schemata expands the tool set of CDWs to better facilitate rural farmers to enhance food security decision-making practices. CDWs are employed by government and Non-governmental organizations at lower levels of local government and communities to empower individuals and groups of people by providing them with skills to effect change in their own communities. Essentially, CDWs help communities to help themselves by inspiring them and offering them guidance and opportunities for making improvements in their own community. CDWs act as a bridge between marginalized communities and government/development agencies at local levels. They provide vital assistance in the implementation of community projects and monitoring the progress of the communities in their jurisdiction.

5. Design of the mobile food security decision enhancement artefact

As a result of the generic understanding from the exploratory study and discussions with farmer, a Food Security Decision Enhancement Artefact (FSDEA) was designed. The FSDEA consists of four suites/components each containing specific services: the Assessment Suite, the Collaboration Suite, the Communication Suite and the Knowledge Management Suite. Each suite of services contains schemes to be followed by the CDWs as they intervene to support rural farmers to enhance their decisions on food security. It was realized that rural farmers needed to be helped to overcome their decision making challenges by first establishing their food security situations and then brainstorming on how to address the challenges via the

collaboration suite. Best indigenous practices that promote food security needed to be enhanced and shared among farmers for sustainable use. Essentially, the artefact provides an assessment form as part of the broader intervention schemata. The data collected is used to generate facts about food security and provide an analysis of the situation in communities as a starting point for intervening. The intervention schemata are set of guidelines on how interventions for enhancing food security should be done. The mobile artefact is accessible at www.fsdes.com

To be able to get informed decisions on how to address food security issues, a periodic assessment of the status of food security is required. The assessment exercise is a vital aspect of finding out the status of household food security as noted by Payne (2014). It is also important for finding out the status of community residents, availability of community resources and the capacity of community resources (ACF, 2010). For these reasons, a mobile assessment form is designed as part of the intervention schemata by CDWs in the assessment exercise. This is designed in such a way that it can be modified by the users to fit the context in which it is being used. The CDW accesses this form when he/she logs in the FSDES as a facilitator but also, he/she get the form from the intervention schemata in the knowledge base. The assessment results are automatically generated and computed statistically in form of percentages, pie charts and graphs for a given village or district. The statistics guide the CDWs on critical areas that need urgent attention as he/she intervenes to help farmers enhance decisions for addressing the situation. In an engaged scholarship, statistics results are put high on the agenda in a village collaboration meeting between farmers and key stakeholders while sharing knowledge and experiences on how food security problems can be jointly solved.

The results are presented in an interpretable and analysable form for effective decision-making. By simply looking at the statistics, the CDW is able to know which district, village or household has the highest incidences of missing meals, malnourished children and which farmers use indigenous/modern knowledge of seed selection, food storage and food processing. The results inform the CDW and farmers on how they are performing in comparison with their neighbours. CDWs together with key stakeholders use assessment statistics to tell which household or village needs urgent intervention. Stakeholders, who include local leaders, NGOs and other government agencies, are able to know which district is doing better or worse and this will enable them make informed decisions as well as required interventions.

In the assessment exercise, it is possible compare two or more districts in terms of the status of food security. Assessment statistics can be evaluated form topics of discussion in collaboration sessions between farmers and key stakeholders in the food security decision-making processes. Farmers and food security stakeholders have the opportunity to brainstorm on assessment results discussing the best and worst practices by individual households, villages, or districts. It is also an opportunity to share knowledge and experiences of those whose food security status is good with those that are performing poorly. The assessment exercise also assists the CDW to carry out analyses of the farmers' best practices and identifying appropriate interventions that can offer improvements to other farmers.

The food security assessment form is part of the broader food security decision enhancement artefact and is meant to help in the process of establishing the status of food security among rural communities/farmers. It is designed to collect information about problems of food security and decisions taken by farmers to address the situation. It is also meant to help in the formulation of interventions to help farmers enhance their decisions for improving food

security. Additionally, it eases the process of interaction by providing key questions to ask but more questions may be added. Figure 1 provides a diagrammatic representation of the FSDEA.

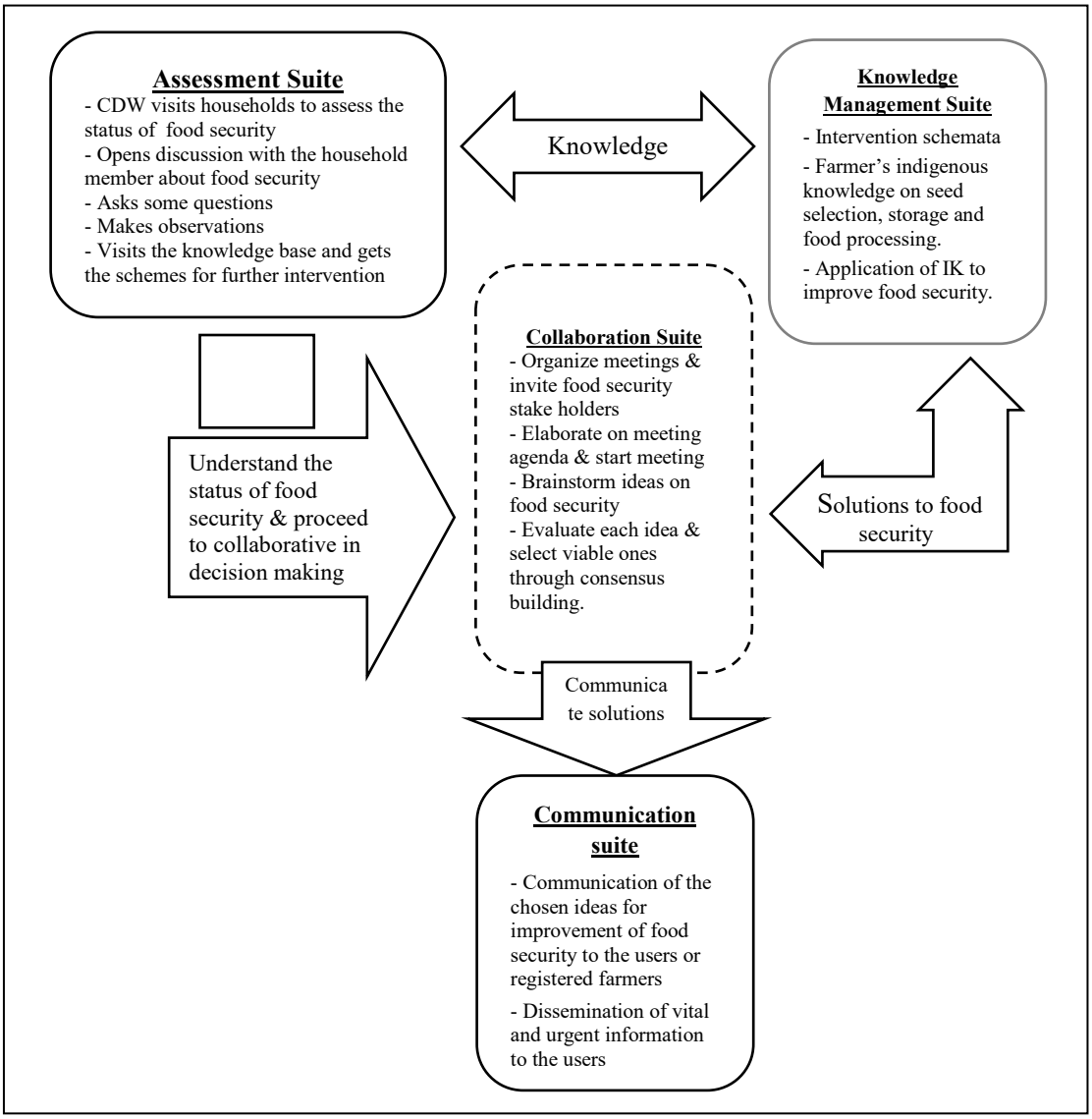

Figure 1. Overview of the mobile FSDEA

The mobile FSDEA consists of four suites each containing specific services: the assessment suite, the collaboration suite, the communication suite and the knowledge management suite. The assessment suite provides recipes for appraising the status of food security in a given community by the CDW. The suite also provides statistical information on the status of food security. It further shows computational analysis of assessment results got from rural communities and gives the CDW a starting point for intervening to address the situation.

The collaboration suite provides steps for engaging farmers and stakeholders in food security decision-making processes. It describes steps that are crucial for collaborative decision-making. It is a platform where farmers and stakeholders freely exchange ideas on food security improvement practices and come up with innovative and strategic decisions.

The communication suite enables instant communication between farmers and stakeholders. Information generated from collaboration sessions concerning food security (seed selection, storage and food processing) is instantly communicated and shared among key stakeholders.

The knowledge management suite provides knowledge and farmer experiences. It also stores the intervention schemata for CDWs to refer to as they facilitate farmers to enhance their decisions. The FSDEA is designed to enable interventions by CDWs using intervention schemata which expand their toolset for helping semi-educated rural farmers enhance their decisions on food security. Intervention schemata are recipes to the intervening agents or facilitators to get to know what to do in the process of helping and facilitating semi-educated rural farmers to enhance their decisions on food security.

6. Evaluation

The FSDEA was evaluated with prospective users (Table 1) and food security experts (Table 2) to establish its usefulness, usability and usage. The usefulness aspect was concerned with the value addition of the intervention schemata to enhancing food security decision processes, i.e. the extent to which it enhances rural farmers' decisions on food security and provides added value to the intervention work of CDWs to enhance rural farmers' decisions on food security. The usability aspect on the other hand focused on the extent to which the intervention schemata is easy to learn and use by the CDWs, farmers, researchers and other intervention agents. The usage aspect covered the actual application of the intervention schemata to enhance farmers' decisions on food security.

In the evaluation of the FSDEA, workshops were held in the two research sites to acquaint participants with the functioning of the artefact before giving time to interact with it on their own but within a specified period of time. During the workshops, participants were taken through FSDEA and its functions and given time to go through it on their own and ask questions/request guidance when necessary. After the workshops, participants were given two weeks to interact with the artefact at their own pace and note areas that needed further improvement. After the two weeks, an evaluation questionnaire was given to each participant to give their opinions on the usefulness, usability and usage of the artefact. A Likert scale was used where 1 means fully disagree, 2 = disagree, 3 = not sure, 4 = agree and 5 = fully agree. This questionnaire was supplemented by in-depth interviews with each participant to obtain explanations of the generic views given in the questionnaire.

Table 1: Categories of user participants in the evaluation of FSDEA

Category	**District**		**Total no. of participants**
	Kabale	**Mbarara**	
Community Development Workers (CDWs)	7	5	12
Local NGO staff	2	1	3
Academics			5
Domain practitioners	4	2	6
Grand total			26

Table 2: Categories of expert participants in the evaluation of FSDEA

Expert	**Affiliation**	**No. of participants**
Extension workers	Mbarara District Local Government	3
Veterinary officer	Mbarara District Local Government	1
Agriculture officer	Kabale District Local Government	1
Information systems officers	Kyambogo University	2
Grand total		7

6.1 – Evaluation Results

According to the results presented in Tables 3 and 4, a majority of the participants agreed that the FSDEA was a useful artefact for enhancing rural farmers' decisions on food security. The results also show that the deviations from the mean were relatively low.

Participants further gave qualitative remarks indicating that the food security decision enhancement artefact (FSDEA) has a potential to improve food security. Some of the qualitative narratives of users of FSDEA that participated in the evaluation are given below in the next subsection.

Table 3: User evaluation results

N = 26		Likert scale 1 – 5			
Usefulness		**Mean**	**Std. Dev.**	**Min**	**Max**
1	The FSDEA enables effective decision making.	3.97	0.89	1	5
2	The FSDEA enables users to share knowledge experiences.	4.29	0.51	3	5
3	The FSDEA provides a platform for farmers to air out their views.	4.30	0.66	3	5
4	The studio enables participants to explore knowledge alternatives for improving food security.	4.40	0.68	3	5
5	The studio facilitates shared understanding among key stakeholders.	4.41	0.55	3	5
6	The intervention provided are useful	4.33	0.67	3	5
7	Using the FSDEA improves my performance in guiding farmers to improve food security.	4.13	0.75	2	5
8	The FSDEA provides alternative ways of improving food security.	4.18	0.65	2	5
9	The FSDEA provides a conducive environment for making effective decisions.	4.22	0.59	3	5
10	Over all, I find the FSDEA a very useful artifact for enhancing farmers' decisions	4.54	0.55	2	5
Usability					
11	The screen layout is good.	4.3	0.82	1	5
12	The arrangement of information is good.	4.16	0.68	2	5
13	The tasks can be performed in a straight forward manner.	4.37	0.49	4	5
14	The language used in the suites is understandable.	4.44	0.50	4	5

15	The user interface is clear and understandable.	4.18	0.61	2	5
16	I find the FSDEA easy to use.	4.25	0.80	2	5
17	The intervention schemata provided is clear and easy to use	4.13	0.82	2	5
18	The design of the FSDEA is intuitive.	4.18	0.65	3	5
19	I am able to access information in the FSDEA.	4.16	0.77	1	5
20	I have experienced difficulties in using the FSDEA.	3.28	1.38	5	1
21	The information generated by the FSDEA is enough and relevant to enable farmers make agile decisions.	3,62	1.28	1	5
	Grand mean	**4.2**	**0.70**		

Table 4: Expert evaluation results

N= 7		Likert scale 1 – 5			
Usefulness		**Mean**	**Std. Dev.**	**Min**	**Max**
1	The FSDEA addresses rural farmers' decision making challenges with regard to food security	4.4	0.55	4	5
2	The FSDEA can be applied in a broader context to cover many areas of food security	3.8	1.10	2	5
3	The intervention schemata provided by the FSDEA can expand CDWs tool set in facilitating rural farmers to overcome food security decision making challenges	3.6	0.90	2	4
4	The FSDEA is potentially useful in addressing the problem of communication among farmers and stakeholders with regard to food security	3.8	1.10	2	5
5	I would not hesitate recommending FSDEA to farmers and stakeholders in the field of food security	4.4	0.89	3	5
6	The FSDEA supports collaboration between farmers and stakeholders	4.4	1.22	2	5
7	The FSDEA addresses key challenges farmers face in decision making	3.8	1.09	2	5
8	The intervention schemata provided by the FSDEA add value to CDWs' task of supporting farmers	4.4	1.34	2	5
9	The FSDEA enables interaction among farmers and stakeholders and experts	4.0	1.22	2	5
10	The FSDEA helps to collect, store and disseminate indigenous knowledge hence preventing it from extinction	5.0	0	5	5
11	The assessment tool is able to capture the actual situation of food security on the ground	4.0	1.22	2	5

Usability					
12	Information is well displayed on the screen	3.4	1.51	1	5
13	Information is arranged logically	3.6	1.14	2	5
14	The FSDEA design is clear and easy to interpret	3.4	0.89	2	4
15	Tasks in the FSDEA are easy to carryout	3.4	0.89	2	4
16	The intervention schemata is easy to use	3.6	0.89	2	4
17	Language used in the FSDEA is clear	3.2	1.30	1	4
18	Information display on the screen is good	3.6	1.14	2	5
19	The FSDEA can be learned with ease	3.6	1.14	2	5
20	Over all, FSDEA is usable	3.6	1.14	2	5
	Grand mean	**3.83**	**1.0**		

6.2 – Qualitative evaluation remarks

Generally, evaluation comments by users and experts show positive rating of the FSDEA in terms of its usefulness and usability towards enhancing decisions of rural farmers. The usefulness and usability aspects of the FSDEA are demonstrated in the following remarks given by participants (pseudonym is used in our examples for confidentiality and to permit free discussions):

1. Didas, a Community Development Worker of Rwanyamahembe Sub county, Mbarara District, narrated that he started using FSDEA in September 2016 after it was installed on his laptop. According to Didas, he had never had an opportunity to see any system related to his work before. He confessed that he was excited to learn of the mobile FSDEA. He stated that previously, he only used his laptop for word processing to write reports and searching for some information on the internet. So, he was so happy with the FSDEA that provides guidelines on how to have local solutions of food insecurity. “It was an exciting moment opening the food security assessment automated tool. “I didn’t know that there could be something useful to my work in electronic format!” Didas remarked.

Didas noted that, the FSDEA has made him efficient and effective in the following ways:

a) He is able to assess the status of food security in his Sub-County using his smart phone or laptop as he goes around the sub county and he is able to share results with farmers for self-appraisal and also with policy makers, and other stakeholders.

b) He has gained knowledge and understanding on various local solutions to food security problems, which he can share with farmers and at the same time, guide people in his Sub County. “The knowledge I have gained has enabled me to perform my duties better than before”, Didas affirmed. What he considers as very important is the automated assessment tool that can compute the assessment results into statistical format. According to Didas, this is very important as he can consult the FSDEA knowledge base for his intervention work to guide farmers on how they can improve household food security.

c) Ease of communication amongst food security stakeholders. Didas is convinced that FSDEA is an invaluable and mobile tool of communication. When the solution of banana bacterial wilt disease was announced by the Ministry of Agriculture in December 2016, Didas immediately posted the announcement on FSDEA. Little did he know that he would receive calls from fellow CDWs and farmers for details about

the announcement. That incident excited Didas and made him confirm that FSDEA is an important tool for collaboration and communication between farmers and experts.

2. Daniel and Sadress are both small scale farmers neighbouring each other in Kitunga, Kabale District. The duo grow sorghum, Irish potatoes, sweet potatoes and beans. They both keep cattle and goats to diversify their income and as a means to sustain household food security. Daniel bought his animals while Sadress received a heifer from World Vision, a charitable NGO working with rural communities of Kabale to boost their standards of living. Daniel and Sadress use both indigenous and modern knowledge in their farming enterprise. From 2016 when the FSDES was launched to date, Daniel and Sadress have attended five farmer group collaboration meetings. From group meetings, they testify that they have learnt how to improve their farming using both indigenous and modern knowledge.

While interacting with Daniel, he remarked: "I have learnt new knowledge from our CDW through the FSDEA. The monthly meetings we have with our community development worker help me learn from him what other farmers do. We meet with experienced model farmers and learn from their ideas and new techniques of farming which have helped us to improve food security. We are encouraged to share our experiences about what we do in the process of improving food security. For instance, I have learnt through FSDEA that "kamurari" (red pepper) is a good preservative for beans against weevils. Since then, I no longer get a problem of weevils"

Sadres manages her cow, which is an improved breed, using both indigenous and modern knowledge learnt in collaboration meetings. She now knows which herbs are used to treat and deworm cows in case she has no modern medicine from vets. This has improved the milk production from her cow from7 litres of milk in the morning and 4 in the evening to 10 and 8 litres respectively. She agrees that the FSDEA has enabled her to learn new methods of farming from fellow farmers and experts through knowledge sharing. By using a smart phone, she is able to consult and get help from experts instantly.

Notwithstanding the efficacy of the FSDEA, there were hiccups in using it particularly those associated with poor internet connectivity and little ICT knowledge among some rural farmers. This is being addressed by the intervention of CDWs.

7. Conclusion

The FSDEA is a platform on which indigenous knowledge on food security are captured and shared when put in the hands of farmers and CDWs. It is a channel through which the voices of rural farmers about tried and tested practices of enhancing food security can be heard by experts, policy makers, researchers and fellow farmers. The FSDEA is an innovative artifact that can lead to socio-economic transformation of rural communities by documenting and disseminating indigenous knowledge. The FSDEA which can be installed on a smart phone, a tablet or laptop is able to transform lives, as it embodies knowledge and practical applications on how the problem of food security can be addressed using local knowledge and innovations thus, contributing to rural peoples' food security decision enhancement. This research uniquely contributes to the enhancement of food security especially in developing countries by developing intervention schemata that can be used by change agents.

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A Proposal for a USSD Name Service (UNS) to Scale USSD Applications

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ABSTRACT This paper seeks to explore how the concepts behind the Domain Name System (DNS), a time tested and core component of the Internet can be extended to solve problems related to Unstructured Supplementary Service Data (USSD) applications. USSD has had innumerable successes especially from supporting mobile money infrastructure, however, its potential is threatened by commercial, regulatory, and technical complexities largely due to unfavourable market structures dictated by not only monolithic Mobile Network Operators (MNO) and regulatory authorities but also the protocol's technical limitations. For USSD Applications (App) to scale, users and developers will require, if not demand, better interfaces and developer experiences. The discussion is centred around a USSD Name Service (UNS), a proposal for the convergence of USSD (based on access and usage) and the concepts behind DNS (where a client sends a query as a single User Datagram Protocol (UDP), and receives of a single UDP datagram in response). The paper briefly looks at the potential benefits of the UNS, but also propose ways it would be administered and managed. Most importantly, the paper heavily borrows literature from industry and academia on imagining possibilities of designing technology for developing countries.

1. Introduction

Human-Computer Interaction (HCI) researchers have been tasked with imagining possibilities of designs of technology. In the recent past, there has been a shift towards the democratisation of technology and its application through 'maker', 'Do It Yourself (DIY)' and 'open source' movements [1].

We begin by revisiting the Information and Communication Technology for Development (ICT4D)/Mobile for Development (M4D)/HCI debate about the need for localised and contextually relevant applications of technology. In particular, circa 2006-2010, technologists debated whether development and deployment of technologies in Sub-Saharan Africa (SSA) should concentrate more on available telephony standards of Short Message Service (SMS)/USSD, or rather the Internet, which was growing in popularity [2]. While the Internet continues to exhibit phenomenal growth, its impact and application within the wider populace remains a subject of dispute [2,3,5]. On the other hand, USSD, despite severe technical limitation does nothing to represent its simplicity, and successes [4].

USSD is a communication protocol over a 3GPP family network which facilitates communication; a) with the mobile device itself, b) directly with the Subscriber Identity Module (SIM) card, c) or with an MNO's application servers. Indeed, USSD can be used for

Value Added Services (VAS) such as prepaid call back, configuring a phone a cellular network, mobile money, location-based content, menu-based information services, and Wireless Application Protocol (WAP) browsing, among others [9].

The USSD protocol was developed primarily in Europe for European markets: GSM and its evolutionary 3rd Generation Partnership Project (3GPP) family of specifications has been described in the Global South as an 'unintended consequence' [5]. Nevertheless, despite the 3GPP developers' lack of user studies, co-design, a 'bottom-up' process of development, or significant cultural adaptation of the underlying technology, mobile telephony has been accepted and widely adopted across SSA [5].

1.1 – The third universal app

The 3GPP telephony family has been elevated by the ubiquity of low cost phones in SSA [6]. 3GPP has particularly enabled real-time communication and low latency transactions through voice and text services which are pillars upon which a major part of the mobile economy is built [7].

The Global South has remodelled USSD into their own specifications, at least at the end points. And as so, USSD has created a new form of 'net' supercharging a critical path towards SSA's digital needs. While the widespread use of USSD applications has largely been a preserve of MNOs (and banks) for obvious reasons, viz. they control critical and proprietary communications infrastructure, there is promise that the use cases can be applied to almost any other digital aspect [5,8]. Indeed, USSD has enabled the development of VAS in sub-Saharan Africa. To illustrate this, of the 276 live mobile money deployments globally, nearly 50% are located in sub-Saharan Africa alone but almost all of the live services entirely rely on USSD as the primary delivery channel [10].

According to the GSMA, in 2017, over 60% of SSA was connected to 2G. From the same publication, projections show that 2G will reduce to 6% by 2025 while 3G connection will rise to 62% from 36% in 2017. Uptake of LTE and NR remain relatively small but with steady growth [13].

1.2 – USSD and how it works

Figure 1 shows a simplified illustration how USSD in GSM (2G), UMTS (3G), and further in LTE (4G) and 5G NR.

In GSM, Mobile Station (MS) or in UMTS, User Equipment (UE) refers to the equipment and software needed for communication with a mobile network [25, 26]. The end user who directly interfaces with the MS/UE can interact with USSD over a cellular service in two ways:

- By dialling a designated short code prefixed by asterisk (*) and terminated by hash (#), a user must choose 'send/OK' to dispatch the instruction to the operator.
- By using an installed application that runs on the SIM Toolkit (STK). Such applications are usually tied to a specific service offered by an operator.

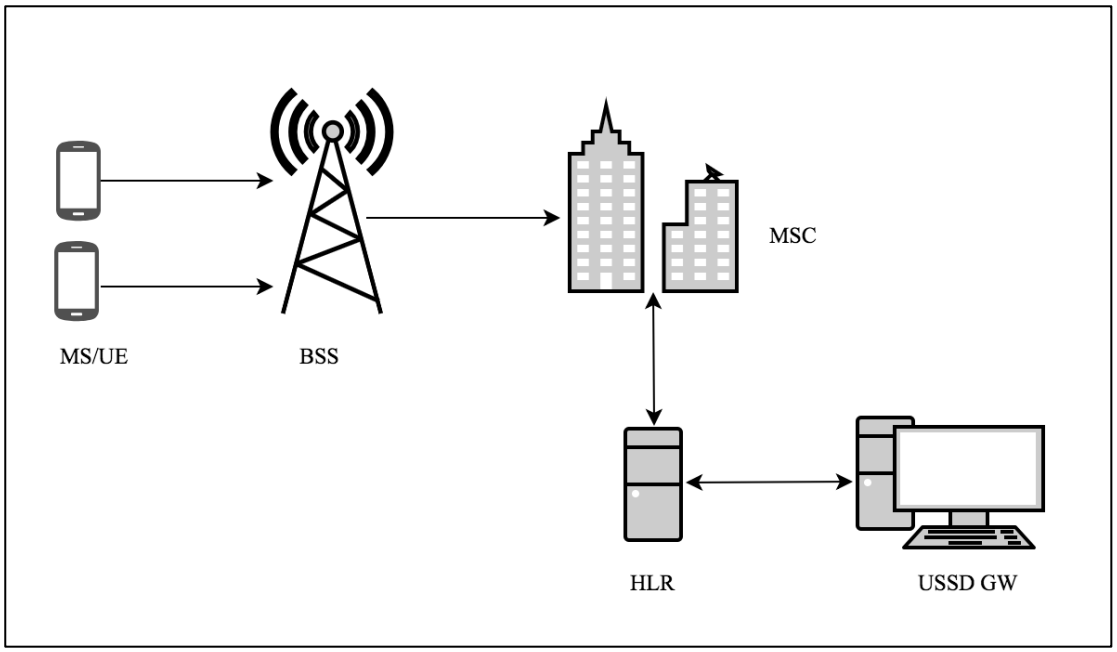

Figure 1: How USSD works

1. USSD Request at the MS/UE
   A USSD request at this stage goes through the Base Station Subsystem (BSS) is responsible for handling cellular traffic and signalling.

   When the end user or an application in the MS initiates a USSD request, the MS initiates a USSD session toward the USSD Gateway (GW). After sending a USSD request, the USSD client in the MS shall wait for a USSD operation from the USSD GW [11].

2. USSD request at the Mobile Service Centre (MSC)
   Upon receipt of a USSD request from the end user in the MS, the MSC determines if the subscriber is authorised for USSD services. If the subscriber is authorised for USSD services the MSC sends the USSD request to the USSD Address identified in the Subscriber Profile in the Home Location Register (HLR). The HLR is a central database that records all details of each mobile phone subscriber authorise on the core network. The MSC does not modify the USSD application data. If the subscriber is not authorised for USSD services the MSC rejects the USSD request [11].

   The Mobile Application Part (MAP) is Signalling System No. 7 (SS7) that provides an application layer for USSD, and other nodes, in GSM and UMTS to communicate with each other. Instead of MAP, LTE and NR generations use Session Initiation Protocol to achieve similar results with the USSD payload.

3. USSD Request at the USSD Gateway (GW)
   The USSD GW may receive a USSD request from a USSD client in the MS at any time. The USSD GW routes the USSD request to the appropriate application server. If the application server requires more information from the USSD client, the application server requests the USSD GW to send a USSD request within the same USSD session to the USSD client. Upon completion of the session by the application server, the

USSD GW sends a USSD response to the USSD client and releases the USSD session [11].

1.3 – The complex web of USSD

Unlike the Internet, USSD administration is within the absolute control of MNOs, backed by regulators. As seen above, USSD has since been stretched, meaningfully, to serve wider needs beyond what it was originally designed to do.

Peppered with a long list of successful use cases, USSD is widely renowned for enabling M-PESA, a mobile money solution debuted by in 2007 by Safaricom in Kenya [19]. The M-PESA model, which has been replicated by several MNOs all over the world. It has particularly been instrumental in facilitating financial inclusion especially to largely unbanked adult populations in the Global South [5,11].

However, despite their sovereign control, MNOs do not have the sole mandate on innovation and technology development. Potential concerns about provision of services (such as financial services) have cropped up in market segments which MNOs seek to serve even when they control communications at infrastructure level, and specifically USSD [12].

The issue is more pronounced in countries where MNOs have higher market power, and can ably get away for their misgivings such as withholding access, charging high prices or offering poor quality USSD connections in order to prevent competitors from meaningful participation. This can effectively deny customers and the market from realising the potential benefits of competition (such as lower prices, increased investment in agents, improved service levels, customer choice and product innovation) [12].

1.4 – Building on top of USSD

Industry pressure to unbundle mobile services especially with regard of encouraging competition, product innovation, among others might have precipitated MNOs to loosen their grip on key infrastructure by, at least partly, opening up their infrastructure by making Application Programming Interfaces (API) available to third party developers largely through onerous accreditation procedures often overlooked by accredited intermediaries [14].

Some of the most impactful applications of USSD have been deployed by non-profits and multilateral agencies in supporting their activities and programmes. For example, Praekelt Foundation; United Nations International Children's Emergency Fund (UNICEF), among others [15].

However, corporations such as Twilio and Africa’s Talking (AT), among others are providing the capabilities and tools to third party developers who might be interested in leveraging MNOs’ infrastructure for different products and services. They do this by building integration pipelines with opaque and complex MNOs gateways [16]. In many cases, this involves resource intensive negotiations and integrations with MNOs and regulators that only corporations could afford.

Intermediaries such as AT capture value by narrowing the gap between developing USSD apps and deploying them on MNO networks. The ingenuity lies not only in the accessibility of their developer APIs but also, if not most importantly, the price factor. For example, to deploy a USSD app in Uganda through AT’s shared short code, a developer would pay just about US$1,700 in annual fees staggered in monthly payments of US$140 [17]. In comparison, a

developer would pay over US$11,000 per annum in Uganda for a dedicated USSD short code. However, some developers might want dedicated short codes such as *100# exclusive to them. While an intermediary could expeditiously organise this arrangement on top of their development platform, the developer is not entitled to any price waivers and is obliged to pay industry standard rates in application and annualised maintenance fees prescribed by regulators and MNOs [18].

Intermediaries have innovated and deployed a sub-lease-model that grants sub-leasees relatively affordable access to short codes and fully developed APIs to integrate with MNOs' infrastructure.

However, with the uptake of the inexpensive access of shared code arrangement compared to short code access has caused a surge of short codes as a result of a myriad of services built on USSD platforms. As supply increases, largely due to accessible developer APIs and the lower cost of USSD services, demand will naturally follow. Short codes will cover more and more services than they are currently restricted to and will range from examples such as *123# (government birth registration platform); *123*18181# (corruption reporting desk); *200*88# (civil society whistleblowing platform) among others which will certainly lead to a dissemination of services driven by industry pressure for deregulation and democratisation of key communication infrastructure [18].

However, for USSD to truly reach its potential, and widespread use, a system that facilitates ease of access and enlivens the user experience is essential. For a truly democratised 'net', the need to have intuitive and memorable short codes will be more nuanced as more and more developers sign up to develop USSD apps.

1.5 – A primer on short codes and allocation fees

USSD short codes can be dedicated or shared. A dedicated short code takes a format such as *123# while a shared short code *123*45#. According to a Uganda Communications Commission (UCC) study, in Uganda, a USSD short code costs US$250 in application fees while it costs US$10,000 in annualised maintenance fees, excluding applicable Value Added Tax (VAT) [20].

Rwanda charges US$30 application fee for short codes. Allocated USSD codes are subject to US$1,000 in annual fees [21].

Tanzania charges a one-time US$2,000 "registration fee" for allocation of "ordinary" USSD and SMS short codes and a US$3,000 "annual maintenance fee" thereafter. "Ordinary" codes are assigned serially by the Tanzania Communications Regulatory Authority (TCRA), but other categories of codes, are assigned based on customer preference and range from "Bronze" to "Gold" as they become increasingly more "memorable," have a higher registration fee but with the same annual maintenance fee [22].

As can be seen, Uganda's annual short code allocation fees are comparatively higher than other similar jurisdictions. Obtaining these highly priced short codes has been cited as a barrier to entry into the VAS markets [20].

2. UNS and proposed use cases

A UNS is modelled on the architecture of the DNS. The DNS provides an essential service on the internet by mapping structured alphabetic names to what would otherwise be semantically meaningless numeric addresses (Internet Protocol addresses) [23]. For example, a user need not memorise the IP address(es) of Facebook (66.220.144.0), other than just Facebook's Uniform Resource Locator (URL) www.facebook.com which translated by the DNS.

In the world of technology and mobile telephony, digital names and addresses, unique identifiers to different product offerings are common sight. Indeed, the Internet has done a great job abstracting away the fine details behind DNS in exchange for terse and memorable names. Just like human-readable domain names and URLs were integral to increasing widespread adoption of the Internet, human readable USSD codes will be integral to increasing widespread adoption of USSD Applications and/or the hybrid between Internet and USSD Applications.

2.1 – Phone address book as DNS

It is tempting to argue that the phone address book can be used to solve the mess associated with USSD short codes. Indeed, a cluster of short codes (for different services) can be saved under generic names in one's phone address book and conveniently dialled if need be. However, this is not standard practice. Just like host files locally hosted on a central server pre-DNS era, a developers' change of USSD short code could cause confusion and wreak havoc. A generic USSD App name would fundamentally solve such a problem through translating human readable domain names in the front end to strings of USSD codes.

2.2 – External USSD Interface

An external USSD interface would facilitate inputting of generic USSD Domain names and would also create an interface for subsequent the data exchange.

Unlike SMS, USSD does not interact with the Short Message Service Centre (SMS-C). USSD is session based. A real-time connection is opened upon instruction, allowing a two-way exchange of a sequence of data limited up to 182 alphanumeric characters [9].

The mobile phone dialler is constrained to numeric characters as a means of interaction, despite USSD's limit up to 182 alphanumeric characters. A handy interface to facilitate input of generic USSD domain names include WAP browser or third party developed clients that enable data transfer from wireless data layers to the USSD layer.

*Generic USSD names such as *REPORT# would be input into a mobile device instead of typing in say *200*88# to access a mobile based whistleblowing platform.*

The UNS would maintain the USSD protocol standards and specifications as per 3GPP2. As explained in Figure 2, an end user enters a short code in a phone dialler—or a USSD URL in an external USSD interface. The steps illustrated in Figure 1 are repeated from the MS/UE to BSS up to the MSC.

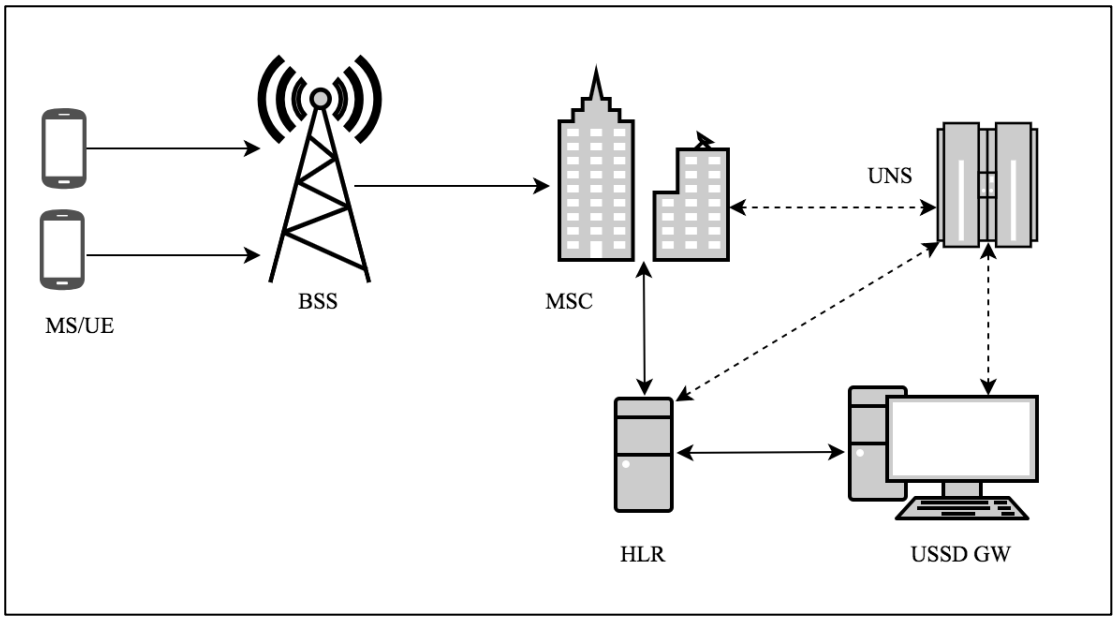

Figure 2: How UNS will work

The MS/UE sends the instruction to the MNO, where it is received by the USSD GW. If granted, further interacts with instructions from a third party leveraging the Internet to dispatch and receive answers—and or by a UNS registry to reconcile USSD domains to short codes—through a gateway provided by the MNO. The answer from this computer is sent back to the phone.

3. Discussion

HCI researchers are challenged to think of technology as a blend of knowledge, intelligence, time, labour, organisation, money and law—a combination that shifts and changes over time [5, p. 6]. Bar the technical specifications, the process of adopting a UNS might appear disorienting to the MNOs who run USSD GWs like black boxes, and to regulators who earn regulatory fees and commissions from the lease of short codes. Similarly, changes on technical specifications by protocol authors and other relevant stakeholders to accommodate a UNS would be an onerous, if not impossible challenge. However, demonstration of a UNS at a country level could validate the concept and pave way for wider adoption.

3.1 – Registrars and governance

A UNS would enable improve USSD UX by enabling users to type generic URLs into their devices to access USSD Applications, yet also enabling developers to refine their products and services maximally.

Granted, the UNS registry would be managed by telecom industry accredited third party organisations and entities. However, they would be decentralised entities independent of regulators and MNOs but guided by their mandate. UNS registrars would have geography specific control over administration of USSD domains insofar as MNOs' geographical scopes are defined. Registrars would run 'open source' software to manage USSD URLs subject to frictionless updates and studious backward compatibility.

3.2 – Deployment and future plans

The deployment of the UNS would be predicated on telecom industry buy-in and cooperation from key stakeholders. As USSD applications grow popular overtime, there would be even more demand for generic USSD domain names. To enable growth and impact, UNS registrars would launch region specific shared codes such that particular generic names could be used from one geographical area to another.

Since the MNOs are location specific (with exception to roaming), it would be prudent for the UNS to be administered by local Internet Registries who manage country code Top Level Domains (ccTLD) within the boundaries of countries and regions.

For example, *REPORT*UG# could be used for a whistleblowing service in Uganda while *REPORT*KE# be used for a community policing service in Kenya [26]. This country level domain segmentation would not only be relatively affordable for the developers (since it would run parallel to shared code structures) but would also be memorable and pleasant for the users.

3.3 – After Access

The author has borrowed the term 'After Access' from ICT4D scholars who continue to investigate trajectories on internet access and connectivity, and the key challenges and opportunities emerging in the Global South.

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Building A Low Cost Obstetric Equipment and Supplies Prediction System Using Modern Mobile Web Technologies

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ABSTRACT Uganda has the 37th highest maternal mortality rate in the world. The maternal mortality rate currently stands at 336 per 100,000 live births. The majority of these deaths are due to avoidable delays in medical intervention. Knowing as precisely as possible what a health centre will need to cater to pregnant mothers can greatly improve the ease and speed of providing medical care to pregnant women at health centres. We propose leveraging recent developments brought on by increasing mobile Internet usage to develop low cost solutions aimed at reducing delays in the delivery of medical care. To demonstrate the applicability and potential benefits of such technologies we developed an application, built using recently developed progressive web application techniques. The application is capable of intelligently predicting the number of pregnant women likely to visit a health in any given month, as well as the medical supplies and equipment that the facility will need to properly attend to them. Predictions will help facilities better plan resource provisioning in order to provide timely medical treatment. Predictions can also improve the currently inadequate referral capabilities in many local health centres. Finally, we demonstrate how such a project can take advantage of the numerous currently available cloud computing solutions to lower the costs of deployment.

1. Introduction

1.1 – Problem

Uganda has the 37th highest maternal mortality rate in the world [1]. According to the 2016 Uganda Demographic Health survey [2], maternal mortality in Uganda is caused by:

- Pre-existing medical conditions accelerated by pregnancy (28%)
- Bleeding (27%)
- Eclampsia (14%)
- Sepsis (11%)
- Obstructed labour (9%)
- Unsafe abortion (8%)
- Blood clots (3%)

Maternal deaths resulting from the above conditions can be reduced or prevented through timely medical treatment [3] [4]. Some of the factors causing delayed medical intervention at health facilities are inadequacy of referral systems and shortage of supplies and equipment [3].

1.2 – e-Health programmes in Uganda

A 2017 review of 48 e-Health programmes in Uganda [5] shows that the country recognizes the potential benefits of e-Health in improving health care in Uganda. This paper focuses on how the technical implementation of such programmes can be improved with modern technologies, most of which did not exist or were not used when these 48 programmes were trailed or implemented. To demonstrate this, we propose a solution concept in the maternal health field and proceed to implement it using said technologies.

1.3 – Progressive Web Applications

Progressive Web Applications (PWA) are mobile applications delivered through the web [6]. PWAs function like native mobile apps but do not need to be downloaded from an app store.

The main attraction of PWAs for the project is the service worker component. The service worker is a key component of PWA architecture that sits between the application and the Internet allowing it to work offline or on low quality networks as can be the case in rural health centres in countries like Uganda. PWAs can use significantly less data than traditional native applications [7], load instantly and are always up to date [8]. Figures 1 and 2 show the difference in view on a computer and tablet.

1.4 – Leveraging low cost application development and deployment solutions

Internet usage has been increasing globally and in 2018, the number of global Internet users stood at 4.1 billion [9]. Over time, this trend has led to innovations around the technologies that are used to build, deploy and run the websites and applications that bring users to the Internet.

One key development is cloud computing [10] which has significantly reduced the infrastructure costs of running web applications [11] [12].

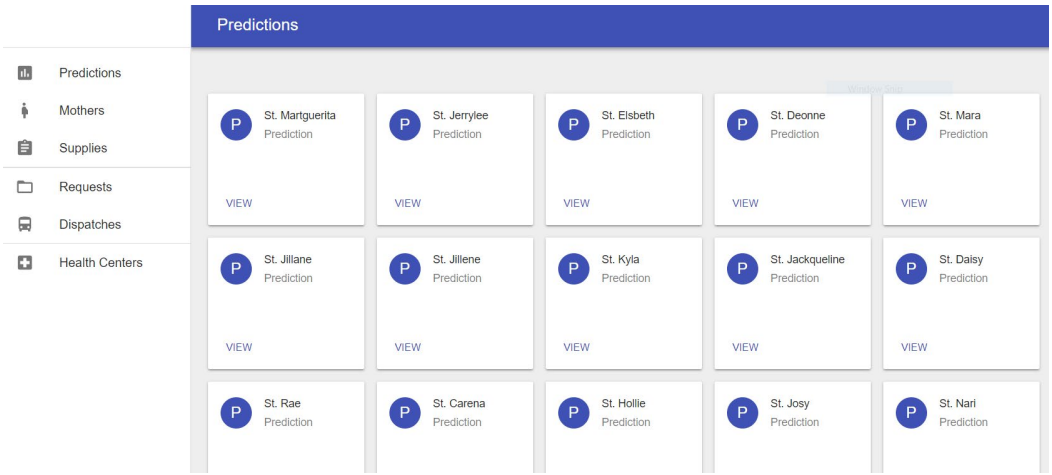

Figure 1: The PWA running in a web browser on a computer

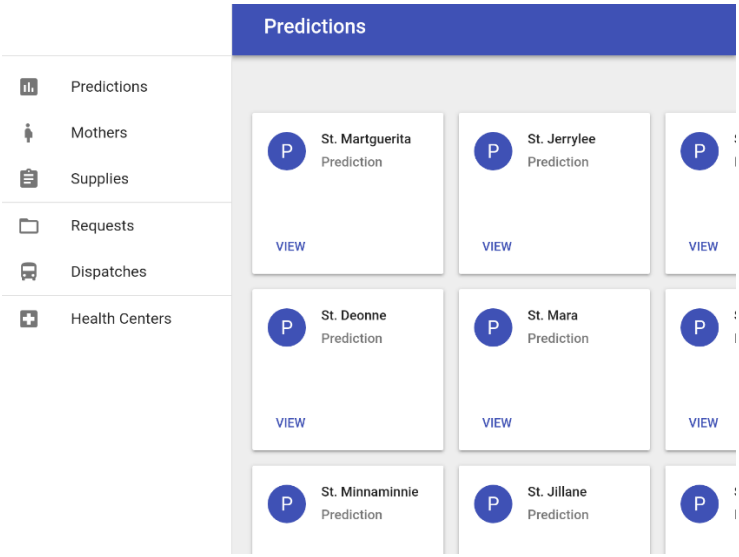

Figure 2: The PWA running on an Android tablet

The project's front-end makes use of the *React JavaScript framework* [13]. The framework simplifies development of relatively complex user interfaces [14]. *React* is paired with *Material-UI* [15], which is a collection of *React* components that implement Google's Material Design [16]. This combination permitted focus on our unique solution instead of spending time building basic user interface components.

The solution's backend is entirely made up of microservices. The microservice software architectural style structures an application as a collection of loosely coupled services, which implement specific capabilities or routines [17]. These microservices are platform agnostic: They have been built and deployed on a Google service called *Firebase*, specifically its cloud functions service [18] but could have just as easily used Amazon Web Service (AWS) *Lambda* [19], Microsoft's Azure functions [20], or a custom deployment using a docker cluster [21] [22].

Currently all the main cloud computing providers have free usage tiers [23] [24] [25] which can be used to drive infrastructure costs during development to nearly zero. Throughout the development of our solution we stayed within the *Firebase* free tier [26] without having to constrain our software development in anyway.

The microservice architecture and cloud deployment path were both chosen for their numerous benefits such as easy scaling, ease of maintenance, robustness and fault-tolerance [27] [28] among other benefits. The application can be rolled out to all the 3000 plus health centres in Uganda and still run smoothly.

The microservice architecture can also significantly reduce deployment costs [29] [12]. This, coupled with the already low cost of cloud computing, goes a long way towards reducing the overall monetary cost of web-application based interventions in economic development challenges.

Firebase also provided us with an easy to integrate authentication framework [30] and a scalable NoSQL database [31] (Figure 3).

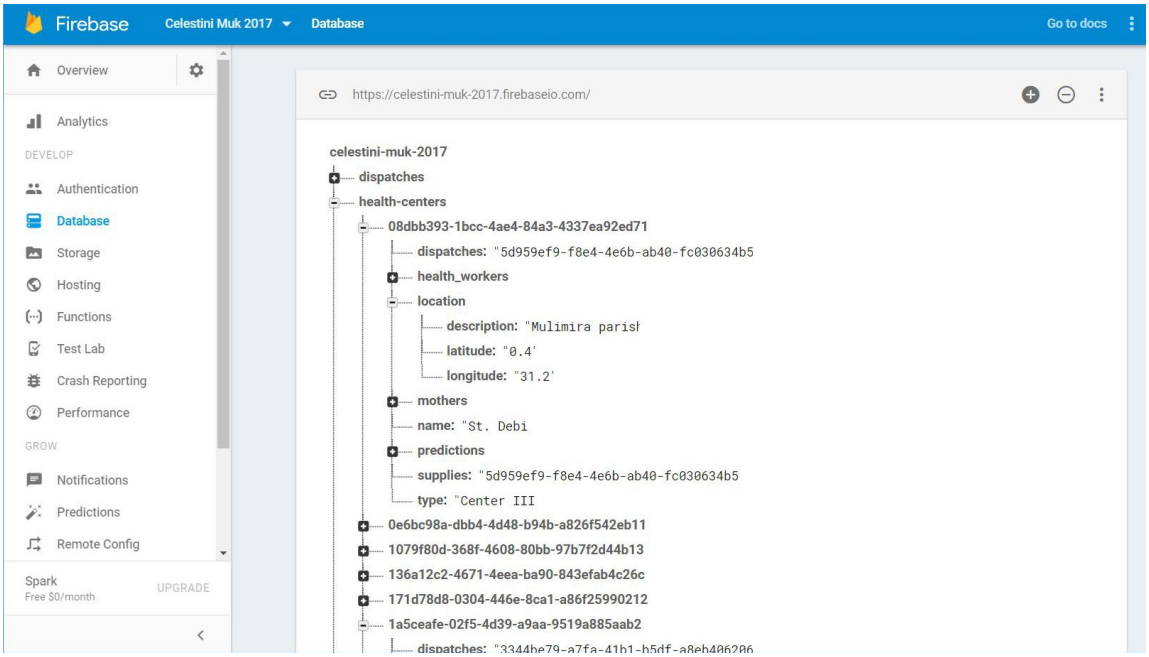

Figure 3: Firebase dashboard showing mock data in our database

2. Building a Solution Using Progressive Web Applications (PWA)

The solution is a web application capable of predicting the medical supplies and equipment that a health facility will need in a month. These predictions can be used to reduce delays at health centres when used to better plan and deploy obstetric equipment and supplies. Predictions can also be used to inform referral decisions.

Broadly, the solution works in the following ways:

1. Health workers register pregnant women on to the system.
2. The system then takes the information on all registered mothers and generates a prediction of medical supplies that the health centre will need in order to properly attend to mothers during antenatal visits or when they are giving birth.
3. The prediction for a given month is shown side by side with information on a health centres current supplies. The current supply units are highlighted in green or red depending on whether or not they are sufficient to handle the mothers expected to visit the health centre in any given month.
4. The list of predictions is accessible by the suppliers. Suppliers in this case refers to both the internal and external suppliers of the health centre. External suppliers in Uganda include the National Medical Stores (which is a government entity mandated to procure, store & distribute essential medicines and medical supplies to all public health facilities in the country) and NGOs such as Joint Medical Stores. Internally, predicted supplies are also visible to the health centre personnel in charge of distributing supplies to different departments within the health centre. Suppliers (internal or external) can then respond to supply requests that they have accessed.
5. Medical workers can view the supplies of the health centres nearest to them so that they can redirect mothers. This option comes in handy in case a health centre is lacking (or is running short of) specific items and needs to refer mothers to a different facility.

The prediction algorithms are influenced by:

- The location of a health centre.

- The number of mothers likely to visit that health centre in a month.
- How far along with the pregnancy these mothers are.

2.1 – Registering health centres onto the system

Health centres are added onto the system from a user interface in which the health centres name, sub-counties and parish (these are administrative divisions used in Uganda) it is located in and its precise geographical co-ordinates in World Geodetic System 1984 (WGS84) format are recorded. Such WGS84 longitudinal and latitudinal co-ordinates of a location can be obtained from a mapping tool such as Google maps.

2.2 – Registering mothers

According to the Uganda Demographic and Health Survey 2016, 98% and 97% of pregnant women in urban and rural areas respectively had at least had one Antenatal Care Visit (ANC) during the previous pregnancy. It is in the earliest of these visits that a mother is registered onto the system.

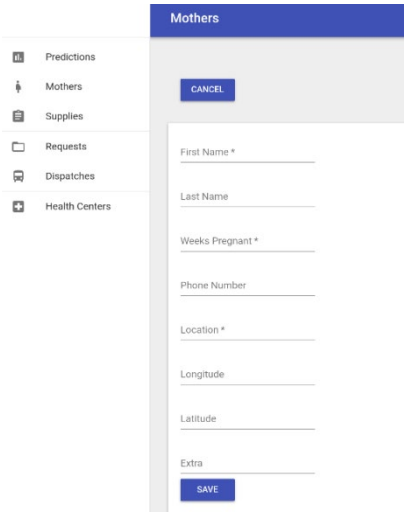

Figure 4: Registering mothers

As is demonstrated in Figure 4, the number of weeks the expectant mother is pregnant as well as the mother's location are two of the compulsory pieces of information the application must capture. This is because both data points heavily influence our predictions. Names are only required for administrative purposes on the part of the health workers registering the mother during an ANC visit.

The mother's location is important because it influences our estimate of the number of mothers likely to visit a health centre in any given month.

The mother's location can be supplied as a sub-county or parish. If a location is supplied as one of these, the sub county or parish is matched with the corresponding sub-county and parish information of health centres in our database (shown in Figure 3) to predict which health centre the mother will likely go to for an ANC visit.

Location can also be supplied as a set of WGS84 longitude and latitude coordinates in case the mother is comfortable with sharing this much information. In this case the health centre will need network connectivity that is reliable enough to load Google maps and the registering personnel require the knowledge of how to use the mapping tool. Once the map has loaded, the mother can provide her precise location.

Location information is then used in a clustering sub-routine that matches mothers' locations with co-ordinate information from the health centres' database to predict which health centre each mother will likely go to for ANC.

2.3 – Generating predictions

The system is capable of tracking and predicting the supplies of 20 items (core obstetric equipment) required to adequately meet the needs of pregnant women.

These items are tape measures, fetoscopes, blood pressure machines, weighing scales, timing watches, thermometers, catheters, surgical gloves, umbilical cord clamps, resuscitation units, surgical blades, baby weighing scales, suturing kits, cotton wool, cannulas, oxytocin, urine testing kits, Human Immunodeficiency Virus (HIV) testing kits, blood grouping kits and blood for transfusion.

Algorithms were developed to predict the volumes for each individual item. Some algorithms were straight forward, for example, to estimate how many blood grouping kits will be need in a month the predicting subroutine simply multiplies the number of mothers expected to visit in a month with the number of kits needed for each mother.

Other algorithms were obtained from consulting with gynaecologists and mid-wives with decades of experience in Uganda's health sector. For example, for estimating how many units of blood for transfusion are required in a month, medical personnel informed us that 10% of mothers that give birth will likely need a blood transfusion. The algorithm we developed in this case looks at the number of weeks pregnant to estimate how many mothers will give birth in a health centre in a month and estimates how many units of blood the predicted 10% (of births in that month) will require.

As is demonstrated in the screenshots in Figure 5, predictions are displayed side by side with the health centres current supply. The rationale for this is that the health workers using the system will be more aware of how much of a particular item they need and contrast it with how much they lack in existing store supplies. They can then plan accordingly.

The health centre must ensure to regularly update their current supply status. The application provides a form for them to easily do this.

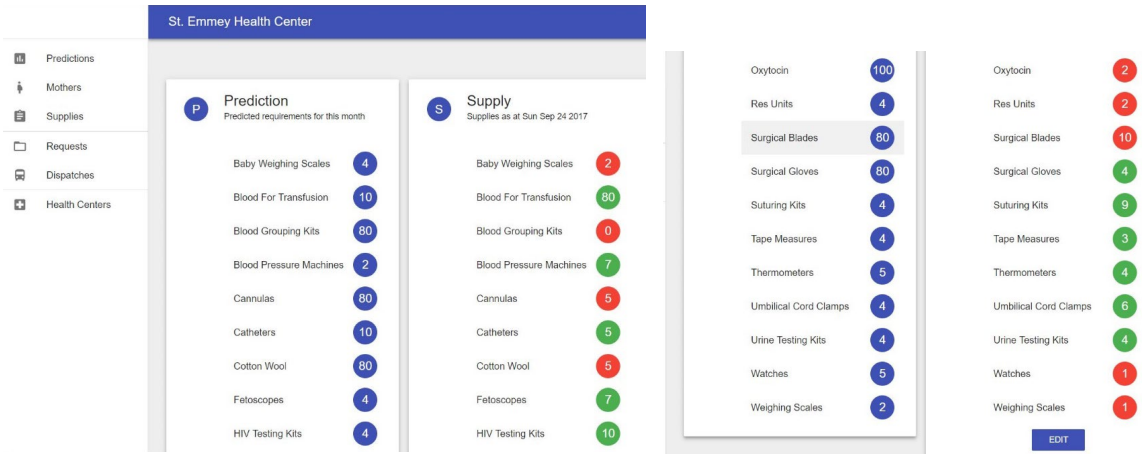

Figure 5: Prediction shown alongside current medical supply

2.4 – Viewing predicted supplies to help with referral

In case a health centre finds itself lacking the supplies to handle a particular situation, medical personnel can use the system to view the five nearest health centres surrounding them and what those centre's current supply levels are.

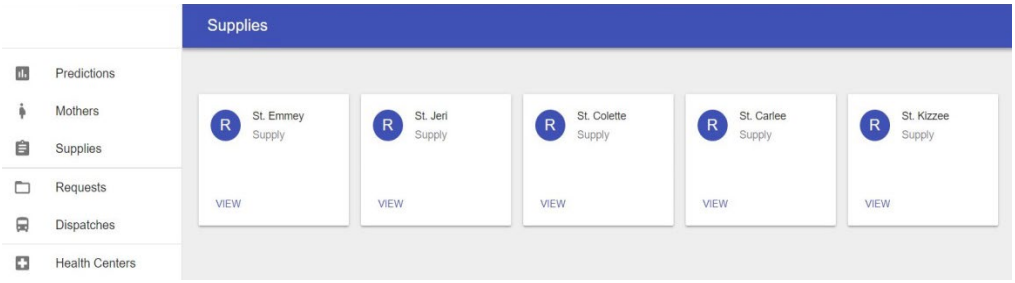

Figure 6: Health centres filtered to the nearest five

The five health centres supplies can then be reviewed to select the one most suitable for handling a particular case before sending the mother there.

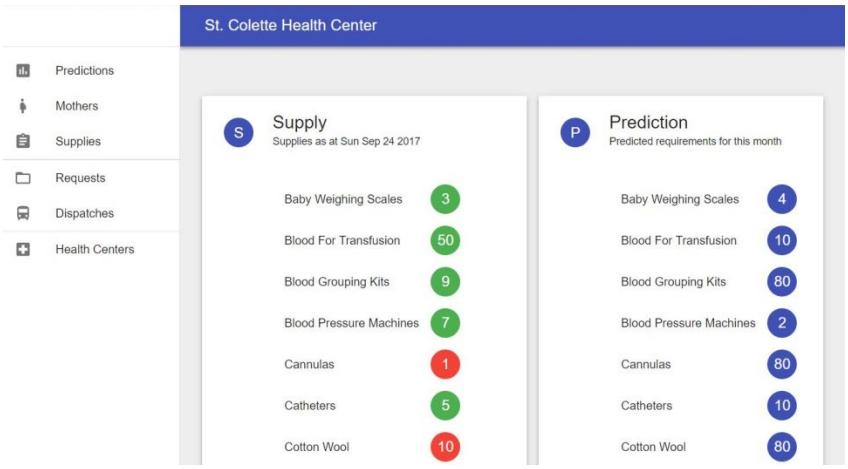

Figure 7: Viewing a different health centres supplies

2.5 – Viewing supply requests

As earlier stated, the list of predictions is accessible by both internal and external suppliers. External suppliers include the National Medical Stores and Non-Governmental Organisations (NGO) such as the Joint Medical Stores. Internally, predicted supplies are also visible to the health centre personnel charged with the distribution of supplies to different departments within the health centre. This is especially useful for large health centres such as hospitals (as opposed to smaller health centre III's and IV's). Figure 8 and 9 show how supply requests can be viewed. Suppliers can then respond to the requests

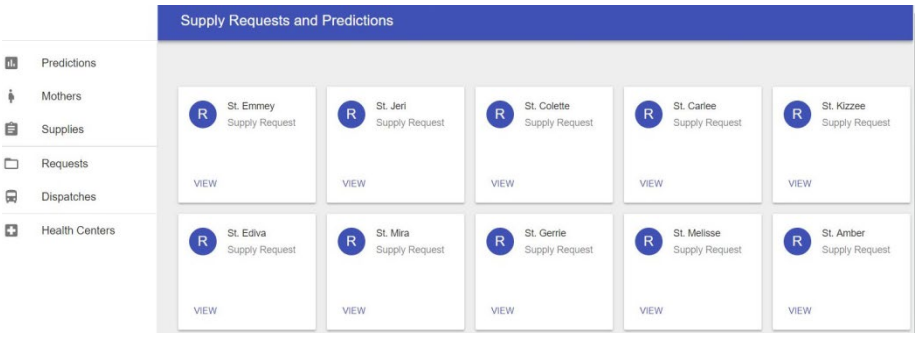

Figure 8: Viewing supply requests

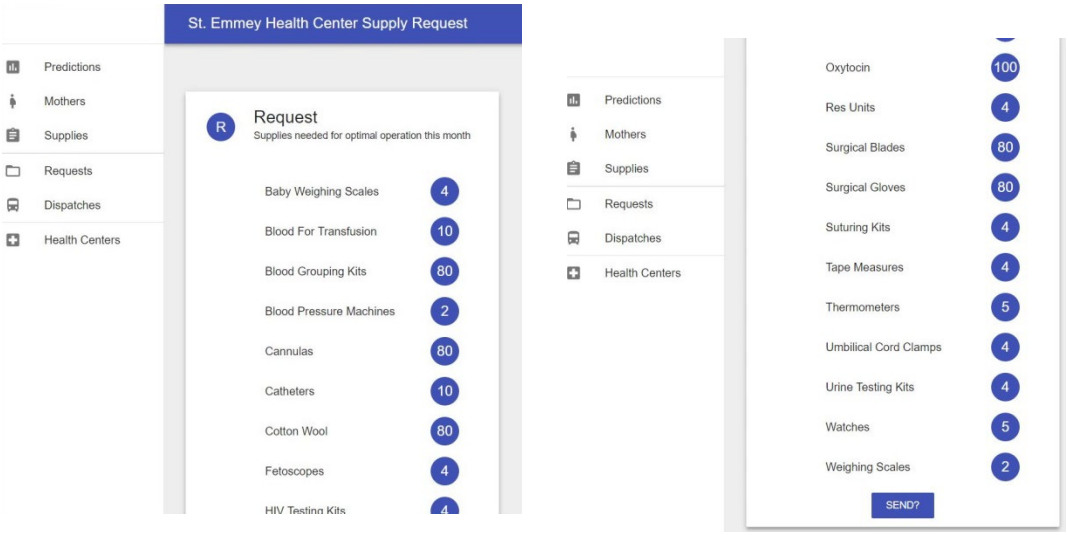

Figure 9: Supply requests in detail

Suppliers can then respond to the requests.

3. Proposal Validation

This proposal was presented before a panel of doctors, a midwife, a gynaecologist, health care policy analysts and engineers during a maternal-healthcare themed design thinking workshop organised by the Resilient Africa Network (RAN). RAN is a partnership of 20 universities in 13 African countries that aims to strengthen the resilience of communities by nurturing and scaling innovations. Recommendations from members of the panel were used to refine the idea into the form presented in this paper.

4. Conclusion

Technologies that have resulted from increased usage of mobile devices can be used to simplify development of low-cost applications aimed at tackling developmental problems. The case study we used resulted in developing a web application that can be used to improve health centre efficiency through better planning, more operational referral capabilities and effective resource distribution.

Such an application can be deployed in the 3000+ health centres in Uganda at a low cost. Improved efficiency will in turn greatly reduce delays at the health centre thereby reducing maternal deaths by ensuring timely medical treatment.

More generally, we believe leveraging advances in mobile web application development can reduce the technical debt involved in building and deploying e-Health solutions in Uganda, allowing more focus to be placed on the non-technical challenges that such solutions face.

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Mobile Devices, Applications and Internet use in Zimbabwe Healthcare

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ABSTRACT The mushrooming of mobile devices for use have presented a promise in the healthcare sector. Whilst mobile devices are being used for general purposes there is a need to provide evidence of how they be used to improve the healthcare environment. Data were gathered through semi-structured questionnaires, interviews and focus group discussions in Zimbabwe. The results showed that 92.12% of maternity care nurses have access to the Internet using their mobile phones (smartphones). The phone brands mainly used are Samsung (39.08%) and Nokia (26.44%). In carrying out clinical processes Maternity Care Nurses prefer the use of laptops (46.24%) and mobile tablets (31.21%). Social networking applications mainly being used are WhatsApp (78.98%) and Facebook (69.32%). Approximately 92% of maternity care nurses are using mobile money payment systems (Unstructured Supplementary Service Data platform) with Econet Wireless Zimbabwe dominating the market. Access to mobile money accounts is generally done approximately at a fortnightly basis. This research adds to the existing body of literature since there were no known researches (at the time of this study) in Zimbabwe which focused on mobile devices and mobile health applications being used and their elements and or preferences by maternity care nurses.

Keywords: mobile devices, elements, phone brands, USSD, mobile health, maternity care nurses.

1. Introduction and Background

The work processes of maternity care nurses (MCNs) can be improved through the use of the Internet and this can be effectively done mainly through mobile devices. Zimbabwe had a mobile penetration rate of 94.3 percent in the third quarter of 2016 [1]. The widespread penetration of mobile devices and mobile phones among healthcare workers is a major factor that makes mobile health (mHealth) essential in healthcare service delivery [2]. Mobile phone and mobile broadband penetration are some of the ICT indicators in the measurement of ICT infrastructure [3]. The standard measure for mobile phone penetration is subscriptions per 100

persons. Individuals can have more than one subscription with the same or different mobile network operators (MNOs), so there is a lack of specificity in this measurement. The mobile network operators in Zimbabwe are Econet Wireless, Netone, and Telecel Zimbabwe [3]. The statistics from POTRAZ shows that in the second quarter of 2016, Econet Wireless had a mobile subscribers market share of 51.6 percent, NetOne with 34.7 percent and Telecel 13.7 percent. The third quarter of 2016, Econet Wireless had a mobile subscribers market share of 49.40 percent, NetOne with 36.38 percent and Telecel 14.22 percent; thus Econet wireless' market share dropped by appproximately 2.2 percent points while Telecel and NetOne experienced an increase [1], [4]. The Internet penetration rate increased from 49.8 percent in the first quarter to 50.1 percent in the second quarter of 2016 and remained the same in the third quarter. The mobile penetration rate (active subscriber base) had a mark of 97 percent by the second quarter of 2016 and declined to 94.3 percent in the third quarter.

In addition, Econet Wireless is dominating the market share of active mobile money subscriptions with 97.8 percent while Telecel has 1.9 percent and Net One has 0.3 percent [1]. Mobile money payments platform is solely based on the use of Unstructured Supplementary Service Data (USSD) platform in making payments, airtime top up and so on. The USSD platform does not require Internet connectivity and is compatible to all mobile devices including basic mobile phones. An online USSD platform can be used to access information from a database and is usually cheaper to use than a Short Message Service (SMS) [5]. Nevertheless, there is an increase in Internet subscriptions over the period of 2009-2016 as shown in Figure 1.

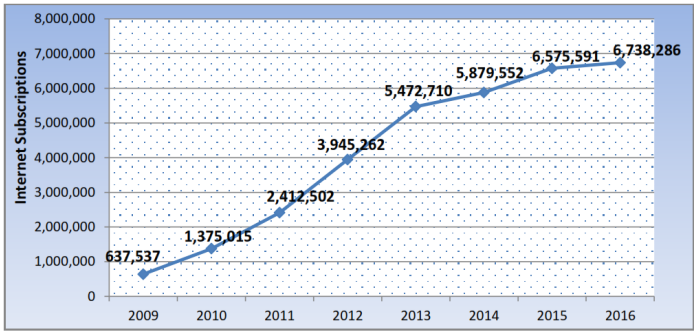

Figure 1: Increase in Internet subscriptions. Source: [4]

The remarkable increase in the number of users connected to the Internet and mobile phone subscribers provides a great opportunity to exploit mobile health in healthcare work processes. Mobile technology provides opportunities in delivery of healthcare services in resource-constrained environments such as Zimbabwe. The next section focuses on mobile devices and hardware elements.

1.1 – Mobile devices hardware elements

Mobile devices consist of a number of hardware elements such as the camera, keyboard, touchscreen, Bluetooth, media players, mouse and so on. All of these are controlled by a processor. Hardware elements in mobile devices are made up of the devices plane, communications plane and application plane. The devices plane consists of the screen, camera, keyboard, media players and so on [6]. The communications plane consists of hardware such as SoCs for WiMax, WiFi, Bluetooth, GSM/CDMA, and or 3G modems to support different types of connectivity. Lastly, the applications plane is the group of programs which provide

the user applications making use of the necessary underlying hardware and communications capabilities. It supports video streaming, music, video calling, mobile TV and so on [6], [7]. Mobile devices hardware and application software are managed by the mobile operating software (MOS). The hardware elements aforementioned supports delivery of health services in a diversified context. The next section focuses on mobile devices software elements.

1.2 – Mobile devices ownership and MOS market share

Mobile devices software is an important aspect in providing services. An Operating Software (OS) governs the application software which can be installed on the device and the mobile device hardware performance requirements. Mobile devices operating software include Android, Windows Mobile, Blackberry, iOS, Linux and so on [6], [8]. Globally, the smartphone market share is dominated by Samsung with 22.3 percent for year 2016 second quarter. However, Zimbabwean statistics shows that the mobile phone and tablet brand is dominated by Nokia followed by Samsung. Table 1 shows the global smartphones market share and Figure 2 shows the proportion of mobile phones and tablets brands in the Zimbabwean market by January 2015.

Table 1: 2016 second quarter global smartphone market share. Source: [9].

Company	2016 Second Quarter market share (%)
Samsung	22.3
Apple	12.9
Huawei	8.9
Oppo	5.4
Xiaomi	4.5
Others	46.0

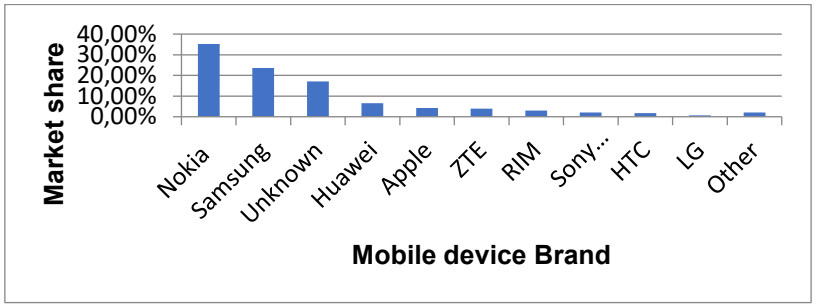

Figure 2: Proportion of Mobile phones and tablets brands in Zimbabwe by January 2015. Source : [10]

The global MOS market share in terms of sales to end users is dominated by Android MOS with 87.8 percent of all smartphones sold to end users using the system. As of 2016, Android was the leading MOS and Apple's iOS the second most popular operating system for smartphones [11]. The now-discontinued MOS Symbian was the most popular in the world from 2009 until Q4 of 2013 when it had a market share of 0.71 percent but has now become almost extinct [11]. Figure 3 shows the Global MOS market share from first quarter of 2009 to third quarter of 2016.

In contrast to the world statistics, the second most popular MOS in Zimbabwe is Series 40 and Symbian still accounts for 6.60 percent of the market share although it has become almost extinct worldwide. The top eight MOS in Zimbabwe by January 2015 are shown in Figure 4

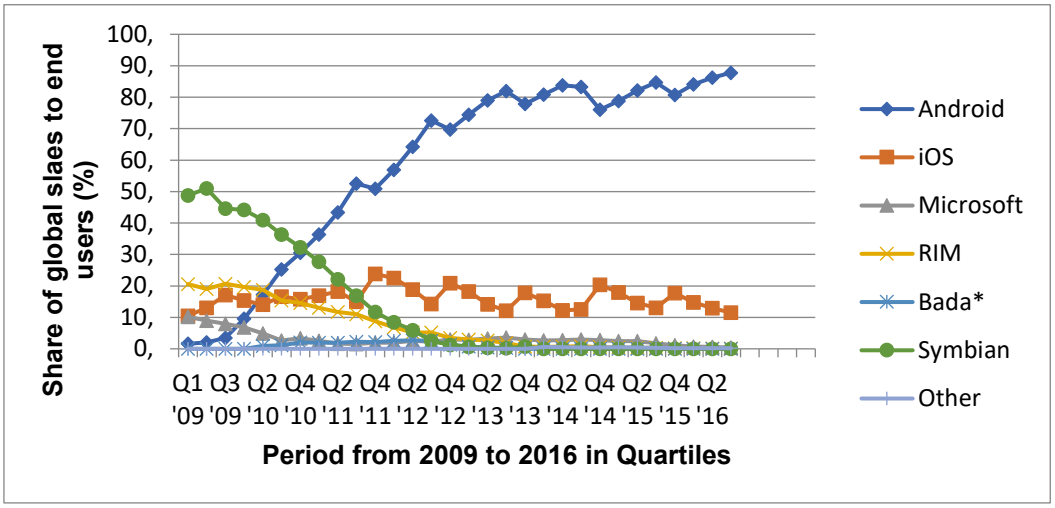

Figure 3: Global market share from 1st Quarter 2009 to 3rd Quarter 2016. Source: [11]

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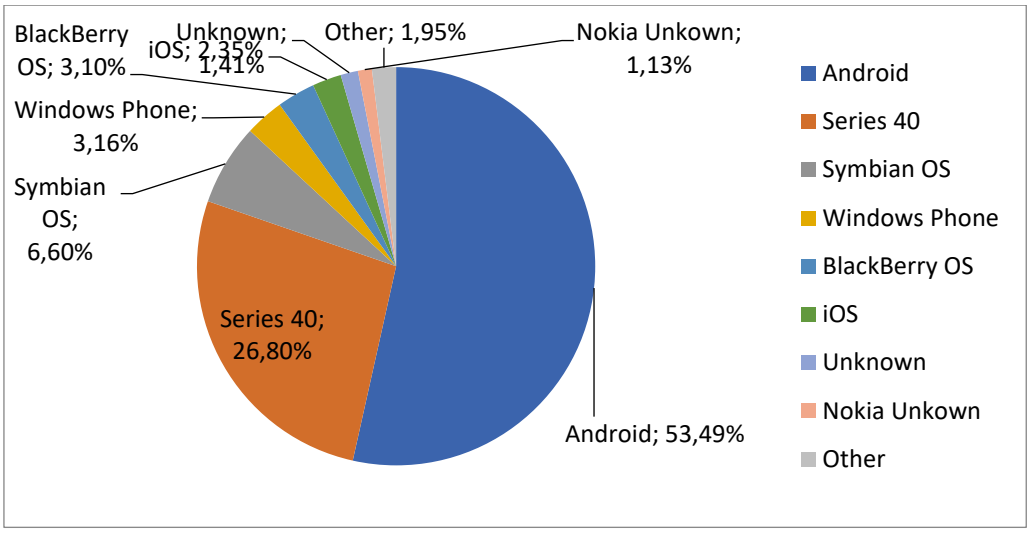

Figure 4: Top 8 MOS in Zimbabwe. Source: [12]

The two dominating phone brands in Zimbabwe are Nokia and Samsung. The Series 40 software platform accounts for 26.8 percent of the market and is based on the "Nokia OS" platform. Nokia's proprietary closed platform only supports Java Micro Edition based programs and mainly runs on feature phones handsets even though other Nokia Series 40 mobile devices have a lot of smartphone features [13], [14]. Furthermore, Nokia devices run on other MOS such as Android and Windows RT OS. Samsung's leading MOS (Android) and Nokia devices running on Android offers a rich environment for the development of healthcare applications since the software is open source based It is therefore essential to identify suitable phone brands to be recommended for a mobile health framework development. Smartphone features are explored in the next section.

1.3 – Features of smartphones

[15] defines a smartphone as 'an electronic handheld device that integrates the functionality of a normal mobile phone, personal digital assistant (PDA) and other information devices'. In addition, [15] postulates that smartphones supports high computing capabilities and have higher resolution display screens, good lens and high resolution cameras. They also support Short Message Service (SMS), Multimedia Messaging Service (MMS), Global System for Mobile communication (GSM), Code division multiple access (CDMA), web browsing, email and other accounts and or data synchronisation, connecting to a personal computer (PC) using a USB, installation of applications and upgrading of the MOS.

The portability of smartphones allows access to information from anywhere since they support mobile Internet and wireless connections such as Wi-Fi and Bluetooth. They also offer global positioning systems (GPS) which can be customised to access medical related data such as locations of health facilities [2]. All the aforementioned smartphone features provide an opportunity to deploy mobile-based and patient-centred applications and systems in healthcare environments. In addition, smartphones have security features to keep patient data secure. Smartphones supports security controls activation such as encryption, and remote wiping which facilitates protection against unauthorised access of healthcare data. This can be achieved when users are technically and security savvy [16]. This supports the Zimbabwean eHealth strategy's objective of promoting and ensuring the confidentiality and security of patient information at any level [17].

Android and iOS are the leading MOS and both supports security controls [16]. Security controls such as multiple authentication procedures are essential since the use of passwords (graphical or consisting of characters (alphanumeric, letters or digits) only to authenticate access to a mobile device is vulnerable to attacks [16]. Furthermore, enforcing authentication using biometrics such as fingerprint, face recognition, hand geometry, iris recognition and voice still poses threats especially when the device is lost or misplaced hence there is need to complement the security options using security controls against device theft. The controls help in increasing post-theft data control. Smartphone manufacturers introduced several controls and these include Find My iPhone of iCloud and Android Device Manager of Google Play and other third party applications such as Norton Mobile Security [16], [18].

All these anti-theft applications support locating a smartphone on a map, playing sound on a smartphone to help finding it, locking and tracking a smartphone, as well as remotely wiping the data on the stolen or lost smartphone. Remote wiping mechanisms allow owners to remotely delete sensitive data by sending a wipe command to the lost devices through the Internet or SMS [19]. Security is supported in android devices since if the device is lost; an Android Device Manager can be used to erase data on the device and protecting the account and this can be manually enabled via the user's Google account [16].

All these anti-theft applications support locating a smartphone on a map, playing a sound on a smartphone to help finding it, locking and tracking a smartphone, encrypting data on the mobile device, as well as remotely wiping the data on a stolen or lost smartphone. Remote wiping mechanisms allow owners to remotely delete sensitive data by sending a wipe command to the lost devices through the Internet or SMS [19]. The security functions that smartphones support make them of no exception to be used in healthcare computerisation. Smartphone use in healthcare is high in developed nations, especially Europe and America, as opposed to

developing countries, specifically those in Africa [5]. mHealth use supported by mobile devices, can be in the form of call centres for patients' enquiries, the use of SMS for appointment reminders, email notifications/automated phone calls/SMS for personal reminders such as time to take medication, raising health awareness, accessing patients' records and medical health workers decision support [20], [21]. In addition, USSD technology can be used to engage patients as they will be able to communicate with healthcare providers through alerts and reminders and access their information through USSD menus [22]. The next section gives a summary of the methods used.

2. Methods

A mixed method strategy during data collection and analysis was used. It consisted of semi-structured questionnaires (N=176), interviews (N=4) and three focus group discussions. The data was analysed inductively and the research philosophy adopted is interpretivism. A purposive (selection of participants) and convenience (selection of hospitals) sampling techniques have been applied. A sequential nested sampling model was used in selection of focus group discussions participants. Focus group discussions and interviews were used as a follow-up to verify results from the questionnaire. The results from the techniques conformed those from the questionnaire.

3. Results of the questionnaire

Mobile devices, applications and Internet use was explored. Ninety-two percent of the MCNs access the Internet at work, home, Internet café or both at work and home (Figure 5). Those who access the Internet at home only, constitute the largest group (39%).

The majority of maternity care nurses access the Internet using a mobile phone (79.64%) as shown in Figure 6.

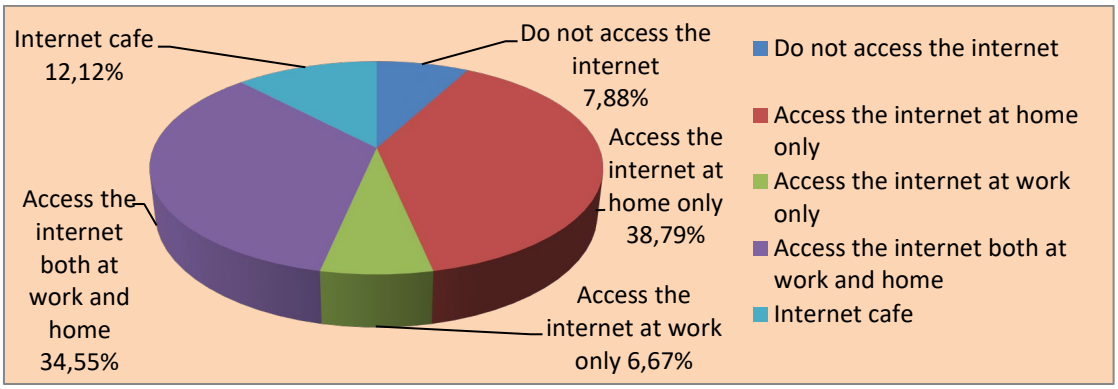

Figure 5: Internet access

The proportion of MCNs accessing the Internet using different mobile devices with respect to the mobile device being used is given in Table 2. On average, a mobile phone is frequently being used by those healthcare workers who use more than one device to access the Internet. The results significantly differ across the hospitals since the standards deviations are large (at least 20).

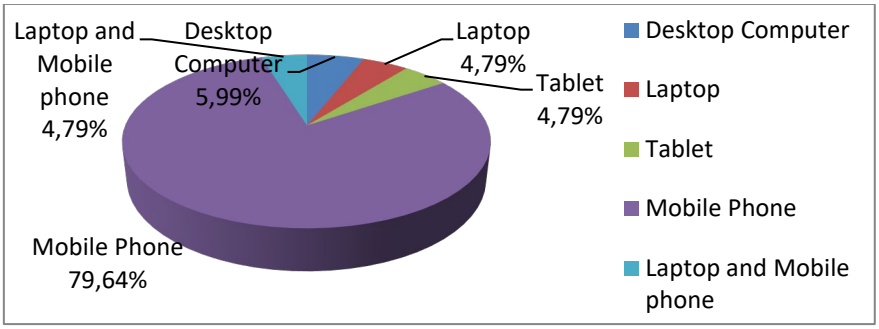

Figure 6: Type of device used to access the Internet

Table 2: Mean and standard deviation on percentage use of mobile device in accessing the Internet

Mobile device	Mean	Standard Deviation
Desktop Computer	28.67442	20.87573
Laptop	29.46032	22.94371
Mobile Tablet	45.07895	30.93968
Mobile phone	63.50833	29.83794

3.1 – Mobile phones used and preferred mobile devices

Seventy point six three percent (70.63%) of MCNs own smartphones, 23.75% own basic mobile phones and 5.00% own feature phones while 0.63% own both basic and feature phones. The phone brands mainly used by MCNs are Samsung (39.08%) and Nokia (26.44%). The least owned phone brand is ZTE (2.87%). Approximately half (46%) of the healthcare workers prefer using laptops in carrying out clinical care processes followed by the use of a mobile tablet (31%). A smartphone preference was indicated by a fifth (22.5%) of the respondents.

3.2 – Non-Healthcare applications used by MCNs

Seventy-eight point nine eight percent (78.98%) of the participants used WhatsApp, (69.32%) Facebook, (40.34 %) Google Play Store while the least used applications that are used are Dropbox (14.20 %), Google Drive (15.91%), and Skype (17.61%).

Table 3 Applications used

Application	Using the application	Undecided/ No Response	Never used the application	Proportion of those using the application (%)
WhatsApp	139	5	32	**78.98**
Facebook	122	19	35	**69.32**
Google Map	50	64	62	**28.41**
YouTube	52	74	50	**29.55**
Dropbox	25	76	75	**14.20**
Viber	44	76	56	**25.00**
Twitter	39	91	46	**22.16**
Skype	31	94	51	**17.61**
Google Play Store	71	55	50	**40.34**
Google Drive	28	84	64	**15.91**

Figure 7 shows the proportion of use of each application. WhatsApp, Facebook and Google Play Store are the mostly used applications respectively. The least used applications are Dropbox, Google Drive, and Skype respectively;

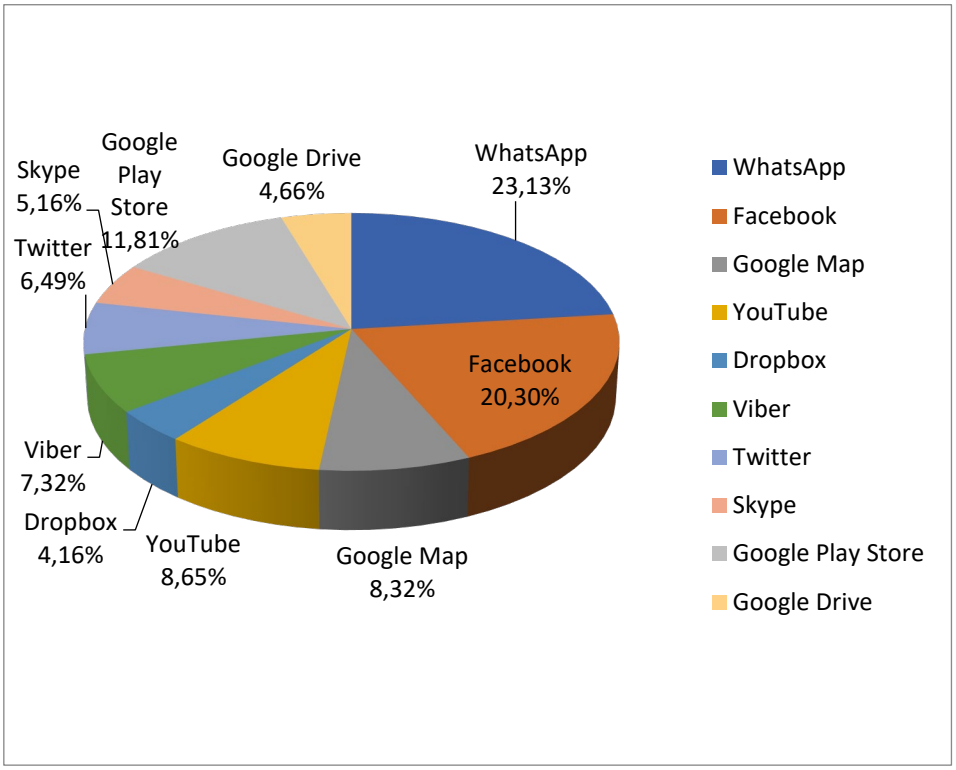

Figure 7 Proportion of use of each application

3.3 – Mobile technologies

EcoCash is the dominant mobile money payment system accounting for 77.24% of the participants. Eight point one three percent (8.13%) of the participants are not using mobile money payment systems. Eight point nine four percent (8.94%) of the participants are using more than one mobile money payment platform.

MCNs using mobile money payments systems access their accounts mostly on a monthly basis (53.25%) and as-needed basis (18.80%) or on a daily basis (17.95%). The average frequency of accessing mobile money payment accounts is 2.71 with a standard deviation of 1.018, implying that the MCNs access their accounts on at least once per fortnight and the frequency of accessing differ significantly as per hospital.

In summary, 92.12% of MCNs have access to the Internet using their mobile phones (smartphones). The phone brands mainly used are Samsung (39.08%) and Nokia (26.44%). In carrying out clinical processes MCNs prefer the use of laptops (46.24%) and mobile tablets (31.21%). Social networking applications mainly being used are WhatsApp (78.98%) and Facebook (69.32%). Approximately 91.87% of MCNs are using mobile money payment systems (USSD platform) with Econet Wireless Zimbabwe dominating the market. Access to mobile money accounts is generally done approximately fortnightly basis.

4. Discussion

The results presented in section 3, indicated that MCNs are already using mobile devices which conforms with the notion that users of mobile devices who can manage their own applications are more likely to adopt and use mobile device services [23]. In Zimbabwe 92.12% of MCNs access the Internet. MCNs who access the Internet at home are the majority (38.79%). The concept of Internet access by MCNs might not have been explored in previous studies on Zimbabwe since POTRAZ reports focus on mobile and Internet penetration at national level [1]. Mobile Health solutions can be accessed both online and offline since the majority of MCNs use the Internet. Furthermore, the majority of maternal care nurses (79.64%) access the Internet using mobile phones Offline applications can be supported through the use of the USSD platform since it utilises signalling channels [24]. The EcoCash platform dominates the market (see Section 3.3) [1], which coincides with results from section 3 thus Econet subscriber identification module (SIM) cards might be preferred for use by MCNs to access health records using USSD codes. The absolute proportion of 6.67% represents MCNs who access the Internet at their workplaces; thus most MCNs do not have access to Internet facilities in their wards and might not be using healthcare applications which could be connected to the Internet.

On average, a mobile phone is being frequently used by healthcare workers who use more than one device to access the Internet with a mean of 63.50833. This is followed by a mobile tablet with a mean of 45.07895 Smartphones constitute 70.63% of the mobile devices used, thus android smartphone applications can be rolled out while being customised to ensure interoperability with existing eHealth systems such as EHRs [25]. This proportion is directly related to the 2014 statistics that 76% of the US physicians were using smartphones and mobile tablets [26]. To ensure security and interoperability compliance with existing systems, MCNs should be provided with mobile devices at their work places.

Mobile healthcare applications to be developed or adopted must comply with the Android operating system since Samsung devices constitute 39.08% of mobile device ownership among MCNs. Also the Samsung smartphone market share was the highest in Zimbabwe by the second quarter of 2016 with a stake of 22.3% and the Android operating software leads the global market share by 87.8% which complies with the results of mobile device ownership by MCNs. Approximately half (46.24%) of the healthcare workers prefer using a laptop in carrying out clinical care processes. This is followed by the use of a mobile tablet (31.21%) and smartphones (22.54%) (see section 5.3.4.3.3). Laptops may not be ideal in carrying out daily routine activities, since MCNs are mobile and usually they must be by the patients' bedsides during clinical care. The mobile devices used must be sterilised routinely to avoid infectious diseases since MCNs get in contact with patients. It is ideal that mobile tablets with SIM card slots and smartphones are used during point of care since these mobile devices allow the clinician to input data and update patient charts while focusing more on the patient, and less on the computer. Mobile devices with SIM card slots support Internet connection using mobile data. Studies show that patients respond favourably to their clinicians when using a mobile tablet during consultation rather than when they are using desktop or laptop computers [27]. The next section focuses on non-healthcare applications used by MCNs.

Non-healthcare applications which can be used for communication and collaboration among MCNs and patients [28]. Each patient profile from the groups can be integrated into silos for decision making. These silos can be linked into EHRs at a later stage. Social media is an

important platform to communicate with patients even though they can pose a threat to health information security. Educational content can be shared across social media to inform patients about health related issues. Twenty-three point one three percent (23.13%) of MCNs use WhatsApp, while Facebook accounts for 20.30%, Google Maps 8.32% and Google Play Store 11.81%. In general, Facebook and WhatsApp can be used for communication, Google Maps for geolocation applications when authenticating MCNs and Google Play Store might prove proficiency of MCNs in installing applications on Android mobile devices. MCNs need to be trained on how to manage Google Play Store which supports installation of mobile applications including applications which might be used for pre-authorisation to access health applicatins. Non–healthcare mobile applications can be used to improve communication among stakeholders such as MCNs and patients as these applications allow processing, storage, integration, modelling and presentation of information [29]. The Google Maps Geolocation API returns a location and accuracy radius based on information about cell towers and WiFi nodes that the mobile client can detect hence it can be used to locate a healthcare provider or facility closest to the patient (it supports modelling and presentation) [30]. Applications which can be used for communication with respect to frequency of use are WhatsApp, Facebook, YouTube, Viber, Twitter and Skype. Dropbox and Google Drive can be used for storage purposes. Proficiency in use of Google Play Store might measure the aptitude of use and management of Android mobile devices applications. The applications can be complemented through the use of Unstructured Supplementary Service Data (USSD). The implementation of USSD technology for use in healthcare can be done using any mobile operator since the SIM cards and mobile devices will be owned by the hospitals. Nevertheless, NetOne which is the second largest mobile operator in Zimbabwe can be preferentially used as a cost-cutting measure since it is government owned. NetOne is already in partnership with NCCH in provision of mobile solutions. The Econet Wireless Zimbabwe mobile operator platform would be ideal if MCNs were to bring their own devices since EcoCash is the dominant mobile money payment system accounting for 77.24% usage amongst participants while its mobile subscriber market share was around 51.6%. An USSD platform supports interaction of MCNs with patients at a relatively low cost [22]. The access of mobile money payment accounts can be used to measure the MCNs' aptitude in using USSD codes and this shows that they can easily interact with patients using the USSD platform [22].

5. Conclusion

This research adds to the existing body of literature since there were no known researches (at the time of this study) in Zimbabwe which focused on mobile devices and mobile health applications being used and their elements and or preferences by MCNs. Elements of mobile phones, such as the USSD facility, and healthcare applications supported by mobile devices were identified and these can be applied in the development of a mobile health framework to improve maternity care nurses' work processes. The findings can result in a successful model in improving healthcare workers' work processes through a mobile health framework. In further research the framework will need to be implemented and evaluated.

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Design Theory for a Persuasive Mobile Application: A Case of Increasing Willingness to Participate in Reducing Theft of Electricity in Kampala

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ABSTRACT Electricity theft is a challenge for electricity utility companies world over, most especially for developing countries. Given that electricity theft is a behavioral and morality problem, lasting solutions lie in behavior change strategies. A recent behavior change strategy is the utilization of persuasive technology. Persuasive technologies are designed to change attitudes and behavior. However, persuasive technology design methods lack methods and tools for prescribing requirements and design features. We address this limitation by use of a design theory. In this paper we explain application of a design theory for a persuasive mobile application to motivate the general public in fighting electricity theft. The design theory comprises of requirements, design features and kernel theories for the proposed application.

Keywords: Persuasive technology, Design theory, Electricity theft, Mobile application

1. Introduction

Electricity utility companies world over are grappling with the issue of electricity theft. Umeme, the largest electricity distribution company in Uganda, lost $30 million in 2016 due to electricity theft [1]. Sustainable and cost efficient efforts to reduce electricity theft rely on honest electricity consumers [2]. Electricity consumers are in a position to know culprits, and by their peer pressure, positively influence these culprits [2]. In light of this, Umeme periodically carries out mass media campaigns to encourage the public to fight electricity theft. However, a study carried out six months after such a campaign revealed that 50% of participants were not willing to engage in electricity theft reduction efforts [3].

In this paper, we demonstrate the potential of persuasive technologies (PT) to convince consumers to participate in fighting electricity theft. Persuasive technologies are interactive computing technologies designed to change people's attitudes or behavior [4]. Unlike public campaigns, persuasive technologies can be tailored, are ubiquitous and offer anonymity. In addition, persuasive technologies like Web 2.0 websites and mobile applications make it possible to get feedback from users who in this case are consumers.

Fogg [5] describes an eight step process for the development of persuasive technology. However, Fogg's steps do not cover definition of requirements and design features [5]. In this paper we address this limitation by use of a design theory.

In general terms, a theory refers to a network of interrelated causal principle(s) that explains and /or predicts a certain phenomenon [6]. An Information System (IS) design theory explains the existence of components of a system and how these components relate [7]. IS design theories are different from natural science theories in that they are not explanations for phenomenon, but are prescriptions of solutions that form the basis of designing a system [8].

A design theory makes the development process transparent, and ensures that knowledge is transferable [9]. Components of a design theory include: *requirements*, which describe the class of goals to which the theory applies; *kernel theories*, i.e. theories from natural or social sciences governing design requirements; *design features* which are attributes that meet the requirements; and a *design method*, a description of procedures for the artefact construction [7], [10].We developed a design theory made up of requirements, kernel theory, design features and design method. The rest of this paper is organized as follows: Section 2 discusses our approach to design theory development, and Section 3 presents components of the design theory. We discuss the theory in Section 4 and conclude in Section 5.

2. Design theory development approach

There are three types of reasoning required in theorising: deductive, inductive and abductive [11]. Deductive theorizing involves drawing a conclusion from a general premise, while inductive theorizing involves drawing a conclusion from specific instances [11]. On the other hand, abductive reasoning involves deriving a possible conclusion in terms of what can be possibly true [11].

Walls *et al* [7] and Vaishani & Keucher [12] used deductive reasoning to propose design theories heavily dependent on kernel theories. Goldkuhl and Cronholm [13] combined both inductive and deductive reasoning to propose a Multi grounded theory (MGT) design theory. Beck *et al* [14] embedded grounded theory into Kuechler and Vaishani's framework [15] to propose a theory generating framework that uses slices of information from both knowledge base and environment to meet both problem solving and knowledge generation requirements of design science research. Patas *et al* [16] proposed an IS design science framework that is strongly empirically grounded. We could not use these empirically based design theorizing processes because they do not clearly map their output to design theory components as defined by Walls *et al* [7].

On the other hand, Walls *et al'*s process requires established kernel theories, such as those explaining non participation in electricity theft reduction, which were unknown in this case. In their absence, it would be impractical to start our theorizing process from natural science kernel theories. In order to identify relevant theories we needed empirical data. We therefore borrow the concept of slices of data as used in Beck *et al*'s [14] grounded theorizing process. These slices of data, which are empirical data and kernel theories, are used to come up with requirements, design features and design method as shown in Figure 1.

3. Components of design theory

3.1 – Requirements

A survey was carried out to understand factors that motivate people to steal electricity in Kampala, Uganda, how it is done and responses to electricity theft. As part of the survey electricity consumers in Kampala were asked: "What would you do if you found your neighbour stealing electricity?" [3]. The responses included; "report to the utility", "tell my neighbour stop", "ask them to show me how to do it", and "nothing". The reasons given for unwillingness to reduce electricity theft were classified under the following themes:

- Individualism: People do not want to be bothered.
- Utility: They feel it is the utility's job to fight electricity theft.
- Financial sympathy: They appreciated the culprit's economic struggles.
- Safety first: These would only take action if their safety was threatened.
- Ignorance: These did not know where to report, or what to do, or the reward for reporting.
- Relationship: These valued their relationship, so they did not want to make enemies.
- Self-preservation: These felt that if they reported others, they too would be reported.
- No reward: These felt there was no benefit from reducing electricity theft.
- Hopeless: These felt it was useless to take any action.

Kernel theories that explain each of these themes were identified. These included Maslow's motivation theory [17], Triandis theory on values, attitudes, and interpersonal behavior [18], social exchange theory [19], Motivation-Opportunity-Ability (MOA) [20] and Vroom's expectancy theory [21]. Having grounded the data in existing knowledge, we abductively derived requirements (R1) / goals for the persuasive technology to counteract each reason from empirical findings. The empirical findings, kernel theories and requirements are shown in Table 1. The code R1_n is used to show requirements based on empirical data and kernel theories. In addition, Oinas-Kukkonen and Harjumaa [22], proposed four general requirements for persuasive technologies (PT) in their persuasive systems design (PSD) model. These made up the R2 requirements. They are shown in Table 2.

Table 1: Requirements from empirical data and Kernel theories

Theme	**Explanatory theory**	**code**	**Requirements**
Individualism	Maslow's theory [17]: Presence of electricity theft does not affect any need so there is no reason for concern.	R1_1	The technology should ensure that the public owns the problem.
		R1_2	The technology should cause a user to appreciate the financial impact of electricity theft to each individual.
Utility	Triandis theory of interpersonal behaviour [18]:	R1_3	The technology should let consumers know their role.

	They do not view fighting electricity theft as their role.		
Safety first	Maslow's theory: People need to feel safe.	R1_4	The technology should ensure that user appreciates dangers of theft.
Ignorance	MOA [20]: Lack of appropriate information limits their ability to act.	R1_5	The technology should educate consumers appropriately.
Relationship	Triandis theory of interpersonal behaviour: They evaluate the outcome of reporting as negative.	R1_6	The technology should assure anonymous action.
No reward	Vroom's expectancy theory [21]: People are motivated if they see a connection between their effort, performance and reward.	R1_7	The technology should have a reward mechanism.
		R1_8	The rewards should be communicated.
		R1_9	The technology should be easy to use.
Hopeless	Vroom's expectancy theory: People are motivated if they see a connection between their effort, performance and reward.	R1_10	The technology should show people positive impact of their effort.

Table 2: Requirements for persuasiveness [5]

	Requirement for persuasiveness
R2_1	Primary task support: The technology should facilitate execution of the target behaviors.
R2_2	Dialogue support: The technology should offer feedback in guiding the user to reach the intended behavior.
R2_3	System credibility support: The technology should have features that enhance its credibility.
R2_4	Social support: The technology should leverage influence of society on behaviour

Figure 1 explains the process of theory development based on general requirements for persuasive technologies and those from the survey.

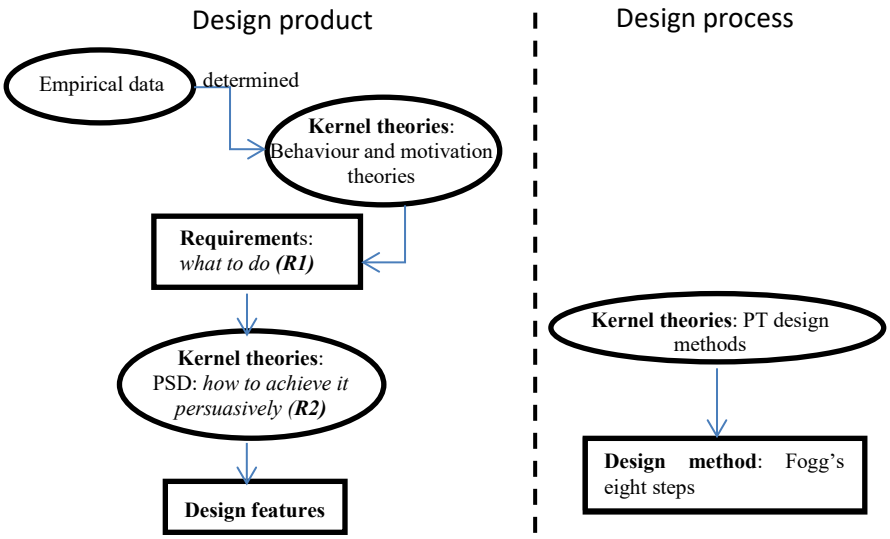


Figure 1: Design theory development approach based on [8]

3.2 – Design features

We analyzed the R1 and R2 requirements; combining those with similar meaning, and those which complement one another, and developed a comprehensive list of requirements used in Table 3.

We proposed design features for each requirement based on persuasive systems design PSD's persuasive techniques [22].These persuasive features include: *reduction*-which involves making a certain task easier to do; tailoring-providing user appropriate information; *notification*- providing users with feedback about other users actions; and *rewards* - proving users with a reward (in this case points) and appreciation after they report electricity theft to the service provider. These design features and the requirements they support are shown in Table 3.

Table 3: Requirements and design features

code	Requirement	Design features
R1_1	The technology should ensure that the public owns the problem.	Tailoring
R2_2	The technology should cause a user to appreciate the financial impact of electricity theft to each individual.	Tailoring of information about cost of electricity theft to consumers
R1_4	The technology should ensure that user appreciates dangers of theft.	Tailoring of accident information
R1_5	The technology should educate consumers appropriately.	

R1_6	The technology should assure anonymous action.	User accounts have account numbers not names
R1_7	The technology should have a reward mechanism.	Awarding points
R1_8	The rewards should be communicated.	Notification
R1_9	The technology should be easy to use.	
R1_10	The technology should show people positive impact of their effort.	Tailoring and notification
R2_1	The technology should facilitate execution of the target behaviours.	Reduction
R2_2	The technology should offer feedback in guiding the user to reach the intended behavior.	Appreciation
R2_3	The technology should have features that enhance its surface credibility.	Brand colour of the utility company

3.3 – Design Method

In order to design and develop the technology with above features, Fogg's eight steps of persuasive development were adapted. The first step was to select an appropriate behavior for change, followed by selecting appropriate audience for the technology. Thirdly, we found out why people are not performing the target behavior through a survey. We then selected mobile technology to implement the features. The application was developed using Android with a PHP website in the backend.

4. Discussion

4.1 – Related work

Developing artifacts through design theory is a rigorous method that results in transparent artifacts [9]. Design theories have been used by Carlsson *et al* for IS integration management systems [23], web based education systems [24], and hedonic systems[25]. However, literature on design theory for persuasive technology is scanty. Most persuasive technologies design is based on persuasive system design model [26]. However due to weaknesses in PSD [27] we used design theory.

We modified Wall's design theory process by applying the concept of slices of data from the grounded theory approach. We combined empirical data with behaviour theories to derive requirements of the application. This combination of empirical data and behavioral theories delivers a theory that is both relevant and rigorous.

4.2 – Requirements

According to Maslow's needs theory [17], humans are motivated by a desire to satisfy five needs, namely: physiological, safety, social, esteem and self-actualization. The PT utilizes

tailoring to communicate the financial implication of electricity theft to consumers which obviously negatively impacts on their capacity to meet their needs.

Tailoring ensures that information meets the "potential needs, interests, personality, usage context, of users" [5]. In this design theory, tailoring is used to achieve four requirements; R1_1, R1_2 R1_4, and R1_10 (refer to Table 3 for details). Possible information to be tailored includes information about the economic loss incurred due to electricity theft and information on electricity theft related accidents like deaths and fires.

Vroom's expectancy theory [21] posits that people are motivated if they see a connection between their effort, performance and reward. This is achieved through tailoring and reward design features. Tailoring presents information on amount of electricity lost per district can be related to participation in electricity theft reduction. The utility company usually rewards people for reporting electricity theft, however this is also implemented in the mobile application as points awarded for reporting electricity theft.

Leveraging peer pressure is important in achieving persuasion. This can be done through notification. Notification involves informing people within a neighborhood of efforts that are being undertaken by other people to reduce electricity theft. This has potential to increase willingness to participate since according to the social proof theory [24], "individuals are more likely to engage in behaviors which they perceive others are also engaged in".

Reduction involves making target behavior simpler to perform. People normally report electricity theft by calling on a toll-free line and they are asked for details of the incident. The process can be made simpler by providing an option for uploading images and a map for entering location of the event. In addition, reporting should be done anonymously to ensure that people can report comfortably.

Requirements R1_5 and R1_9 could not be mapped to an existing persuasive feature but would be implemented while developing the application.

4.3 –Development

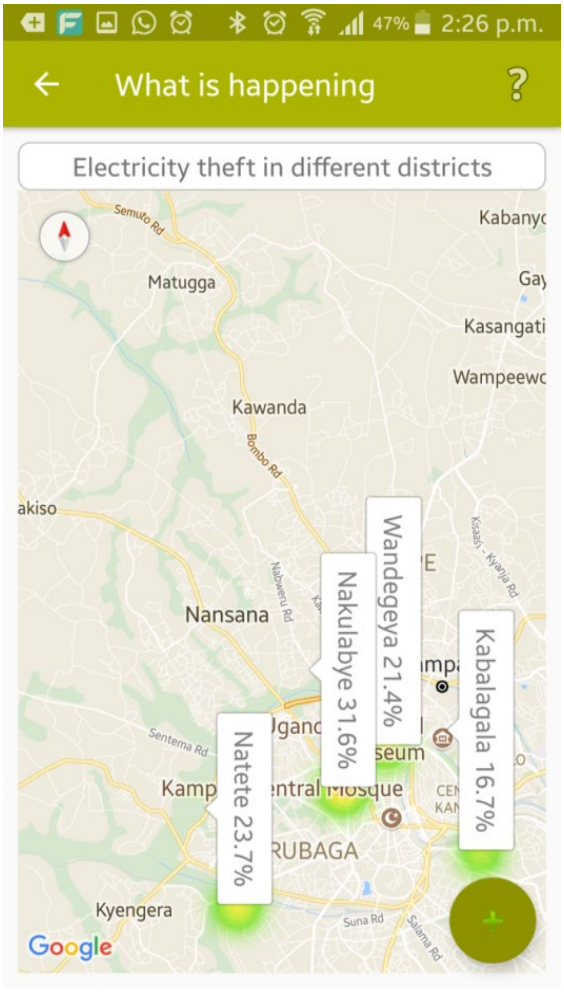
The mobile application called "*Faayo*" which means "be concerned or care", in Luganda, the most widely spoken language in Uganda". Its design uses brand colours of the electricity utility company, Umeme. It also has a slider that informs users of dangers of electricity theft and how to respond to electricity theft.

The persuasive information provided in *Faayo* includes: amount of electricity lost per district in Uganda (Figure 2), number of electricity accidents and location, people participating in electricity theft reduction, people rewarded for reporting electricity theft, financial losses incurred by individual consumers and the Utility's efforts to reduce internal corruption. This information is provided using Google maps and a bar graph.

Faayo's target behavior is reporting electricity theft. The application gives users an opportunity to report cases of electricity theft, vandalism, and electricity theft related deaths and fires. When reporting these cases, the user's location is automatically recorded by the application and a specified map is provided so that the user can select another location. After a user reports, he/she is automatically thanked and awarded free electricity units/points by the application. These points are aggregated to show most active area(s). Additionally, whenever someone

reports electricity theft or is rewarded for it, other users in their location are notified. Figure 2 shows the home screen of *Faayo*.

A: Welcome screen



B: Electricity loss map

Figure 2: Welcome screens of Faayo and one of the Google maps

The application is available on www.faayo.net.

5. Conclusion and Future work

Persuasive technologies (PTs) are a promising method for transforming attitudes and behaviors of people towards a desired behavior/action. Persuasive technology design methods have weaknesses that could be overcome using a design theory. In this paper we applied a grounded design theory to propose requirements, design features and design method for a persuasive technology aimed at increasing willingness to fight electricity theft in Kampala, Uganda. This theory was used to guide the development of mobile application called, "*Faayo*". In the near future, *Faayo* will be evaluated with three types of participants; employees of the utility company, psychology experts from Makerere University and electricity consumers that will be purposively selected. The mixed methods approach combining both qualitative and quantitative data collection methods will be used. These will include face-to-face interviews, a survey

questionnaire and experimentation. We will evaluate *Faayo*'s for persuasive potential and discover new features.

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The Impact of Smart Phones on the Students' Learning Experience in Higher Education Institutions in South Africa

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ABSTRACT The enhancement in smart phone functionality has created exceptional opportunities for learning and teaching enabling smart phones to play a vital supportive role in enriching students' learning experience. This study investigates the impact of smart phones on students learning experience in South Africa based on findings from one South African university's first year students. We found that students are mainly using smart phones to support their learning, but it is important to note that the use of smart phones hasn't yielded the same level of satisfaction for all students. Further analysis indicates that smart phones generally enhance student's learning experience but there is need to consider the hinderances and issues that stand in the way of students getting optimal returns from these devices.

Keywords: Smartphone, Learning experience, M-Learning, Impact of smartphones, Higher Education, South Africa

1. Introduction

Traditionally, lectures occur in a face to face manner, where by the lecturer teaches and the students must be physically available to interact and learn in the process. Smartphones can greatly enrich this process since they are mobile (Elfeky & Yakoub, 2016). The constantly changing smartphone functionality has significantly changed the ways students learn and communicate with their instructors. This transformation in student learning experience is the central concern of this research.

The purpose of this study is to investigate the impact of smartphones on the students' learning experience in higher learning institutions in South Africa. This research bases on the sample of first year students at a top-ranked South Africa university, namely the University of Cape Town to investigate the impact that smartphones have on students' learning experience. The researcher uses a positivist approach and is guided by a conceptual framework derived after borrowing concepts from Delone and McLean's information systems success model (Delone & Mclean, 2003; discussed in section 2.3).

Universities and individual students have many questions that require evidence based responses. They want to know, how do smartphones impact their learning experience? Is there any significant benefits for intergrating these devices in their learning process and if so, why? The specific sub-objectives of the study are

1. to assess the issues or hindrances that arise as students use their smartphones to study;
2. to describe the outcomes or effects resulting from smart phone usage for studying (i.e. receiving and delivering academic content); and
3. to examine the user satisfaction gained by students as they use their smart phones for learning.

The findings from this research should show how students use smartphones to optimise and enrich their learning experience. It also highlights considerations and concerns about smartphone use during and after lectures. The findings from this research are valuable to the decision makers and stake holders of higher institutions of learning as they could be used as a basis for making informed decisions with regard to smartphone use and regulation. The framework used in this paper borrows concepts from the Information Systems (IS) success model.

2. Literature Review

2.1 – Context

While investigating the changing trends of mobile phone adoption and internet usage in South Africa, Brown points out that "*67% of the SA population owns a cell phone*" and that student cell phone ownership was as high as 98.5% (Czerniewicz & Brown, 2010, p. 862). Smart phones enables collaboration between learners and teachers anywhere, anytime (Keengwe & Bhargava, 2013) but are also increasingly causing sleep deprivation and attention deficits to students among other notable effects (Kuznekoff & Titsworth, 2013). According to Kuznekoff and Titsworth (2013), "*given the many possible ways that digital communication tools [like smartphones] will continue to influence practices of teaching and learning, scholars should enact research to understand how these tools impact classroom communication and subsequent learning outcomes*" (Kuznekoff and Titsworth, 2013, p. 234).

2.2 – Definition of mobile learning

It is becoming increasingly hard to fully define mobile learning (m-Learning) since mobile learning platforms are undergoing a rapid and continuous transformation as new technologies are being developed. As a result, scholars have defined mobile learning differently but they do agree on what it involves/entails. To qualify as mobile learning, the process must involve two critical concepts i.e. Mobility and learning. Ozdamli and Cavus (2011) define mobile learning as a model which allows learners to obtain learning material from anywhere at any time using mobile technologies and the internet. It can be simplified as "*learning that is supported through any mobile device/s and is accessible from anywhere and anytime*" (Keengwe & Bhargava, 2013, p. 674).

Regardless of the various definitions, there are certain key concepts or qualities that cut across these definitions. The first one is mobility, meaning that students are free to move within and beyond and the second is the use of portable or mobile devices. It is important to realise that m-Learning encompasses learning within the traditional classroom setting as well as the possibility of formal or informal education outside the traditional classroom facilitated by any of the possible mobile devices like smartphones (Alrasheedi, 2015). In our study, we define M-learning as "*learning, i.e. obtaining knowledge or skill, by means of mobile technology, regardless of place or time*."

Enhanced mart phone functionality has enabled smartphones to play a vital supportive role in enriching students' learning experience and thus smart phones have become part of student lives (Gloria, 2016). Students use smart phones to perform activities such as sending text messages, calling, chatting, opening documents, checking e-mails, browsing internet and downloading files (Alson & Misagal, 2016).

2.3 – Benefits and Challenges of Mobile Learning

Learners use smartphones to access up-to-date and relevant educational resources and they also enable students to communicate with experts in the field of their studies so that they gain more insight and enrich their learning (Ally & Prieto-Blázquez, 2014). Domingo and Garganté (2016) also reveal that providing access to information and increasing engagement while learning are the two main impacts of mobile technology in the classroom. Martin and Ertzberger (2013) point out that "*a mobile-based learning environment, by virtue of its portability, will provide scaffolding when and where students need it whether in the classroom or investigating in the field*" (p. 78). This was also pointed out by (Mbogo, Blake & Suleman, 2014). Obviously, mobile learning provides a range of opportunities and a certain level of flexibility to students.

Much as continuous connection to resources is good for the learner, Güliz Uğur and Koç (2015) warn that this use of smartphones during class creates a negative impression towards the lectures or instructors. Rather than enriching the learner's education, continuous use of smartphone during class might ends up destroying the student's reputation towards the lecturer. Some lecturers consider phone use disrespectful especially when it occurs during lectures (Güliz Uğur & Koç, 2015). From their research on misuse of mobile technology, they found that "*about 40% of the students indicated that they used their phones during class*" (Güliz Uğur & Koç, 2015, p. 59), and this activity interrupted about 85% of their colleagues. Their article emphasises the fact that smartphone use causes loss of attention to students during studies. Students interacting with their phones tend to miss out on what is being taught. The use of smart phones during class to receive calls, text or notification does not only affect the recipient or user but also those around him or her.

Smart phones are expected to play a supportive role in the learning process. Providing variety of resources in different formats that can be conveniently accessed by the students. Some scholars on the other hand report that student use smart phones for academically unrelated endevors e.g. to play games and other things that are unrelated to their studies. Martin and Ertzberger (2013) claim that "*a third of college students in the U.S. play video games on their mobile phones during class*" (p.58). This undermines the supportive role of smart phones in the learning process.

Keengwe and Bhargava (2013) stress the value of texting or instant messaging which is one of the celebrated functionalities of smart phones. They argue that this is one effective way of sharing ideas and gaining insight for the learners. "Knowledge develops through interactions among human beings and these social interactions lead to knowledge transformation" (Keengwe & Bhargava, 2013, p. 744). Kuznekoff and Titsworth (2013) on ther other hand believe that texting during classes is an interference to learning. While studying the impact of phone usage on students during class, they found out that "*64% of teens who own cell phones have texted during class, even in schools where cell phones are technically banned*" (Kuznekoff & Titsworth, 2013). According to Kuznekoff and Titsworth (2013), these "texts

potentially come at the expense of learning, as texting during class reduces students' ability to self-regulate and give sustained attention to classroom tasks" (p. 234). Besides the challenges posed to learning, "*classroom texting/posting produces negative consequences for students and instructors*" (Kuznekoff & Titsworth, 2013, p. 236).

In summary, it is important to understand that smartphones provide the means for students to access and disseminate information rapidly in a very timely and convenient way. This is why they can greatly enhance the learning process but if their use is not carefully regulated, they can compromise learning. "*Students are spending time texting, they are not paying attention in class*" (Guliz Ugur & Koc, 2015, p. 1024). It is therefore crucial for students to take required steps and ensure that their use of smart phones supplements their learning experience.

2.4 – A Conceptual Framework for Mobile Learning

The continually evolving concepts in m-Learning, related to both technology and communication networking, makes research into m-Learning challenging in every aspect including evaluation (Alrasheedi, 2015). In order to overcome the challenges of evaluation, contextualised tools and frameworks need to be developed. "*Presently, researchers in this field borrow frameworks and tools from other areas based on their similarities*" (Alrasheedi, 2015, p. 2). For this study, the researcher borrows and customises concepts from Holsapple and Lee-Post's e-learning success model developed based on DeLone and McLean's information systems (IS) success model. The IS success model was originally developed by DeLone and McLean in 1992 and modified later in further work in 1992, 2003 and 2004 (DeLone & McLean, 1992, 2003, 2004). Ultimately, Holsapple and Lee-Post (2006) approached assessing e-learning from an IS perspective. They developed a model that grounds on both of DeLone and McLean's model versions.

Holsapple and Lee-Post (2006) combined in the model the system development phases and introduced a modified e-learning success model. The measures in their model are mostly adjectives that describe the system. The developed model is divided in three phases explaining the IS development phases: 'System design', 'System delivery' and 'System outcome' (Holsapple & Lee-Post, 2006). In this paper, the model is contextualised and used as a descriptive tool in evaluating the impact of mobile learning on students' learning experience. Contrary to earlier use of the model in e-learning systems, this study focuses on examining how mobile learning (smart phone learning in particular) impact students' learning experience in higher education.

We eliminated the system design option/consideration since the research does not comprise of designing a system to be used in mobile learning. The concept this paper borrows are those pertaining to system delivery and outcome. In the e-learning success model, system delivery is comprised of use and user satisfaction. The model also includes outcomes which are the success metrics. These concepts and ideas are applied in this research to derive a model developed specifically for m-learning in the context of this investigation. The framework proposes that the overall impact of m-learning initiatives depends on the interplay between device use, arising issues, outcomes and the satisfaction resulting from smartphone use. These relationships are depicted in figure 1.

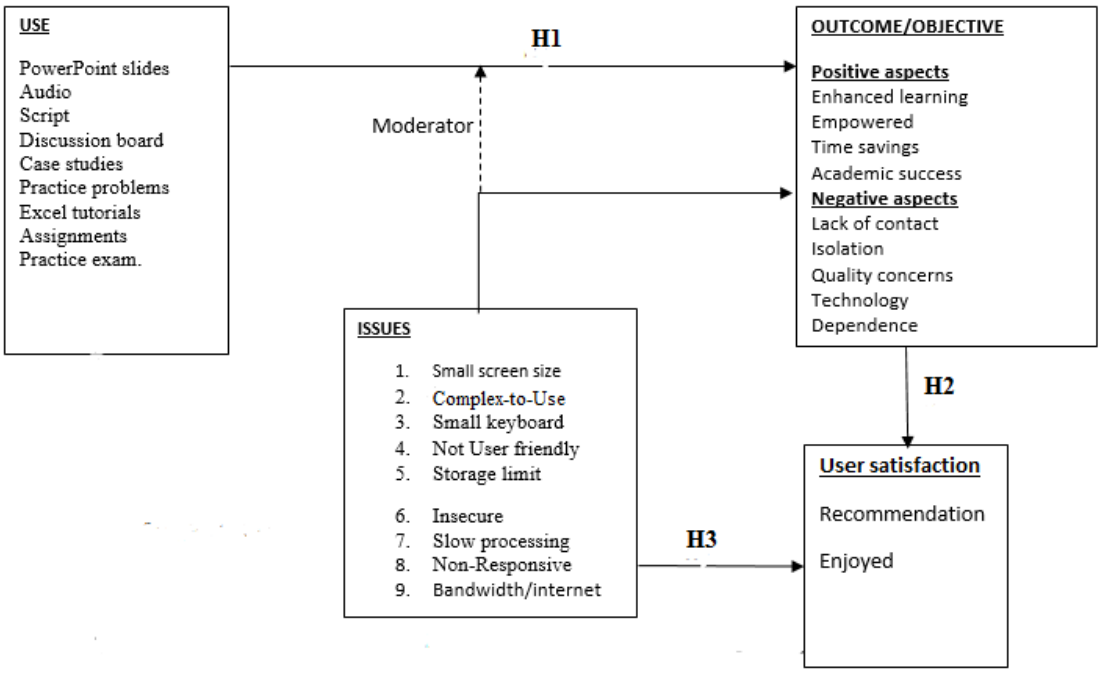

Figure 1: Conceptual framework for mobile learning based on Holsapple & Lee-Post's e-learning success model (2006)

3. Research methodology

This research adopted a positivist paradigm since only observable and measurable phenomena was considered to provide credible data that could constitute acceptable knowledge (Wahyuni, 2012). This research employs a mainly quantitative approach and used a survey to collect data. The study adopted a deductive approach as it was guided by the selected research framework. The University of Cape Town (UCT) was used as the case study, both because of convenience (it is the authors' university) but also because it is one of the leading universities in South Africa with a mature and sophisticated technical and teaching infrastructure. Thus, what transpires at UCT can be hypothesized to eventually happen at other South African universities as well. First year students at this university comprised the target population, given that they are likely to have spent the most of their life with mobile phone technology but also to ensure homogeneity in the sample. The questionnaire incorporated test items (questions) based on the conceptual framework, testing only the three most important relationships between the four core variables. The complete instrument is available from the authors on request.

Since questionnaires were the main data collection method for this study, there was a risk of none response or leaving the questions partially answered. As a matter of fact, some questionnaires were submitted with partial responses and therefore could not be considered to qualify for the research. This caused the respondents to reduce from 117 to 98 after data cleaning. The researchers obtained a formal ethics approval from the University of Cape Town Ethics Committee, Respondents were informed about what the research entails and it was made clear that they were participating voluntarily and could pull out at any time they feelt like. The research did not require participants to be personally identified ensuring that confidentiality and privacy were enforced.

4. Research Findings, Analysis AND Discussion

4.1 – Descriptive Statistics

The majority of the respondents were females comprising of 65 out of 98 and representing 66% of the study population. This was followed by males representing 31% and the remaining 3% comprised of those respondents that preferred not to disclose their gender. All but one respondent owned a smart phone; this confirms the claims that have been made by various scholars concerning the high ownership of smart phones by university students: Among the biggest complaints encountered in regard to using the smart phone for studying is the hinderance caused by the small screen size. This is not surprising given the fact that 32 students representing 37% of the sample have phones with screens between 4 to 5 inches. Those that are not sure of their phone screen size and those with phones screens larger than 5 inches have an almost equal representation of 31% and 30% respectively. There are only two students representing 2% with phone screen size less than 4 inches.

4.2 – Frequency of use

The use patterns of the various applications (Figure 2) reveal that there is a relatively high smartphone use by students. This is in line with Kuznekoff and Titsworth (2013)'s argument that "instructors face many challenges as they compete for students' attention among a variety of communication stimuli". In the same way, Ally and Prieto-Blázquez (2014) acknowledge that students are intensively engaged on their smartphones but defends this by pointing out that that learners depend the wireless capability of smartphones to access up-to-date and relevant educational resources.

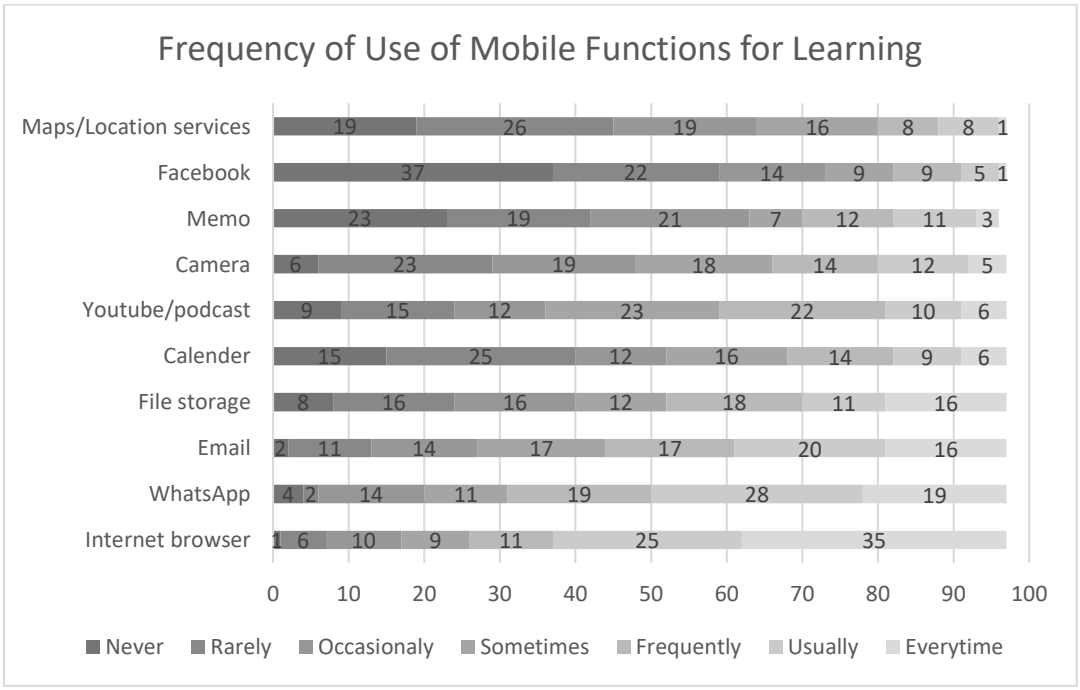

Figure 2: Frequency of use of mobile phone functionality for learning

From the above results, Facebook has the lowest rating for studying. A large number of 37 respondents indicated that they never use facebook for learning. Only a small portion of 5

student usually use this platform. Students might be using Facebook a lot for other purposes but since they do not consider these to fall in the scope of learning, they had to rate it low.

The data suggests that the highest used application is the **internet browser**. To double check this response, students were asked which of the above-mentioned applications is most important to your learning and the largest response was internet browser. This is probably because the internet browser provides a platform for student to find academic resources from various sources. **WhatsApp** also had an impressive mean rating of 5 out of 7. This indicates that students significantly engage in learning on this platform (e.g. they create class and smaller study groups). Given this high rating, it is reasonable to understand why Kuznekoff and Titsworth (2013) argue that students predominantly use their smartphones for texting. **Email** and **file storage** both had 16 respondents indicating that they use them every time. The general usage rating for these two applications is relatively high. This could be because Email communication is one of the primary communication channels at the University of Cape Town. Also, file storage is a key functionality.

4.3 – Positive and Negative Outcomes

The literature review adequately discussed the challenges and benefits of smartphone use. The challenges were reflected by the negative outcomes while the positive outcomes portrayed the positive outcomes.

The responses regarding ***positive outcomes*** reveals some interesting trends (Figure 3). Students generally agree that smartphones provide a range of benefits that contribute to their learning experience. As Domingo and Garganté (2016) reveal, these positive outcomes include providing access to information and increasing engagement while learning.

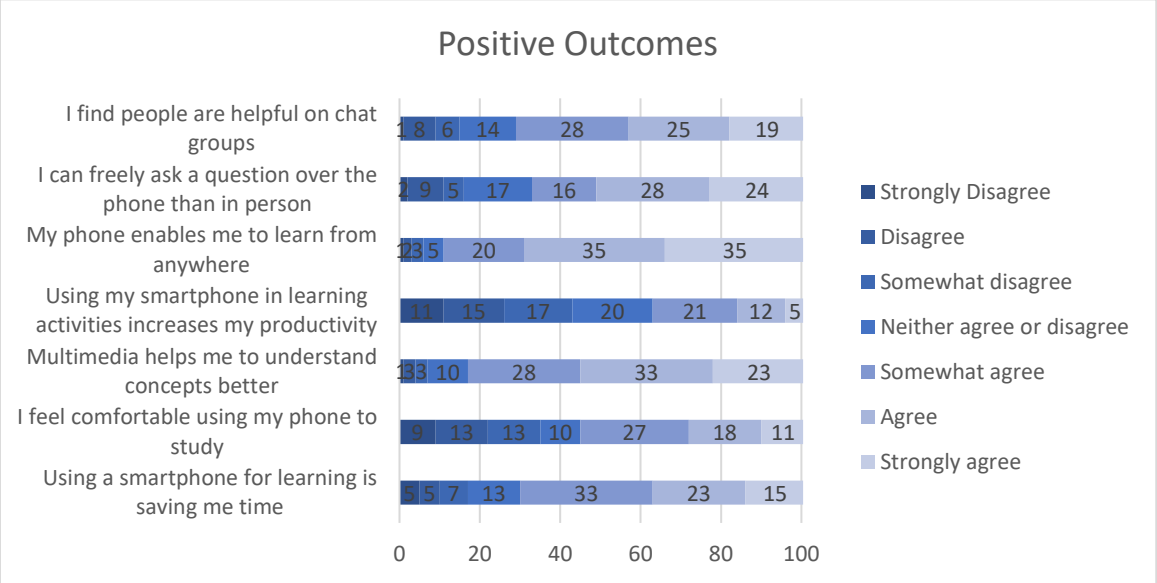

Figure 3: Postive Outcomes from phone use for learning

When respondents are asked if their phone enables them to learn from anywhere, the majority of the respondents are in total agreement. This reflection supports Martin and Ertzberger (2013) who claim that by nature of their portability, smartphones provide information "*when and where students need it whether in the classroom or investigating in the field*".

The general responses regarding (actual or possible) ***negative outcomes*** presented in Figure 4 reflect that a slight majority of the respondents strongly acknowledge the existence of negative outcomes while using their smart phones.

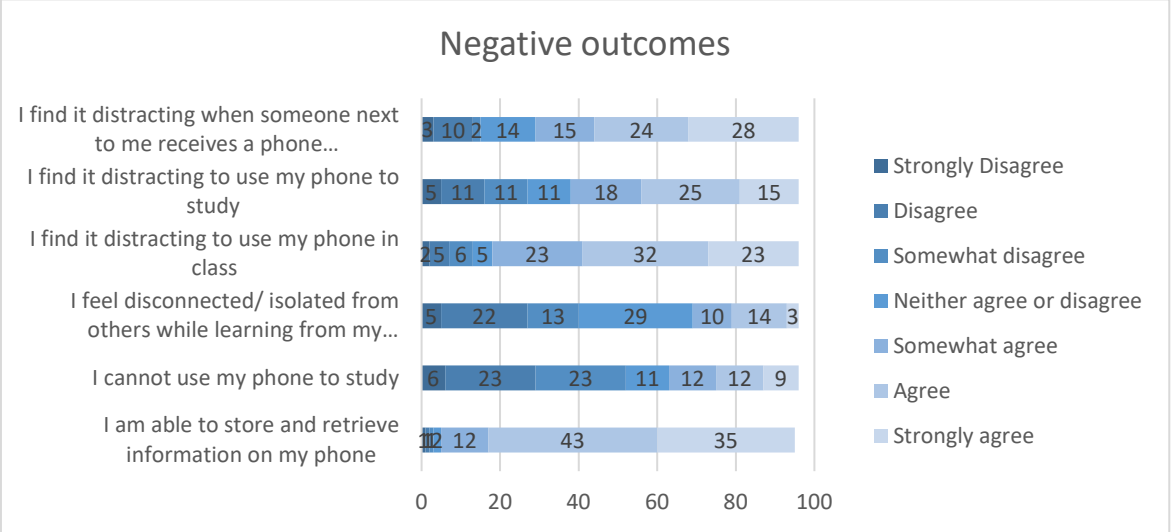

Figure 4: Negative Outcomes from phone use for learning

Kuznekoff and Titsworth (2013) argue that "*students using their mobile devices to text, play games, check Facebook, tweet, or engage in other activities available to them in a rapidly evolving digital terrain*". The results appear to be in agreement with this claim as a significant majority of the 55 out of 98 students reported that using their phones in class disrupts their learning. It is also important to note that a significant number of students confessed that their concetration is affected when someone next to them receives a phone call or notification in class. This outcome supports Güliz Uğur and Koç (2015)'s claim when they point out that students who used their smartphone during class interrupted about 85% of their collegues. However, lack of storage capacity was *not* perceived as an issue; less than 20 respondents had an issue with this.

4.4 – Issues and Satisfaction

The literature review discussed a number of issues that or hinder users from getting maximum gain as they use their phones. While talking about these issues, Park (2011) cautions readers to keep in mind the fact that "*every technology has some limitations and weaknesses, and mobile devices are no exception*". In the context of this study, issues refer to those unpleasant instances that arise to hinder or block the phone user from enjoying or getting the most out of their smart phone. For instance, the user might want to use their phone to access resources through the internet, but their data runs out. The limitation of access to the internet by data is considered an issue in the context of this research.

Thus, students were also asked about ***issues and hindrances*** experienced in the use of their phones for learning (Figure 5). 75 out of the 98 respondents depend on free WIFI to access learning materials from their phones. This means that generally, access to internet is not a problem to the students. On the other hand, a vast majority (83 out of the 98 respondents) expresed their concern for the small screen size of their smartphones. In his argument, Park (2011) suggests that physical attributes of mobile devices such as small screen size which limit learners from effectively accessing online resources through their smart phones (Park, 2011).

This is especially true when it comes to mobile unfriendly websites. The findings strongly support his claim. However, this issue of small screen size does not come as a surprise given that in the demographics, the largest category of 37 respondents indicated that they have phones with screens between 4 to 5 inches.

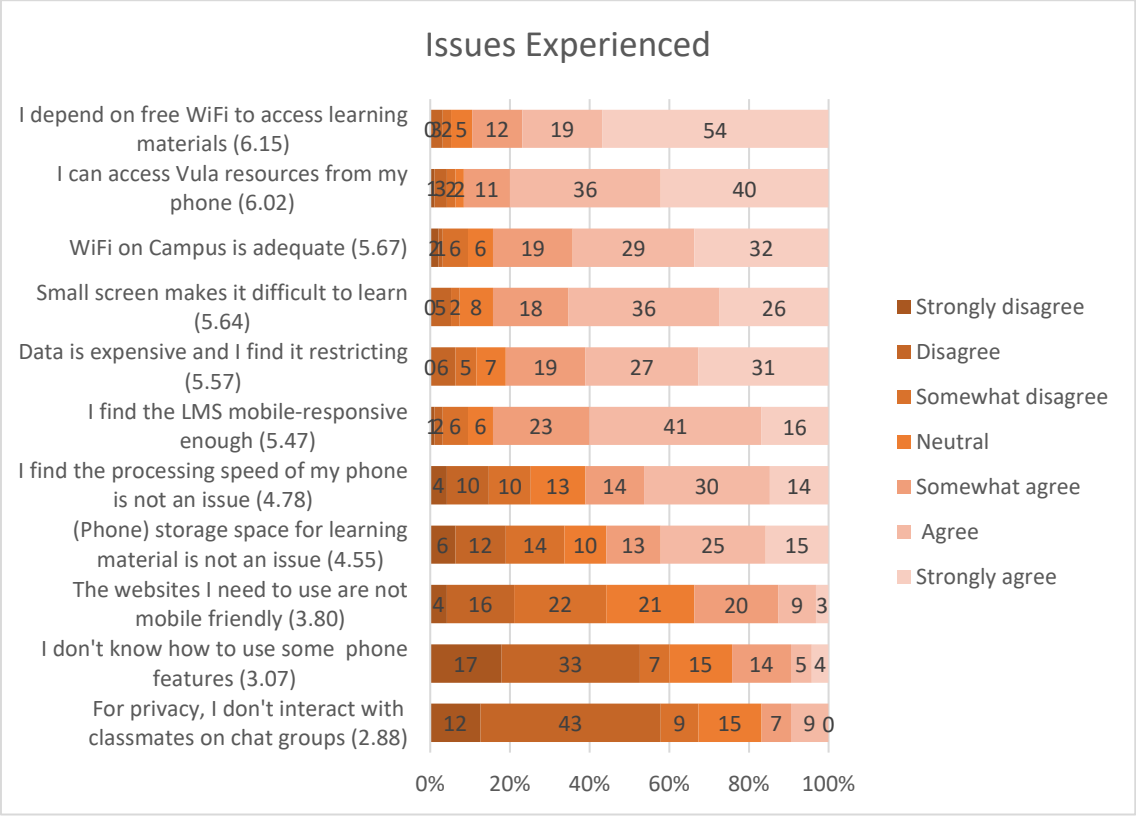

Figure 5: Issues experienced with mobile phone use for learning (sorted by average)

Park (2011) points out that inadequate memory obstructs the learner from getting maximum benefits out of mobile learning experience. However, the responses tend to be in disagreement with this claim since most students do not consider storage space an issue. This could be because smartphones being produced nowadays have increased memory that provides adequate storage when compared to the time period when Park (2011) collected his data. Most students also indicate that they do not consider their phones complex and there can use all the features available. Park (2011) pointed out that users have issues installing applications and challenges in learning how to work with a mobile device. This does not seem to be a limitation given the responses collected from the students.

Students are generally ***satisfied*** using their phones to study (Figure 6). Domingo and Garganté (2016)'s claimed that providing access to information and increasing engagement while learning are the two main impacts of mobile technology in the classroom. This claim is highly supported by the findings since the highest ranked quality resulting into satisfaction is the ability for students to access learning materials on their phone. However, the data collected also projects that some students do not enjoy learning on their phones. This could be resulting from the small screen size which was accounted for in the issues.

The majority of the students tend to stay neutral when asked if they would recommend mobile to others. This is quite interesting given that over 70 % of the respondents confessed to

accessing learning materials on their phones. The large number of students accessing learning materials could also be explained by the free Eduroam WIFI on campus premises and the residences.

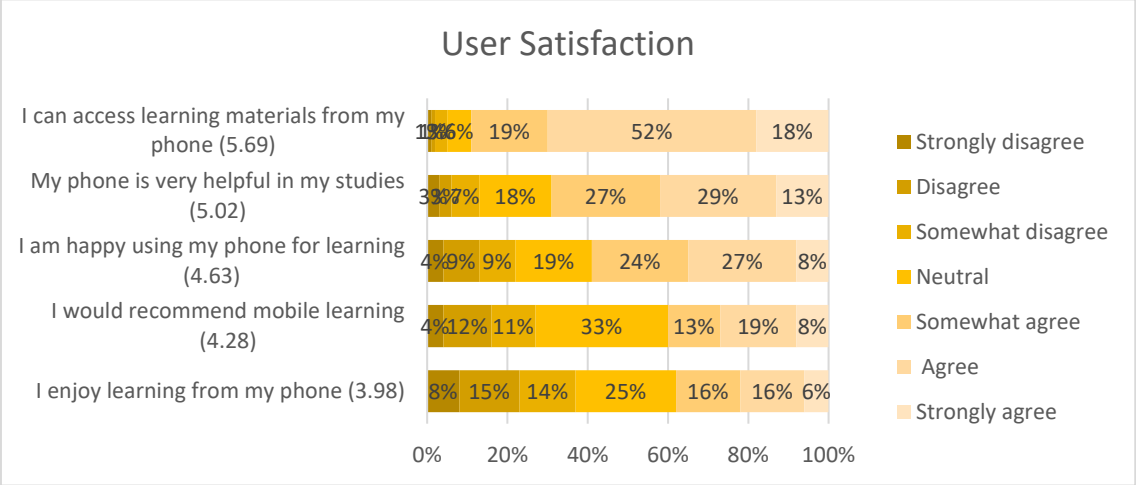

Figure 6: User satisfaction (sorted by average)

4.5 – Correlation Analysis

Given that the model is fairly simple, stipulating only 3 one-to-one relationships, the Spearman correlation coefficient was calculated to test the relationships stipulated in the model.

H1: The relationship between ***"frequency of use" and "positive outcome" will be positive***

We found that there is a generally weak inverse relationship between frequency of use for facebook and the positive outcomes (POC_1 to POC_5). With the exception of facebook, there is a statistically significant but weak positive relationship between the frequency of use of various applications and the positive outcomes (POC) reported by the students. In conclusion, the relationship between 'Frequency of use' and 'positive outcomes' is positive but weak.

H2: The relationship between "positive outcome" and "user satisfaction" will be positive.

The correlation matrix clearly showed a relationship between "positive outcomes" and "user satisfaction". All correlation coefficients are portraying a positive relationship between the variables. There is actually strong positive relationship between "positive outcome" and "user satisfaction". Basing on the individual correlation coefficients, we can already conclude that the relationship between "positive outcome" and "user satisfaction" is positive.

This hypothesis was further confirmed by running a multiple regression analysis. We found an R^2 value of 0.4349 which means that 43% of the variance in the dependent variable (Average user satisfaction) could be explained by a change in positive outcomes. This confirms the model reasonably but points the way to other factors also playing a role.

H3: The relationship between "issues" and "user satisfaction" will be negative.

The correlation matrix reveals a generally weak relationship between the various "issues" and "user satisfaction". Even though there are some significant variables that portray a positive relationship between the two constructs, the general significant association is largely inverse in nature. Basing on the statistical results, we conclude that the relationship between "issues" and "user satisfaction" is largely inverse i.e. negative in nature.

5. Conclusion

The research question was how do smartphones impact student's learning experience in higher education institutions in South Africa. The research model was based on a combination of the e-learning model (Holsapple & Lee-Post, 2006) and the IS Success Model (DeLone & McLean, 2003) (Figure 1). Based on the data collected, it is evident that a vast majority of the respondents are generally satisfied with using their smart phones to study and access academic resources in an effort to enhance their learning experience. It is important, however, to note that a significant number of studens do not enjoy learning from their smart phones. There was only a slight correlation between the frequency of phone use for learning and positive learning outcomes. However, we confirmed a strong positive correlation between positive learning outcomes and user satisfaction, as well as a significant negative impact of issues experienced on the user satisfaction.

Some interesting observations or considerations in regard to this topic include the fact that ownership of a smartphone does not guarantee proficiency. Although most student responded that they had no problem using all the features of their phone, there are a few who indicated otherwise. It should also be noted that knowing how to use the smartphone does not mean students know how to use it for learning.

The research should be repeated at other higher education institutions and with larger sample sizes. Additional qualitative research would also uncover what interventions can be undertaken to improve mobile learning outcomes.

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Factors Influencing the Use of Mobile Internet Services Among Young People: A Case of Zanzibar, Tanzania

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ABSTRACT Mobile Internet is the Internet services accessed through mobile devices. The uses of mobile Internet have been dramatically increasing among young people around the world, with both positive and negative effects. This paper investigates factors influencing the use of mobile Internet services among young people in Zanzibar. A total of 104 youth, aged 16-40 were contacted for interview and focus group discussion. The participants were selected from both rural and urban of Zanzibar. The findings reveal that there are several factors influencing young people to use the mobile Internet such as joining online education, applying for a job online, entertainment, and socializing. The findings further reveal that there is a negative side of mobile Internet use among youth such as wasting time, misuse of information, early exposure to sex habits, and loss in ethical culture and traditions. The study concludes with recommendations to address the challenges facing Zanzibar youth and the world in general on the uses of the mobile Internet.

1. Introduction

Mobile Internet refers to the Internet services accessed through mobile devices (Schiller, 2003). Globally, in 2016 the number of people accessing Internet through their mobile devices doubled the number of desktop/laptop-only users (Kemp, 2017). The rapid growth of mobile Internet usage is more evident in the developing countries. According to the International Telecommunication Union (ITU), in 2017 the number of people accessing mobile Internet in Africa surpassed those accessing Internet through fixed line connection (ITU, 2017).

In Tanzania the number of people subscribed to mobile services has been increasing dramatically, where 40 million users adopted mobile phone services by 2016 and more than 17 million use the Internet services (TCRA, 2017).

Meanwhile, Zanzibar the semi-autonomous part of Tanzania has also witnessed significant increase of usage of mobile Internet services among young people. Zanzibar is located in the Indian Ocean about 30km of the east coast of Africa, between latitude 5 and 7 degrees south of the equator. It consists of two main islands namely Unguja and Pemba, and several other smaller islands. The country has an area of 2,654 sqkm. According to 2012 sensor, Zanzibar has population of 1.303,569 (NBS, 2012). The use of mobile phones is spread in every corner of the country and people use their phone for providing daily social services such as news,

weather forecasting, sports, and etc. It is important to look into how the young generation use mobile Internet because, youth is the main labour force and mostly engaged in education in Zanzibar. Mobile Internet can be used to increase social ties and accelerate development (Rashid & Elder, 2009).

There are six telecommunication Companies that are operating in Zanzibar. These companies are Zantel, Vodacom, Airtel, Tigo, Halotel, and TTCL. In general, mobile penetration rate and the coverage of telecommunication services are at satisfactory level (WorksReport. 2016). Nowadays, everyone possesses at least one social networking account in which they interact with others (Tamwa, 2013). The young generation has especially adapted social networking sites to get connected, exchange ideas and experiences with like-minded people.

DeBell et al. (2006) found that adolescents and young adults are the heaviest users of mobile and the Internet. Young people spend most of their time on the Internet for different online activities (Boyd, 2007; Lewis et al., 2008). As Social Networking becomes an activity that is done primarily on the Internet, the most common social media are Whatsapp, Facebook, Twitter, YouTube, and Instagram (Scott, 2017; Masele, 2017). Both positive and negative online activities are reported among young people. A number of young people use mobile Internet to access vital information about health, education, civic engagement, online purchasing, searching for job or employment opportunities (Lenhart et al., 2010; Smith, 2015). In addition to that, social network provides a link among students and improves academic engagement (Mwadime, 2015). Students use their mobile phones to search for and collect studying materials, discuss and share ideas with other students.

On the other hand, some young people use mobile Internet in unproductive ways causing wastage of their precious time on the negative things. The study by Williams et al. (2008) suggested that, university students are often preoccupied by their Facebook profiles or Twitter pages. Further, there are statistically negative impacts on student grades and academic performance due to time spent by students on online social networks (Paul et al., 2012). Akanlisikum et al. (2014) revealed that most of young adults in Ghana use their phones for leisure instead of educational and business purposes. These young adults were found spending most of their time on chatting, browsing Internet, and making or receiving calls.

In this regard, schools are advised to incorporate technology in their teaching and learning. For instance, in a study conducted by the British Educational and Communications Technology agency, Personalizing Learning with Technology, backed up the findings by Harrison and colleagues (2004) in England that positively associated higher levels of technology use and school achievement at different key stages in schools but also highlighted the challenges of isolating technology among many other factors that might affect students' achievement (Becta, 2007).

A survey conducted in the United States showed that approximately 90% of youth have Internet access, and about 25% of these youth use the Internet more than once per day (Kist et al., 2008). In doing so, students prefer to chat with their friends online rather than doing their home works. Wasting time on social networks is mostly linked to lower academic performance of student users (Kirschner & Karpinski, 2010). Understanding the trends and factors influencing the use of mobile Internet communication among young people is an essential aspect of socio-economic development. This paper explores the factors influencing the use of mobile Internet among young people in Zanzibar.

The rest of this paper describes the factors influencing young people to use the mobile Internet services and in what ways do Zanzibar youth make use of the mobile Internet. Section 2 presents the methodology, including research design, participants' inclusion, materials and data analysis method. Section 3 presents the findings while Section 4 describes the discussion and Section 5 provides the conclusion of the study.

2. Methodology

This section presents the methodology used in this study, including design, participants, materials and data analysis.

2.1 - Design

The study was a qualitative investigation of perceptions of mobile phone Internet use in young people's lives. Semi-structured interviews and focus group discussions were utilized as the data collection methods. As illustrated by Dawson (2007), qualitative approaches are the best way to have an accurate and thorough communication of ideas between researcher and the person from whom you are gathering information. Also, by the interview method one has control of the question order, and can make sure that all the questions are answered.

2.2 - Participants

A total of 104 Zanzibar youth were interviewed in this study. Participants were randomly selected among youth aged 16-40 from different urban and rural areas of Zanzibar. Included participants should have had Internet supported mobile phones. The interviews were conducted between July and December, 2017. The interview sessions were conducted groups and individually sessions. Each interview session lasted between 20 to 30 minutes. The focus groups were mixed gender and the other groups comprised females or males only. This is because, based on cultural and norms of Zanzibar it is believed that in groups where male present female could not participate as fully in the discussion such that females were open in female only group (ActionAid, 2014).

2.3 - Materials

A focus group discussion guide was developed prior to the commencement of the groups. The discussion guide contained a series of discussion points and suggested various questions. The interview questions were divided into three sections. First part covered participant's demographic information. The second part covered the awareness of the use of mobile Internet services and the third part covered questions on the positive and negative impact of the use of Internet services for Zanzibar youth. Text notes and audio recording were used as data collection tools. The State University of Zanzibar (SUZA) granted ethical clearance for this study. Before the interview discussions began, participants were briefed on the purpose of the research and were requested to complete consent forms and permission forms for the researchers to record the interviews using text notes and audio.

2.4 - Data Analysis

At the end of the discussion sessions, the researches transcribed the audio-tape discussions verbatim. Throughout the transcription process, the researchers noted every interesting idea or concept which was repeated across the discussion groups, allowing for the identification of common concepts. Once transcription was completed, thematic analysis was conducted using

a qualitative software analysis program (NVivo version 10). First, data were coded into the broad categories of each focus group question. Each category was then analysed for evidence of the general concepts which the researchers had noted throughout the discussion and transcription process. Common ideas or concepts, which emerged in the focus group questions across the focus group discussions, were identified as themes. Finally, the discussions were explored for obtaining reliable concepts related to the factors influencing Zanzibar youth to use the mobile Internet services.

3. Findings

This section presents the findings of the study, including participants' demographic information, positive and negative factors that influencing Zanzibar youth to use the mobile Internet services.

3.1 - Participants' Demographic Information

Table 1 shows the demographic information of participants. The 104 youth participated in the study and were evaluated. Among them 61% were male and 39% female. The participants were of different ages, the majority of them aged 16-23 (46%). Young people were from both urban (57%) and rural (43%) areas. Fifty-seven percent (57%) of participants were single, followed by married (38%), divorce (4%) and widower (1%). The participants were from different occupations; students (51%), government employed (13%), self-employed (13%), business (7%), farmers (6%), fishers (4%) and other job (8%) such as driver and mechanical. All the participants had mobile phone and accessed the Internet services. The majority of them had smart phones (66%), followed by features phones (30%), PDA (2%) and other types (2%) such as Tablet and iPad, as shown in Figure 1. In addition, the students' participants were pursuing different level of education, including primary, secondary and university. The majority of them were university students (67%). Selection of the respondents is based on the fact that, the usage of mobile phones, where other factors such as age, education, gender, and occupation are linked with mobile phone usage and associated developmental outcomes (Rashid & Elder, 2009).

Table 1: Demographic Information of Participants

	Gender		**Residence**		**Marital Status**				**Occupation**							
Age group	Male	Female	Rural	Urban	Single	Married	Divorce	Widower	Student	Employed	Self-employed	Farmer	Business	Fisher	Other	**Total**
16-23	27	21	26	22	46	2	0	0	38	0	8	0	1	1	0	**48**
24-31	19	12	15	16	12	18	1	0	15	2	1	4	5	1	3	**31**
32-40	17	8	4	21	1	20	3	1	0	11	4	2	1	2	5	**25**
Total	**63**	**41**	**45**	**59**	**59**	**40**	**4**	**1**	**53**	**13**	**13**	**6**	**7**	**4**	**8**	**104**

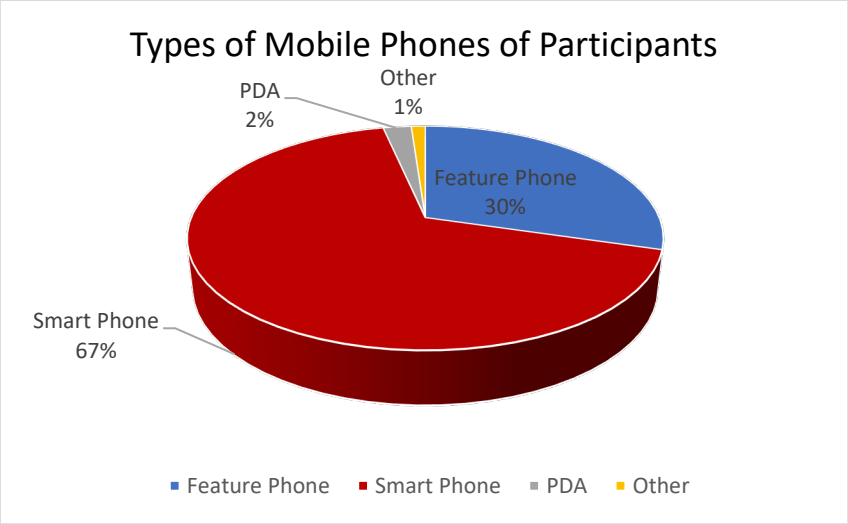

Figure 1: Types of Mobile Phones of Participants

3.2 - Positive Factors

The findings indicated that there are a number of positive factors that influence the Zanzibar youth to use the mobile Internet services. The major factors are: join online education, apply for a job online, entertaining, and socializing by connecting with family and friends.

Join online education

The findings showed that 59% of participants, specifically students, responded that they mostly use the mobile Internet for online learning purposes. They suggested that online learning represents an easy and comfortable method to acquire knowledge in almost every field of study because nowadays everything is on the Internet. Online learning is a great alternative, especially for extra learning after teacher–student class interaction. Some of participants, mainly students indicated they do discussion with other students or finding a solution for their take-home assignment through social media. They added that when they did not understand in the classroom they join online education at home as additional learning. For instance, one student participant said that "Goggle and the Internet in general, are my second teacher, everything I need I can get there [online], I always search information in the Internet especially, if I did not understand well in the class". However, other participants responded that they rarely use the mobile Internet for online education rather than other things such as social networking.

Apply for a job online

Almost half of the participants (49%), the majority with secondary education and above revealed that they use mobile Internet for applying for jobs. Compared to traditional ways which require a person to physically visit job sites, the Internet allows people to find jobs online. The participants indicated that the resources and information related to jobs they found online are the most important which places the mobile Internet just behind personal computers' Internet and physical visit. For instance, one participant said that "I finished my university two years ago and I don't have a job so, I usually use my phone [mobile Internet] to find and apply for jobs". He added that "I believe this way [mobile Internet] would enable me to find and get employed to good job". Furthermore, the participants added that searching for a job using mobile Internet is costless compared to physically visiting job sites as indicated by one

participant who said that "I live in rural area and most offices [job sites] are found in urban areas, so I should spend a lot of money to get there, but when I use mobile Internet I can search and apply for any job I want".

Entertaining

The findings indicated that entertainment is one of the most prominent factors that are influencing Zanzibar youth to use the mobile Internet services. Almost all participants responded that they usually use their phones for listening music, watching movies, religion clips and playing games. The findings further indicated that some of the participants use their phones for downloading and watching sex videos. For instance, one of participant said that "I use my phone to find beautiful women and of course sometimes I watch sex videos". However, some of participants responded that they never use their phones for pornographic activities. The findings showed that the participants aged 16-23 are the most to use their phones for watching pornography. It was further found that young people frequently access the Internet for getting update news, specifically sport news. The youth also are mostly streaming live radio and television, reading newspapers, websites, blogs and other online contents. The participants aged 24-31 are the ones most inclined to spend time on their phones for entertainment activities.

Socializing

The findings revealed that the majority of participants use their phones for socializing issues. The participants accessed different social network sites, including Whatsapp, Facebook, Instagram, Youtube, Twitter, Blogs and other social network sites such as LinkedIn and Viber. Figure 2 shows the social networks sites mostly accessed by participants. The majority of participants responded that they use social network to communicate with family and friends. They added that social network is the major factor contributed them to have the Internet supported phones. Here are some responses from participants; "If I don't physically meet my friends for a long time, the social network gives me happiness and joy once we communicate with each other", "I like social networks especially Instagram and Facebook as they provide me with a great opportunity to understand various kinds of people and their personalities." Moreover, over half of the participants (52%) believed that social networks are not only a form of communication but also for other purposes such as business, learning and advertisement.

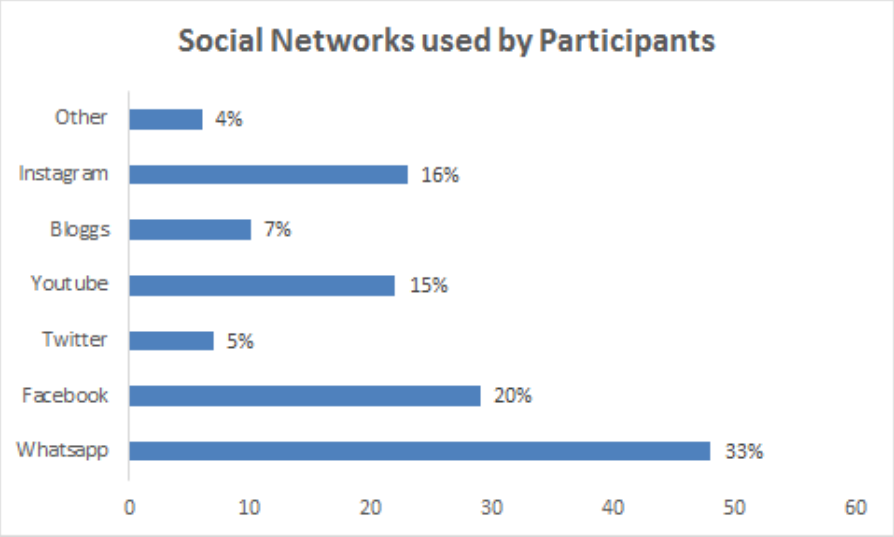

Figure 2: Social Networks used by Participants

3.3 - Negative Factors

Apart from the positive factors, there are also negative factors resulting from the use of mobile Internet for young people. These factors include:- wasting precious time, misuse of information, early exposure to sex habits and loss in ethical culture and traditions.

Wasting of time

The findings however indicated that the majority of Zanzibar youth have mobile phones and mostly use their phones for surfing the Internet on various purposes, such as education, entertainment, socializing and job application, most of them were addicted to mobile Internet and wasting so much energy and time on it. While some people were busy with their study, career plan and dream, most of Zanzibar youth were busy to run day and night in mobile Internet for inappropriate things for their age or stage of development through the websites and social networks. “I spend more than three hours a day to communicate with friends and browsing things”, “I cannot sit anywhere even ten minutes without browsing through my phone”, “I spend almost five hours on mobile phone connected with Internet per day for searching things and reading news”. These are responses feedback from three participants. Many other assertions were also reported by various participants as they responded that they usually spend too much time on their mobile phones for browsing than doing other things. Figure 3 shows time spent by participants on mobile Internet services. Additionally, most of participants reported that they usually sit on their phone in the night for socializing and browsing news than at day time.

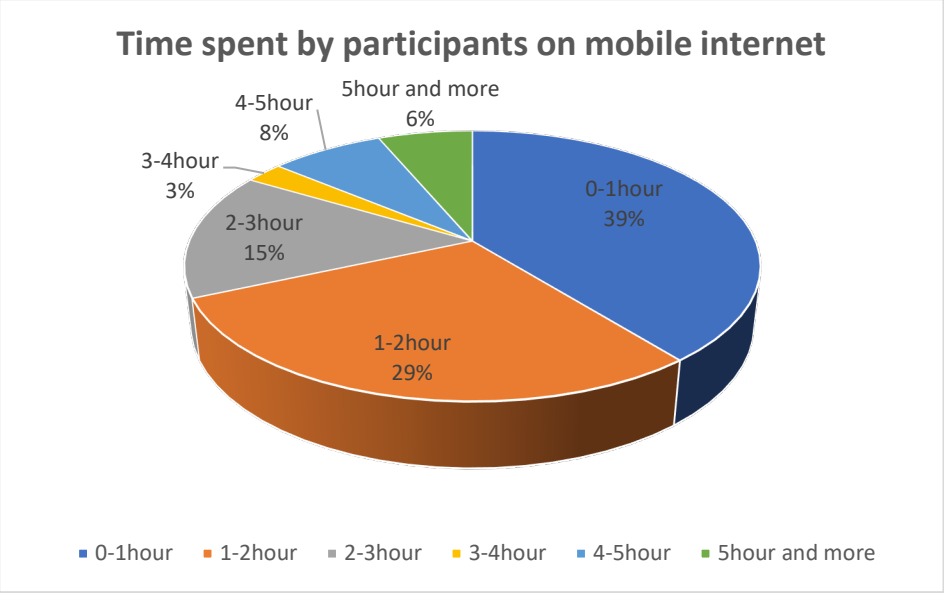

Figure 3: Time spent by participants on mobile internet

Misuse of information

Though, it was found that Zanzibar youth use their phones for different purposes such as searching and applying for jobs, entertaining and communication, some of them use mobile Internet negatively. The findings revealed that more than half (54%) of the participants have at least once been sent inappropriate information. The participants indicated that they sometimes either created false information and send to groups or received information from someone else and forward it to other people. When they were asked why they created false information and

spread to others, five participants responded that it is just a fun and they want other people to laugh or get attention. “One day I created a false message that one of my friend got accident and I forwarded to other friends in my WhatsApp groups, I did not think if that information could cause a problem to others, I realized that when one of fellow friend was taken to hospital after read and shocked by the information”, “I forward everything that I received from other groups, I don’t care because I am not the one who created them”. The findings revealed that the youth, aged 16-23 are the ones who most forward every message which they have received from other people without even reading them.

Early exposure to sex habits

This study found that among the most negative factor affecting Zanzibar youth is early exposure to sex habits. The participants aged groups: 16-31 are the most affected with sexual behaviors. The most of participants in this age group are unmarried, 55% of all participants. Some participants reported that they usually practice sexual activities such as sex styles and positions which they see in different adult websites using their mobile Internet. For instance, one participant said that “I always watch pornographic videos and sometimes I practice what I have seen”. And another one said that “I have a smart phone but my mom and my dad don’t know if I have a phone - I usually use it when I am out of home, mostly for studying, chatting with friends and of course sometimes for watching pornography”. Though, few participants responded that they do watch pornography but not necessarily practice what they see and some responded that they never watch pornography. “I have never watched pornography [laughing], no! I don’t like it, it is bad things and unethical”. On the other hand, around 9% of the participants – all were married men- said that they do usually watch pornography for educational purposes and not for entertaining. They added that if they want to practice new sex positions they see in the Internet they do that to their wives. For instance, one participant said that “I always copy sex positions from the Internet, it helps me to know different sex techniques”.

Loss in ethical culture and traditions

It is clear that the mobile Internet has many advantages today especially for young generation. People are using the mobile Internet for various purposes as previously mentioned in Section 3.2. However, if the mobile Internet is used in negative way may it affects culture and traditions, particularly for young people. This study found that the Zanzibar youths lowly decline their traditions and imitate the foreign traditions which have seen from the Internet. The youth copy other people – mostly famous people, including actors, musicians and football players – wearing styles, haircut styles, talking and their lifestyle. For instance, one participant said that “I always check new hair styles from abroad, if I find one which I like then I have my hair cut in the same style”. Another participant said that “I have my role model from [*she mention name of country*] - I always wear the same way she wears”. This assertion is evident as the researchers have seen new haircut styles from abroad and advertisements to attract the customers in many saloons in Zanzibar.

4. Discussion

This study aimed at exploring factors influencing the use of mobile Internet services among Zanzibar youth. Results revealed that, generally, mobile Internet services play an important part in the life of Zanzibar youth and have become not only a tool for communication but for

other activities such as studying, applying for jobs and entertainment. The mobile Internet use has replaced some personal computers, such as desktops and laptops, for most of the users, particularly students. The participants reported that they are attached so much to their phones than anything else and they felt mobile phones connected with Internet are part of their life. There is no denying the fact that the mobile Internet has significantly evolved over the past years. The Internet and technology in general have been developed with the purpose of creating useful and inspiring experiences for young people (Rashid & Elder, 2009; ITU, 2017). The result is that nowadays there are various sites that can be browsed and accessed straight forwardly through mobile phones.

The findings of this study showed that the majority of young people use mobile Internet for social networks, including entertaining and communicating with family and friends. The most frequently used social network sites by participants are WhatsApp, Facebook, Instagram, YouTube, Blogs and Twitter. However, the most popular apps visited were WhatsApp (33%) and Facebook (20%). The findings of this study concur with the findings of Mwadime (2015), who also found that the most visited sites were WhatsApp (50%) followed by Facebook (42%).

Further, it is shown in the findings that the Zanzibar youth spent at least two hours a day chatting and browsing different websites. The participants of the study indicated that the social networks are helping them academically in one side, and on the other side facilitate communication with other people. Similar results are reported by Khan et al. (2012) who found that young people spend much time on the social networks and most popular activities done on the sites are looking at profiles of one another, updating their own profiles and searching for pictures, videos and games.

The findings further revealed that the majority of participants who are students use the mobile Internet for online learning, including:- searching online materials such as books, papers, notes, etc, they suggested that this form of learning (online learning) is easy and comfortable compared with a physical learning such as face-to-face interaction with teachers in the classroom, or looking for a book in the library. The online learning method helps students learn many things broadly compared to what they have learned in the classroom with teachers.

It was also found that young people use their phones for searching for jobs online. They suggested that searching for jobs online is costless compared with physical job seeking. They added that most jobs are found far away from their residence, such as urban areas and it was a challenge for them to travel from where they stay to the jobs site. They said that in order to avoid this, they use their phones instead for searching and applying for jobs online because this is very easy and convenient for them. This finding is also notable in developed countries: Smith (2015) found that 54% of United States adults have gone online to search for job information and nearly 45% have applied for a job online.

A part from positive factors influencing Zanzibar youth to use mobile Internet services, there were also negative factors found influencing them to use the mobile Internet. These include misuse of information and early exposure to sex habits. The study also found indirect negative factors affecting youth from the use of the Internet such as wasting of time and loss of culture and traditions. In this study culture is defined as a social domain that emphasizes the practices, discourses, and material expressions which includes knowledge, art, morals, law, customs, and any other capabilities and habits acquired by person as a member of society. Tradition would describe a belief or behavior. It is the forms of artistic heritage of a particular culture. Culture

is much broader term encompasses tradition. Basically traditions are a part of culture (Ravuvu, 1992). It was found in the findings that some of youth spent much of their time a day for surfing in the mobile Internet. It is clear that if a person spends much time on the Internet, he/she won't have enough time for other activities. For example, students do not have enough time to concentrate on their studies, when they spend much time on social media (Vcool, 2017). As it was indicated in the findings that a lot of youth spend most of their time surfing social networks, playing games and watching pornography instead of learning or doing other meaningful activities. If the purpose of the Internet was to help people, including young people to learn new things and work more effectively (Lenhart et al., 2010), it now makes them do no learning or work at all. Literature indicates that social networks have a big impact on students' grades and negatively impacting on academic performance (Paul et al., 2012; Kieschner & Karpinski, 2010). Because students spend so much time engaging with media, they spend less time doing home works, attending classes, revising what they have learned in the school, and even tire themselves by not getting enough sleep (Vcool, 2017; Pempek et al., 2009).

The findings further indicated that young people, quite often misuse information when they use the mobile Internet. A lot of youth are publishing or forwarding false information to other people. According to the Tanzania Cybercrimes Act, publishing or sending false, deceptive, misleading or inaccurate information and with intent to defame threaten, abuse, insult or otherwise deceive or mislead the public of an offence shall on conviction be liable to a fine of not less than 5,000,000TSZ (Tanzania Shillings) or to imprisonment for a term of not less than three years or both (Cybercrimes Act, 2015, p.15). It was also found that young people often imitate and follow new life styles from abroad, which they have seen from the mobile Internet. For instance, this study found that most of Zanzibar youth follow any fashion which appears in town such as clothes and haircut styles as famous people do, especially from Europe and America, while most of the styles are not part of Zanzibar or African traditions.

The local culture and traditions can be destroyed if the Internet be used negatively. Young people are quick to embrace anything appearing in the Internet, without considering if the thing is useful or harmful. The study found that the most affected age group imitating lifestyles of other people and habitual sex offenders are aged, 16-31.

Additionally, some participants suggested that they watch pornography specifically, for educational purposes and not for entertaining or for destroying culture and traditions, as indicated in Section 3.3. In spite of that, watching pornography is not acceptable in Tanzania. If someone is arrested for watching pornography for educational, entertainment or any other purpose, it is illegal and the offence punishable with a fine of not less than 20,000,000TZS (Tanzania shillings) or to imprisonment for a term of not less than seven years or both (Cybercrimes Act, 2015, p.14).

It is worth noting that mobile Internet seems to be the primary and significant thing in young people' life. The Internet enables young people to learn new things from different sources in an easy way. It also enables young people to be open-minded by enjoying contacting new things from different cultures, and associate themselves with people from different places around the world. In contrast, a lot of false information can be found on the Internet. In addition, the mobile Internet is also frequently used by criminals to take advantage of young people and children (Livingstone et al., 2011).

5. Conclusion and Recommendations

This study explored the factors influencing the use of mobile Internet services among Zanzibar youth. Based on the results of the study and previous studies the following conclusions can be drawn.

The study concludes that the rate of adoption of mobile Internet in young people is increasing rapidly. Among factors that contributed to increasing the use of mobile Internet are social networks, such that people are offered the options of entertainment and communication with other people such as family and friends. The adoption of mobile Internet services has the potential to be used as a means of learning, entertainment and communicating.

The study also concludes that despite the fact that there are various positive factors influencing young people to frequently use the mobile Internet services, there are also negative consequences such as the destruction of local culture and traditions. It was also found in the study that youth use the mobile Internet to imitate and practice lifestyles of other people, including clothes, haircut styles, sexual and other activities which are in contrast with their local culture and traditions. Finally, the study recommends that parents should monitor the use of mobile phones by their children, especially children below twenty. If there are such bad or unethical sites which may cause the destruction of their culture and traditions, the parents should forbid their children to visit even block that sites. This may lead them to use the mobile Internet properly, such as learning new things and communicate with people from different countries around the world (Dogruer et al., 2011).

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Gender technology relations in the access to and use of mobile phones for agricultural information: a case of farmers in Apac district, Northern Uganda

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Abstract Household decision making is influenced by the existing household gender relations that determine what one accesses, how they access services and benefits as well as how they use what they access. These gender relations are eclectic and may change with introduction of new technologies since technology itself has a direct influence on gender relations due to preferences by both male and female household members. A dash to improve access to agricultural information has led to introduction of mobile phones for farmers in Uganda as a way of supporting agricultural extension services with varying reflections on existing gender relations. The technologies themselves have proved to be gendered in nature and thus espouse interesting gender technology relations for male and female farmers as discussed in this paper. The paper is based on quantitative field findings from farmers that belong to farmer groups that actively use mobile phones in Apac district Northern Uganda.

1. Introduction

This paper interrogates the technology and gender relations embedded in the access to and use of mobile phones by farmers belonging to farmer groups formerly supported by Women of Uganda Network (WOUGNET) through Kubere Information Center (KIC) in Apac District, Northern Uganda. The decision making process to access and use technology is informed by gender relations. Gender relations refers to the particular power dynamics embodied in our conceptualizations of difference and sameness, that is, unequal variances or assumed equalities between men and women (Gillard et al, 2008). Therefore, the decision to adopt information and communication technology (ICTs) like mobile phones for agricultural information is arrived at through negotiations (Rudeman and Glick, 2008).

Technology studies have previously ably demonstrated gender relations surrounding technology access to favour men because of their affinity to technology and the supposed dislike of the same by women (Bray, 2007). That men love machines while women are passive beneficiaries (Bray, 2007) and thus to understand technology, which is masculine, one must understand gender (Lohan & Faulkner, 2004).

Nevertheless, some men and are excluded because of poverty and lack of the requisite skills to use the technologies (Faulkner & Lee, 2007) (Faulkner & Lee, Gender in the information society: strategies of inlcusion, 2007). Needless to say, men have more technical skills for technology use and the cultural images of technology itself are masculine (Faulkner, 2001), in many cases influenced by their upbringing as 'technologists' (Holth & Mellström, 2011). Such men feel passionately about technology which symbolycally becomes their extension (Mellström, 2004).

Accordingly, gender relations can also be traced in the technologies themselves and the anticipated use of the technologies hence creating what is known as technology gender relations (Faulkner, 2001). Gender technology relations include but are not limited to: technology control, technology use and distribution of technology benefits. These are mediated by existing household gender relations but at adoption, they too impact household gender relations (Ghertner, 2006). The mobile phone is owned by the individual within a certain space but in a household as a social group, this creates contestations and conflict that manifest with mere intention to own one. The mobile phone is also multifunctional in nature allowing the owner to make calls, receive and send short messages, access the internet and use it as a radio at the same time. Contestation may thus arise from the amount of time an individual spends talking on the phone, amount of money they invest in airtime and internet bundles, control resources for charging the phone like solar or electricity, the people one communicates with and the amount of secrecy in communication. In India for instance, women had to stop making phone calls due to the negative attachments to mobile phones by their husbands (Masika and Bailur, 2015).

1.1 – Gender Relations in Apac District

Historically, the Langis, an agro-pastoral ethnic group found in Apac district, organised their society on patriarchal lines where men were providers and controlled land as a factor of production (Curley, 1973, LANDac, 2016). Marriage was polygamous, men were the dominant decision-makers, while women were subordinate, domesticated and seen as a source of labour with their children (Amone, 2014). These gender relations were upset by both colonialism and the two decade long Lord's Resistance Army (LRA) conflict that herded people into internally displaced camps (Namuggala & Mulumba, 2014; Lehrer, 2009). Men lost their authority in the households as providers and started looking for casual jobs like women (Lehrer, 2009). Women were on the other hand empowered with picking food rations from aid agencies; save for households that only had boys or men (Namuggala & Mulumba, 2014; Lehrer, 2009).

The official ending of the conflict in 2008 led to a resettlement programme in Apac district so that residents could live a 'normal' life (Namuggala & Mulumba, 2014). Men were reintroduced into labour and household authority, a space that women had occupied for over a decade (Namuggala & Mulumba 2014). It is also significant to note that as the war scaled down in 2003, mobile phones had been introduced (Wamala, 2010; Nicholl, 2007). Men dominated the new technology as women could not afford it though a few women accessed the mobile phones as gifts from non-governmental organisations (Nicholl, 2007). All this points to negotiation and renegotiation of gender relations that later on dictated access to resources like mobile phones by individual men and women.

The interest of this paper is the power relations that influence access to mobile phones once a man or woman conceives the idea to buy one. The paper is an extract from a larger study that

looked at gender relations in the access to and use of mobile phones and radio for agricultural information and the ensuing decision making process itself to access and use the technologies. The interrogation of gender relations in Apac district, Northern Uganda becomes the more important given the Langi ethnic group's communal land ownership that vests agricultural land in the hands of male chiefs and by extension male members. Female farmers apply the use of technology on land allocated to their husbands. This shows a skewed gender relations landscape for female farmers compared to the male farmers.

2. Technology Adoption through the Unified Theory of Acceptance and Use of Technology (UTAUT)

The paper utilizes UTAUT which is both a theory and model in one. It was initially used to explain technology adoption decisions in organisations by Venkatesh et al (2003). UTAUT was initially used to explain technology adoption in organisations like education institutions, hospitals, academic societies, government agencies, the internet and social media (Venkatesh, Thong, & Xu, 2016). This study however applied the theory to a household situation. UTAUT as seen in **figure 1** presents four core determinants of intention and usage of technology namely; performance expectancy, effort expectancy, social influence and facilitating conditions as moderated by gender. In this study as, my interest was to make use of the effect of gender on the core determinants instead of using all the four moderators of the core determinants that include age, experience and voluntariness.

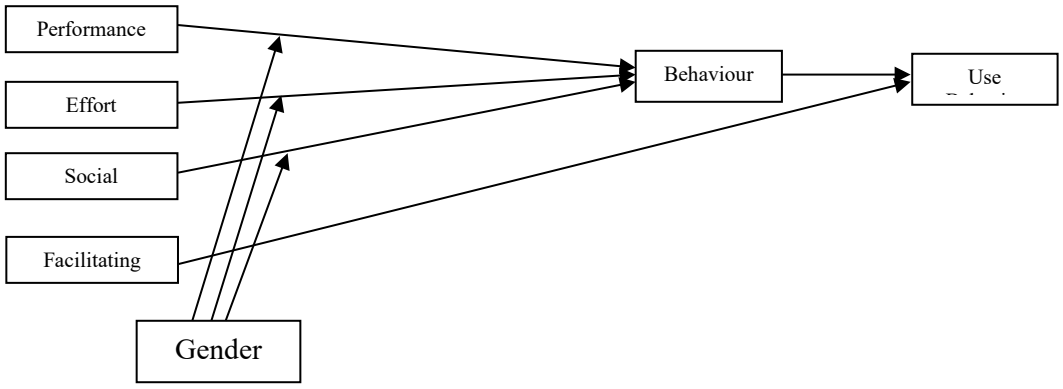

Figure 1: Diagrammatic illustration of UTAUT as adapted from Venkatesh et al (2003)

Performance expectancy is the degree to which an individual perceives that using the emerging technology will enhance job performance. It is rooted in gender where socialization and gender roles play a significant role in whether a man or woman's work requires them to use a certain technology to improve performance in their ascribed roles. Performance expectancy was found by Venkatesh's team to favour men more than women. Performance expectancy is also moderated by age as one of the factors that determine uptake of technology because age blurs gender differences as one grows older.

Effort expectancy explains the degree of ease to adopt that emerging technology. Venkatesh (2000) argues that in the short term, the perceived ease of use has two direct effects; 1) a direct effect on intention, and 2), an indirect effect on intention to use. The direct effect thus suggests that ease of use could be a potential catalyst for increasing the likelihood of user acceptance. On the other hand, indirect effect suggests that the easier a technology is to use, the more useful

it can be. An easier system to use may ultimately be more useful by facilitating system use, task accomplishments and generating the best cost benefit ratio for achievement oriented individuals. This, according to Venkatesh and his team, was found to be more pronounced for women than men since women are normally introduced late to technology use. It has more impact in the early days of technology adoption when behaviour changes in terms of the gender roles men and women play. It is also more salient for older women but with little experience in using the technology thus it reduces with more experience. Contrary to Venkatesh et al (2003), a study by Wang, Wu and Wang (2009) concluded that social influence was significant for men but insiginificant for women.

Social influence explains the degree to which an individual perceives that, important others believe that he or she should adopt a new technology. Social influence is most important where use is mandated rather than voluntary. If one feels that they must use a certain technology to fit in then they are mandated to use the technology yet if it is voluntary, the decision to use a technology is solely made by the intended user. Social influence is significant in the early days of technology adoption but fades as time goes by. Social influence has three influences namely: compliance, internalization and identification. An individual internalizes and identifies with the technology so as to realize social status gains while compliance requires the individual to alter his or her intention in response to social pressure. This happens if individuals may be rewarded or punished depending on their choices. Women yield more to social pressure and use others' opinions to learn more about their own abilities while men are more individualistic. The long-term assumption is that the gender differences are salient at the time of adoption will be sustained over time with increasing technology experience. Nevertheless, several qualitative studies by Holth & Mellström (2011), Mellström (2004) and Faulkner (2001) show that social influence applies pressure on men to take on technology.

Facilitating condition is the degree to which an individual believes that there is organizational and technical infrastructure to support the adoption of the new technology. There must be aspects within the technology and the household environment that deal with barriers to access and use of technology. Venkatesh et al (2003) argue that facilitating conditions do not have significant influence on behavioural intention to use technology. Nonetheless, studies by (Guo, 2015) and Afonso et al (2015) this assertion as they found that facilitating conditions indeed have varied gender significance. Both studies found out that women rate organizational support and technical conditions. Guo (2015) further argued that this is because men already have greater passion and desire for technology exploration and thus are better compared to women who need to be influenced by the environment. Women as a category have different needs and experiences that may need different solutions to problems that may look similar at first (Buskens & Webb, 2009). It is important to appreciate the gendered barriers, constraints and support within different societies, communities that make women want to be supported to adopt technology.

3. Methodological note

This quantitative study with a cross sectional design, was based on farmer groups formerly supported by Women of Uganda Network (WOUGNET) through Kubere Information Centre (KIC) found in Apac District, Lango sub-region in Northern Uganda. Inherently the study had a focus on sustainability to increase generalization to other farmers who are not supported by any organisation with ICT but own phones that they use for agricultural information. Through

probability proportionate to size sampling technique, 34 male and 95 female group members were selected from a pool of 192 farmers who belong to the 5 farmers groups. In the end, all active male group members participated in the study because of their statistically small number. The small number of men was due to the fact that the farmer groups were primarily formed to empower women though later on men joined voluntarily on the request of their spouses or because they wanted to access agricultural information.

Probability proportionate to size sampling was necessary because I needed to select a sample from two clusters from the same groups; that is male and female farmers with probabilities proportionate to their sizes based on the number of farmer group members that needed to be sub-sampled. Probability proportionate to size sampling is a type of multistage cluster sampling in which clusters are selected, not with equal probabilities but with probabilities proportionate to their sizes (Babbie, 2008). The data was analyzed using SPSS that generated statistics and chi square tests to ascertain gender significance.

4. Findings on access to and ownership of mobile phones

4.1 – Access to mobile phones

There was a no gender significance (P=0.066) in accessing mobile phones. A total of 97.1% of the male respondents accessed mobile phones compared to 85.3% of the female members. However, findings contained in table 1 showed a very strong gender relationship (P=0.000) in the nature of access to the mobile phones. Most male respondents (93.9%) indicated that the mobile phones they accessed were personal compared to 55.6% of the female respondents. Twenty one percent of the female famers accessed mobile phones through their husbands, while 23.1 percent used mobile phones owned by co-wives, sons, daughters, friends or relatives.

Table 1: Phone ownership by gender

Nature of Getting the Mobile Phone	**Gender**		**P-value**
	Male N=33	Female N=48	0.008
I bought it	96.9	68.8	
Gift (from NGO, relatives)	3.1	18.8	
Bought by spouse	0	12.5	

Field findings February-March 2017

4.2 – Means of acquiring the mobile phones by gender

There was a strong relationship (P=0.008) between the means of mobile phones acquisition and gender distribution of respondents. More male farmers (96.9%) acquired their mobile phone handsets by buying them compared to 68.8% of the female respondents. On the other hand, 18.8% of the female farmers acquired the mobile phones as gifts from relatives and NGOs compared to only 3.1% of the male respondents. Another 12.5% of the female farmers acquired their mobile phone handsets through their spouses while no single male respondent received a mobile phone from his spouse.

4.3 – Informing Partner about the impending acquisition of the mobile phone

There was no gender significance (P=0.140) in the need to inform partners when acquiring mobile phones by both male and female respondents even when the reasons vary to some extent. Many male respondents informed their spouses to either promote transparemcy (34.8%) or avoid domestic violence (30.4%), while female respondents mainly informed their spouses about the impending acquisition of mobile phones because of the fear of domestic violence (34.5%). A further 24.1% simply said that they were aware that the husbands were in charge so they had to inform them.

4.4 – Spousal response to partner's acquisition of a mobile phone

There was no gender significance (P=0.508) in the ways both male and female farmers' partners responded to their acquisition of mobile phones. Majority of male farmers (73.1%) and female farmers (68.8%) indicated that their partners were supportive, while the second biggest percentage of women (21.9%) said that their husbands didn't say anything compared to 11.5% of the male respondents. Fifteen percent of the male farmers indicated that their partners loved the fact that their husbands had got mobile phones compared to 9.4% of the female farmers.

4.5 – Use of mobile phone by gender

All male farmers and 98.5% of the female framer group members used mobile phones for making calls, while a majority of women used them for the same function. Three quarters of the male respondents used mobile phones for mobile money transactions compared to half of the female respondents. More male farmers (66.7%) used mobile phones for SMS services compared to 45.6% of the female farmers. Furthermore, slightly more than half of the male farmers used mobile phones to access radio compared to 33.8% of the female farmers. Forty two percent of the male farmers used mobile phone calculators compared to about a quarter of the female farmers. The number of male farmers that were using mobile phone enabled internet was 30.3%, while a quarter of them were accessing social media compared to 1.5% of female farmers. About a quarter of both male and female farmers were using their mobile phone handsets for photograhy.

Findings indicate that phone calls were made for varied reasons. Fifty three percent of the 32 male farmers used mobile phones to make calls to friends compared to 43.9% of the 68 female farmers. On the other hand, 51.5% of the 68 female farmers used mobile phones to call home to check on domestic issues like a checking on a sick child. Mobile phones were also used to enquire about farmer group plans by 25% of the male farmers and 34.8% of the female farmers. In addition, 34.4% of the male farmers used their mobile phones to check on market prices compared to 12.1% female farmers. A further 21.9% of the male farmers and 24.2% of the female farmers used the mobile phones to enquire about farming practices. These findings imply great use of mobile phones for agricultural information.

5. Discussion

Technology gender relations were evident at the point of access to and use of mobile phones by farmers. These gender technology relations are evident in three categories: 1) technology access, 2) technology control, and 3) technology functionality.

5.1 – Technology Access

Technology access is mediated by affordability of the technology by the farmer. Affordability is not limited to finances but also social affordability[1]. Whereas financial affordability[2] would require that male and female farmers should afford to buy a mobile phone to cater for their communication needs, some of them especially the female farmers, cannot financially afford. This is what leads to social affordability of the technology where a financially challenged farmer, relies on his or her social networks of friends, spouse and other houshold members to afford access. In some rare cases, social affordability goes beyond the social network to include NGOs that would extend mobile phone gifts to female leaders of farmers groups for the benefit of the rest of the group members. Whereas financial affordability expands access for both male and female farmers, it is social affordability that allows all farmers to access a mobile phone that they would have otherwise not been able to access, own or use. The findings corroborate the UTAUT findings by Venkatesh et al (2003) that indicated that social influence has an impact on women's decisions to access technology based especially if access is mandated rather than voluntary. The findings though add that social affordabilty could be institutional rather than social relations especially if an institution like an NGO is supporting a group of people.

The study findings show that for both male and female farmers that access mobile phones through purchase, majority male farmers deemed it ethical to inform their spouses of the impending acquisition of the technology based on the quality of their relationship compared to about half of the female farmers. The findings also indicated that some of the farmers were either not married, were divorced when they acquired the mobile phones and thus had no partner to tell about their acquisition. The findings about female farmers informing their spouses about the impending purchase of mobile phones are in agreement with Venkatesh et al (2003) and Venkatesh and Morris (2000) that argued that women yield more to significant others in technology access. However, the same was true for male farmers as they too informed their spouses of the impending purchase of the mobile phones. In many respects, this was a way spouses negotiated the access to mobile phones by informing their spouses about the possibility of purchasing a mobile phone before hand.

Acquiring the mobile phone through social networks by female farmers was an external decision that they could not control and thus they could not inform their spouses. Nonetheless, the gift increases access to the mobile phone for female farmers. This affirms Venkatesh et al (2003) argument about facilitating conditions that support technology adoption. Despite the fact that Venkatesh's team had concluded that facilitating conditions have no significance in behavioural intention to use technology, the ability of social networks to step in and provide mobile phones to female farmers was significant in increasing access.

Facilitatting conditions were also evident in the fear of or anticipation of domestic violence caused by the acquisition of mobile phones either due to suspicion of infidelity or increased expenditure on the mobile phone. This induced transperancy for both male and female farmers informed their spouses. Informing the partner of the impending acquisition of a mobile phone

[1] I use the term social affordability as the ability to harness social networks to access a technology that would otherwise not be secured financially.

[2] I use the term financial affordability as the ability to marshal resources to buy a technology at the prevailing price

implies that the partner is respectful and sensitive to their spouse's needs or fears. Mobile phones were reported to cause anguish and suspicion among spouses especially if the mobile phone goes off or a partner leaves it behind. Earlier studies about mobile phones by Watson and Atuick (2015), USAID (2012) and Madanda, Ngolobe and Amuriat (2009) indicate that mobile phones lead to social tensions and suspicion of infidelity that may cause domestic violence.

5.2 – Technology Control

If both male and female farmers have access to mobile phones, who then has control of the technologies? What is the implication of this technology control on gender relations? Control increases mobile phone access and reduces dependence in access.

According to the findings, the ability and decisions to access mobile phones does not favour either male or female farmers. Further interrogation of the findings though shows a clear preference for mobile phones by male. Mobile phones were preferred by male farmers for their speed of conveying information as well as their portability. Akin to Venkatesh et al (2003), performance expectancy that is rooted in socialisation and gender roles. Male farmers need a portable mobile phone because they must operate in the public sphere as teachers, builders and shop owners and thus need a quick way of transfering information to the domestic realm and the public arena to fellow traders, middlemen and sources of agricultural inputs.

Preference for mobile phones influences ownership and it is at this point that a mobile phone becomes more more masculine. Regardless of how female farmers acquired their mobile phones, many have limited ownership of and control over the two technology in comparison to the male farmers. Consistent with Doss (2001) who argued that men take advantage of new technology as it favours male power, findings indicate that female farmers have limited ownership and control of the mobile phone. This turns female farmers into technology dependants who have to depend on either husbands, relatives or friends to make or receive calls. The mobile phone is majorly controlled by the male farmers and has taken on the identity of a male status symbol, some sort of embodiment of masculine power. Husbands possess this masculine power and use it at the point of granting access to their wives when they need to communicate within their social networks or with agricultural traders or to ensure control over their wives by enquiring about their whereabouts or allocate them domestic work. The internalisation of the mobile phone as a masculine technology coupled with little or no income by the female farmers is the reason why female farmers cautiously own mobile phones and many get them through social networks hence eroding their control of the technology.

Furthermore, reciept of a phone as a gift diminishes the control of the recipient. Earlier studies indicate that technology as a gift has the potential to take away the agency of the recipient beyond limiting discussions on its use between partners as argued by Ghertner (2006). Essentially, technology as a gift further dimishes the recipients' control and agency at the acquisition stage since it stiffles debate about access so as to increase the barganining power of the recipient and ends up increasing the power and control of the source of the technology gift. If a member of the recipient's social network extends a mobile phone to the recipient, it is their choice not the recipient's. This results into more male domination and control of wives' and their movements in corroboration of earlier findings by Ngu (2013), Nnadi et al (2012), Wajcman (2010) and Ghertner (2006).

The ownership of the technologies also espouses masculine and feminine traits that influence control. A mobile phone is not only a technology transfer to an individual but it is also a multi-function technology that that can be used as a radio, internet source, making and recieving calls or SMS, and calculations in the event of a transaction. The mobility of the mobile phone technology and the individual control and ownership of the same, unlike say a landline, suits male farmers' mobility, power and control. The male mobile phone owner in this case chooses either to use it alone, or allow other household members to access and use it. Whereas the mobile phone has the same influence on some female farmers' mobility, to other female farmers, it is a control tool that domesticates market services by turning the home into a psuedo-market or by allowing the husband control her movements. The advantage though of domesticating the market is creating a safer environment for female farmers to sell produce, save time for other activities and it's far cheaper than incurring transport costs to far off markets.

5.3 – Technology Functionality

As Venkatesh et al (2003) argued that effort expectancy has a direct effect on intention to use and acceptance of a technology, the findings in my study corroborate this argument. Mobile phones are easily used by the educated because of their ease of use. A mobile phone turned out to be a technology transfer to the educated male and female farmers. This favoured male farmers as most female farmers were either not educated at all or had very low education levels and lacked basic literacy to operate the handset however basic it was. Unlike the male farmers, findings indicate that many female farmers could not read and interprete messages or be able to record contacts, scroll and select names of contacts in their phonebooks for dialling. In the event that an illiterate woman has to invite the husband to help her scroll and make calls, she surrenders any control she has over who she communicates with and over what. The trouble with the mobile phone for such a female farmer is that all her agricultural transactions are dependent on her ability to initiate communication with either traders or potential buyers whenever she gains access to a mobile phone or risk missing out.

6. Conclusion

The paper reveals that UTAUT is central in explaining technology access and use for male and female farmers. It is evident that performance expectance, effort expectance, social influence, and facilitating condition play a crucial role but in ways slightly different from what Venkatesh et al (2003) envisaged in some respects. For instance, social influence previously thought to only impact women by Venkatesh's team, was found to be high for male farmers as well. In so doing, the study highlights the importance of social networks and context in technology access and use. UTAUT was originally meant for organisations but not households and this could have influenced the changes in conclusions about its applicability in a household setting. This may also account for the fact that facilitating conditions were found to be important in decisions to access and use mobile phones by farmers yet Venkatesh and group did not find any significance. This significance was seen in the fear of domestic violence by spouses and hence both male and female farmers would inform their spouses whenever they wanted to buy a mobile phone.

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Practitioners and Work-in-Progress

Short Papers

Strategy for the adoption and effective utilization of mobile phone technologies in smallholder agriculture in Zimbabwe

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ABSTRACT There is a growth in research on the benefits and use of mobile phone technology in the whole world. Zimbabwe as a country has seen that this is a feasible route to explore. This paper explores how other countries are using this technology to improve agriculture yields. It analyses factors that are hindering mobile phone technology use and adoption among smallholder farmers in Zimbabwe. The paper employed qualitative research design, guided by inductive approach underpinned by interpretivism philosophy. Findings from the gathered data showed that smallholder farmers are willing to make use of mobile phone technologies in their farming context. The cost of gathering data, lack of training and poor infrastructure was seen as the main hindrances to adopting mobile technology in agriculture. The paper then designs a strategy that can be used for mobile technology adoption and effective utilization by smallholder farmers in Zimbabwe. Recommendations such as farmer training, government involvement and infrastructure development in rural areas were suggested. This research adds to the existing body of literature since there was no known research in Zimbabwe which focused on developing a mobile phone strategy for smallholder farmers.

Keywords: Smallholder farmers, Mobile phone, Rural, Interpretivism, Strategy, Adoption of Technology.

1. Introduction

Agriculture is the backbone of the economic growth and poverty eradication solutions especially in the rural areas of Zimbabwe (Muchati, 2014). The majority of the country's population owns a mobile device known as cell phone that is being used for communication (Musungwini, 2016). Mobile ICT is one of the trending technologies that are providing solutions to problems encountered in any industry such as education, health and agriculture. The use of mobile devices do offer great potential in improving level of services and reducing costs in most industries. After investing huge amounts of money in mobile ICT technologies, if the mobile devices are used for communication purpose only (such as making calls and texting) they will be underutilized. This research develops a strategy for adoption and effective utilization of mobile phone technologies by small holder farmers in Zimbabwe in order to

improve the living conditions of smallholder farmers. Mobile technology and mobile phone technology is used in this research to mean mobile and cellular communication devices and services. These terms are used interchangeably to mean those technologies that can be moved from one place to another when accessing information.

2. Background and Context

Mobile phone technology is one of the many ICT technologies that have evolved in the recent years (ICT4Ag project 2014-2015). Asongu (2015) and Aker and Mbiti, (2010) highlighted that the fast penetration of ICT will bring in new opportunities for African farmers in improving their knowledge and lifestyles. Mobile phone based services have been developed in recent years, to provide marketing information and for use in agriculture (Gakuru et al 2009; Quiang et al, 2011). More so researchers have discovered that mobile phones have a positive impact on poverty reduction (Silarszky et al, 2008). However adoption of these mobile phone technologies and their utilization are low in developing countries and there is need to design adoption and utilization strategies for specific groups (Aguilar-Gallegos et al, 2015).

Mobile phone technology has become the most omnipresent technology in developing countries (Aker & Mbiti, 2010b; Musungwini, Zhou, & Ruvinga, 2014). Mobile devices such as mobile phones that are normally being used to communicate with family members can be used for agriculture business. As a result it can help transform businesses including the agriculture sector (Deloitte, 2012; Ewing et al 2014). Nyamba & Mlozi (2012) and Oladele (2015), research have shown that mobile phone technologies can improve production among rural area small holder farmers. Small holder farmers in rural areas require information on weather, markets, cultivation timing among others and mobile phone technology has been used in other countries so that this information reach farmers (Chisita & Malapela 2012).

In Sub- Saharan Africa mobile phone applications in agriculture are being used to monitor rainfall tracking, soil composition, maps, and inventory management. According to the World Bank about 67.72% of the people in Zimbabwe live in rural areas and these people depend on agriculture for survival. An increase in the number of base stations in rural areas has been noted in the past year (POTRAZ 2017). Base stations are needed for one to be able to utilize mobile phones or cell phones; therefore mobile phone technology plays a significant role in improving the livelihood of smallholder farmers in Zimbabwe.

Chisita & Malapela (2012) agrees that mobile technology adoption is providing agriculture industry with opportunities to extend their services to those who are disadvantaged and geographically dispersed especially in rural areas. According to researches done in countries such as Tanzania, Uganda, China, Ethiopia, Kenya, mobile technology plays an important role in providing information to farmers (Furuholt & Matotay, 2011; Gichamba, Lukandu, & Lukandu, 2012; Martin & Abbott, 2011; Nickitas, 2011; Qiang, Kuek, Dymond, & Esselaar, 2011; Tadesse & Bahiigwa, 2015).

In Zimbabwe some mobile phone technologies are there for agriculture but there is slower adoption because of lack of strategies. These include mobile services and apps for agriculture. The following are some of the mobile phone technologies in Zimbabwe agriculture sector:

- EMkambo Nest – this is a mobile app for Zimbabwe's agriculture sector which complements SMS, call centers and face to face knowledge sharing among farmers.

- Kurima Mari – this is an e-extension mobile farming App created for small holder farmers and extension workers.
- E-Hurudza Africa – a market driven platform developed by the Hurudza team to provide information to farmers regarding different markets and agriculture activities.
- Eco-Farmer – an ECONET owned mobile farming platform used to deliver farming tips and advice through SMS's
- Agro Axess – a mobile app developed by XDS (eXpert Decision Systems) that provides farmers and merchants with an input –output management solution.

At the time of carrying out this research many articles had been published on adoption and use of ICTs particularly mobile phones adoption and use by smallholder farmers in Sub-Saharan Africa. However, we established that, the diffusion models are at the epicentre of ongoing efforts to scale ICT use in agriculture. At the time of carrying out this research there was still debate on how best to achieve effective use of mobile phones in smallholder agriculture with no end in sight. Even in the developed countries the adoption and use of mobile phones is not extensive, maybe because the technology play more of a complementary role whereas in the developing countries it is the only technology available. Usually, research on the diffusion of technology is used when the researcher seeks to understand how the spread of an innovation happens among certain groups in a given environment.

At the time of carrying out this research there was no known research which specifically focused of development of a strategy for the adoption and effective utilization of mobile phones by smallholder farmers.

3. Strategy Formulation

A strategy is concerned with the future. It can be explained as a roadmap to achieve future goals. To come up with an effective strategy in the adoption of mobile phone technologies among smallholder farmers the following strategy formulation phases as explained by (Wheelen and Hunger, 2006) will be explained:

- Diagnosis
- Formulation
- Strategy implementation

The research will assist in coming up with a strategy for the adoption and effective utilization of mobile phone technology in smallholder agriculture in Zimbabwe. The mobile phone technologies are there but not known by smallholder farmers in Zimbabwe.

4. Problem Statement

(Aguilar-Gallegos et al, 2015) highlighted that adoption of mobile phone technologies and their utilization among smallholder farmers are low in developing countries and there is need to design adoption and utilization strategies for specific groups. With that in mind this can be seen as the best time to come up with strategies that can enhance adoption and use of mobile phone ICT in agriculture.

5. Research Objective

The main objective of the research is to develop a strategy for the adoption and effective utilization of mobile phone technologies by smallholder agriculture in Zimbabwe.

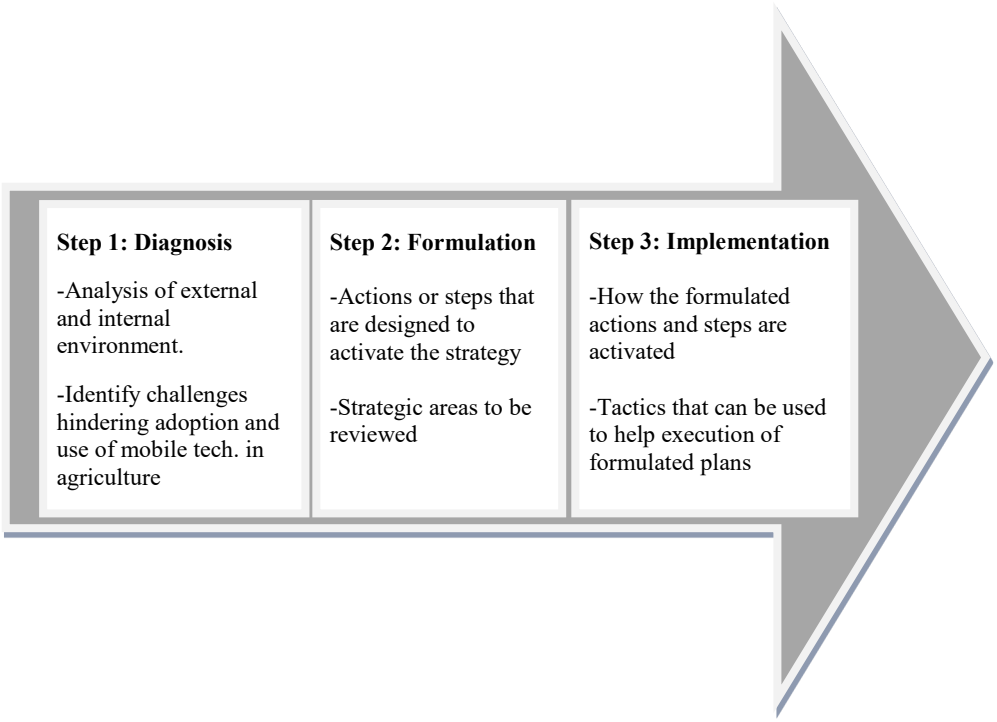

Figure 1: Strategy formulation steps

6. Research Methodology

In order to meet the research objective, the methodology employed is based on an exploratory research in the agriculture sector in Zimbabwe, involving deployment of semi-structured interviews and questionnaires. The research was done in accordance with the case study guidelines as explained by Yin (2014). Case studies do allow for the use of multiple sources of evidence. The impact of Mobile technology adoption and use in the agriculture sector in Zimbabwe is the real life phenomenon. Zimbabwe was chosen because it is a developing country which relies on agriculture and because of the new strategy of command agriculture that has been introduced. The portion of the population that the researchers used is the accessible population (Korb, 2012). Smallholder farmers in the Midlands province were used for this research because the province has a high number of populations as compared to others and the population is diverse. In this research snowball sampling was employed were participants with the required characteristics identify other participants. The results from such a study can however be generalised to other African countries which have the same context as Zimbabwe.

7. Data Collection

Data collection involved the use of semi-structured interviews with small holder farmers and agriculture extension workers. The interviews were held in Midlands's province and this included 10 extension workers and 2 supervisors. Other small scale farmers were interviewed to give their view on mobile technology use in agriculture. Most of the small scale farmers filled in the given questionnaires. A total of 40 hard copy questionnaires were distributed to different small holder farmers through their extension workers. The main aim of questionnaires was to find out which media is used by farmers to get agriculture information and the challenges

they face when using mobile technology for agriculture purposes. Of the 40 questionnaires distributed 5 were not returned giving 87.5% response rate from small holder farmers.

8. Data Analysis

Gathered data was analysed using a thematic analysis method. Braun and Clarke (2012) explained this way of analysing data as involving identifying themes and patterns within the gathered data. In cases were responses from interviewees and those who answered questionnaires pointed to a common aspect a general phrase was identified. The phrase provided a collective description to the unstructured data. Relevant aspects of the research are explained in the following section were the strategy is developed.

9. Strategy Development

To come up with an effective strategy in the adoption of mobile phone technologies among smallholder farmers the following strategy formulation phases that is Diagnosis, Formulation and implementation as explained by Wheelen and Hunger (2006) will be explained.

9.1– Diagnosis

This involves an analysis of external and internal environment. A look at the challenges hindering adoption and use of mobile technology in agriculture. Diagnosis was done through engaging farmers and other stakeholders in environmental scanning. This helped in identifying challenges that are hindering mobile technology use in agriculture, gaps and weaknesses that are there in the agriculture sector. From the environmental scanning and assessment, the results were placed into 5 groups titled diagnostics (D). These are as follows:

D1: Poor Infrastructure: Internet challenges, expensive mobile services and power shortage were seen as the main factors that affect the use of mobile technology in agriculture. Since mobile technology requires power and mobile network facilities such as base stations, most respondents highlighted the challenges in these infrastructures and the highly priced mobile services as hindrances to mobile technology use in agriculture. From this diagnostic it can be seen that there is a problem in the infrastructure and enabling services.

D2: Poor Human Skills: The second diagnostic was the issue of Human skills. The level of education, lack of technological skills of the farmers and involved stakeholders keep them away from utilizing mobile technologies for agriculture. Most stakeholders in the agriculture sector especially farmers only understand that mobile phones and technology are used for making calls and texting and they are not familiar with other functions on these mobile devices.

D3: Poor Content and Information Collaboration: The third diagnostic looks at the information and content needed by the famers. There is a high demand for high quality agricultural information to the smallholder farmers. Provision of quality information through the mobile phone can increase production. Appropriate information which is related to farmers needs in terms of its relevance and format is needed. Information related to best crop selection, access to inputs, sound management of the farming activities and post-harvest techniques should be available to all smallholder farmers. Since they believe mostly information provided by the government and the ministry of agriculture as their main sources of information, these stakeholders should be part and parcel of information delivery. Content should be created from reliable sources. Local languages and local content should be taken into considerations. This

information should be mobilized and packed to meet different users. Smallholder rural communities' information should be widely shared.

D4: Policies and Regulations: Implementations of policy that govern Mobile ICTs have an impact on technology diffusion and use. There is need to restore international relations with other mobile ICT providers so as to increase competition among the service providers. Foreign investment is also needed in our country to increase the use of mobile ICT among farmers. Poor or lack of strategic alignment between the ICT policies and ministry of agriculture policies is a challenge in this sector. If these two ministries work hand in hand they can achieve the goal of mobile technology use in agriculture.

D5: Financial Resources: With all the above mentioned areas finance should be included as well. As a country we suffer from under capitalization of projects and to get profits from those projects it becomes difficult. This under capitalization affects mobile phone apps and services developers to be reluctant in providing good apps and services. To this end high pricing strategy is being used so that those providing for mobile service can profit as well. Mobile data and devises are highly priced to the extent that few farmers can afford these.

9.2 – Formulation and implementation

To be able to solve and respond to the given diagnostics, gaps and challenges, action plans need to be identified for the five diagnostics. The following action plans can assist in solving the highlighted challenges.

Action Plan 1 (AP1): Poor infrastructure was identified as a challenge and factor that hinder adoption and use of mobile technology in agriculture in Zimbabwe. The suggested action plan is enhancement of the rural infrastructure. Electricity should be availed to rural citizens and it should be consistent and reliable. Mobile technologies and internet should be deployed to even the most remote areas at an affordable price.

Action Plan 2 (AP2): Poor human skills were identified as a challenge in the agriculture sector and the action plan suggested will be training of famers. Training can be done on extension workers and model farmers, and these can act as change agents. This training will involve training of different functions that are found on mobile phones. Weather information is found on mobile devices but very few can interpret their meanings. With training farmers are likely to be exposed and to be empowered thereby making proper use of mobile phones for agriculture purposes. Adult literacy programs and capacity building programs sponsored by mobile phone service providers and the government can enhance the literacy rate.

Action plan 3 (AP3): Content and information collaboration problem can be solved by rural councils. These can assist in establishing coordination among farmers, extension workers, ICT providers and agriculture institutions. If these are well coordinated relevant content will be passed through the use of mobile phones. When there is good coordination extension workers can sensitize smallholder farmers on the effectiveness of mobile phone technology in their farming activities. This helps in creating awareness

Action plan 4 (AP4): Policies should be created by the ministry of agriculture to aid mobile phone use in agriculture. Government, ministry of Agriculture and ICT should support mobile-Agriculture applications. Results from gathered data showed that most initiatives are donor based and when these are no longer there, there is no one to continue with the initiative.

Nationwide initiatives are needed that makes use of mobile phone-based systems among smallholder farmers and agriculture practitioners. Policies that guide continuation after donor-based initiatives can help curb technology use problems.

Action plan 5 (AP5): In the case of finances Subsidizing mobile devices and services can assist in higher adoption and utilization since most of them indicated that the cost of the technology is on the higher side. This can only be achieved if mobile phone service providers work hand in hand with the government and ICT ministry. Subsidizing of prices of data bundles, internet charges can also assist in utilization of mobile technology. Various actors in the value chain such as buyers of output products and sellers of inputs should also be engaged. Technology cost to farmers in rural areas should be affordable. In this case banks and mobile money service providers should consider interest free loans on mobile phone purchases to farmers and the repayments should be easy instalments.

Figure 2 summarises the challenges for adoption and use of mobile technology in agriculture, the action plans that can be used to aid adoption and how these plans can be executed.

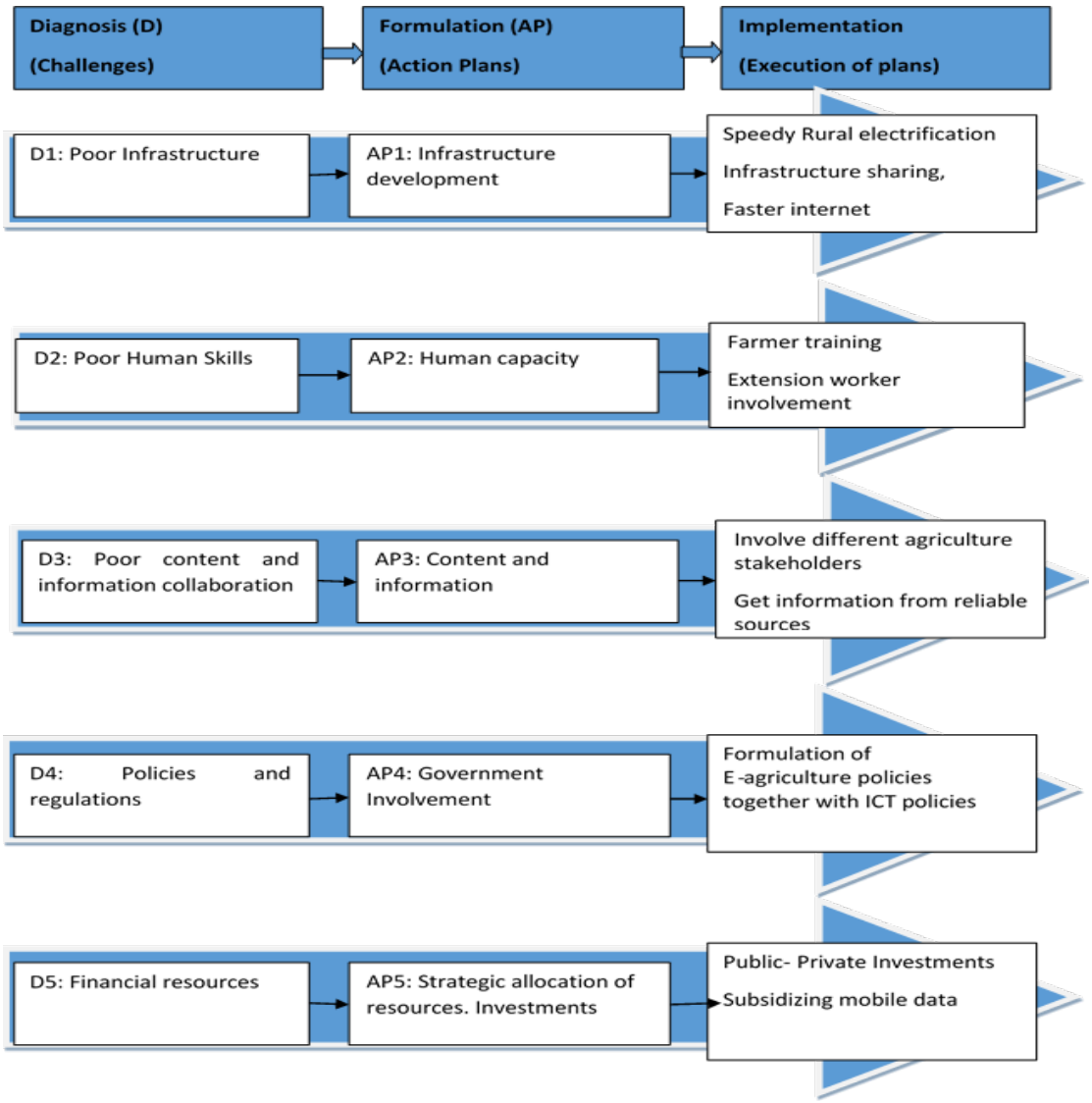

Figure 2: Summary of the five courses of diagnosis, planning, and implementation.

10. Conclusion

This research looked at the benefits and factors that affect the adoption and use of mobile technologies in agriculture. A strategy was proposed to encourage the adoption and utilization of mobile technology among smallholder farmers in Zimbabwe. Further research to test how the strategy will operate in a real environment can be done.

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Using Mobile Phones to improve Veterinary Service Delivery and provision of First Aid Information for Livestock Owners in Nakasongola Uganda

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ABSTRACT Delays or any constraints on the access to quality veterinary services can lead to loss of livestock. For farmers in rural areas this is a big challenge as professionals such as para-veterinarians and veterinarians on the ground are few. Attempts have been made to bridge this gap using IT; however, a lot of challenges have been met. These IT solutions are biased to using desktop computers. In the rural setting power is a big challenge if this is to operate. Secondly, the mobility of pastoralist cannot allow them to use computers. Some developing countries use Community Animal Health workers to treat animals and capture infections details. This study investigates how to use mobile phones to improve veterinary service delivery and provide first aid information to livestock owners, especially in rural setting in the developing world.

1. Introduction

According to the International Telecommunications Union, global interconnectedness continues to grow rapidly, with 95% of the world's population living in an area covered by a mobile network, and the majority of Internet users now located in developing countries (Holmstrom and Beckham, 2017). Network services and mobile devices are also becoming more affordable and their usage across the globe is increasing. As of November 2016, there were 7.5 billion mobile device subscriptions worldwide with smartphone subscriptions accounting for the majority of these source. Information technologies are rapidly advancing the way in which animal health data and information are collected, analyzed and shared in order to support animal health management, disease surveillance and response plus decision-making (Holmstrom and Beckham, 2017). Mobile devices have been used to perform mobile health technologies, or mHealth technologies, these include handheld devices such as mobile phones, smartphones, and tablets that allow data to be collected at the location and time at which animals are examined (Gichamba and Lukandu, 2012; EllyssaKrosk, 2008). Mobile phone health technologies avail for the collection of data and ability to reach to big numbers of people at a low cost. By the portable nature of such technologies, they can be used in rural areas of developing countries where livestock and pastoralism are commonly practiced. Mobile phone health technologies provide data collectors with the ability to quickly reach large numbers of people at a low cost. In addition, such technologies, by their portable nature, can be utilized in

rural areas of developed and developing countries where livestock are commonly located (Karimuriboet al., 2016). Furthermore, they enable all members of an animal health enterprise (e.g. livestock owners, community animal health workers and technicians, veterinarians, etc.) to be active participants in bidirectional information exchange (Holmstrom and Beckham, 2017, pp. 527-529).

The key problem that is encountered in treatment and control of endemic diseases within the pastoral communities of Uganda is the delay in the disease reporting. By the time a disease is reported it is already out of control. Second, there is a very long distance between the veterinarians and the nomadic pastoral lands. Cars and motorcycles cannot access the pastoral lands and most times the veterinarians a left to walk long distances without marked roads or access. The main means of transport used to move to those distant places are walking and riding a bicycle. Farmers noted that sometimes it takes them two to three days on the way to reach the drug shop and market places. This study investigates on how to integrate Mobile phone devices in IT solutions to reinforce efficient delivery of veterinary services especially to rural setting in the developing world. The research further explores the use of mobile devices and a mobile application to report symptoms, diseases and areas where there is an outbreak to the online system. The farmers are provided with a mobile application to send symptoms to the veterinary system, where the information is processed. The system indicates the location of the farmer and avail him with first aid information and nearby veterinarian's contact information if any. This information is stored in database to be used to analyze areas that are most affected with diseases. Besides the aim of giving first aid information to the farmers, the system also has the capability of giving an early warning for disease outbreak in some areas.

This paper is organized into 5 sections. In Section 2, a brief overview of the related studies is provided. Section 3 presents methodology used to accomplish the study. Section 4 provides findings and the proposed system. The paper ends with section 5 which presents discussions, conclusion and recommendations.

2. Related Work

A lot of literature exits about work that has applied livestock disease management using ICT as an extension services delivery tool. A review was done on different models developed to control, monitor, record and analyze livestock diseases. The first model reviewed in this study is Animal Resource Information System (ARIS) which was developed by African Union's Interafrican Bureau for Animal Resources (AU-IBAR) with the aim of providing a comprehensive information system within its member states (Chibeu, 2011). The idea of ARIS was founded by the Pan African Program for the Control of Epizootics (PACE). ARIS provides "early warning and rapid response, allocating resources, assessing the level of livestock contribution to livelihoods and GDP, and formulating policies" (Chibeu, 2011). ARIS is a multilevel and multiple usage system that integrates all Animal Resources information; allowing for visualization of information in the form of tables, and maps. The system was developed using Oracle as the database engine technology (Chibeu, 2011).

The second model reviewed is Transboundary Animal Disease Information (TADinfo) System which is a veterinary data management system deployed at the Epidiomology Unit offices in Entebbe Uganda. It was designed to provide national veterinary officers with a tool capable to enhance epidemiological analysis and decision making (Kamata, 2011). In 1994 FAO launched a program known as Emergency Prevention Systems (EMPRES) for Trans-boundary Animal

and 32 Plants Pests and Diseases that led to the development of TADinfo. The system has five data entry modules to record all the events related to animal health and these include Field Observations, Abattoir Observations, Active Surveillance, Vaccination and Census. TADinfo also has the capability of presenting vaccination coverage, sero-prevalence or distribution of outbreaks on a map, and export data for further analysis with minimal data (Kamata, 2011).

The third model is the World Animal Health Information System (WAHIS) is an international early warning and response system for human and animal diseases. It is used in monitoring exceptional epidemiological situations, and any detected exceptional epidemiological event occurring in a given territory or country in real time (Jebara,2011).WAHIS is owned and operated by the OIE, in the case of disease reporting, the system is limited to a country representative from member countries who feeds into it the information (Vallat et al., 2013). For monitoring the disease WAHIS also depends on disease intelligence. Disease intelligence is the tracking of unofficial information using channels like the media, to update disease outbreaks and other animal information (Jebara, 2011).

The fourth model reviewed is a web-based GIS system, ArcIMS, that establish interactive mapping capability that allows veterinarians to use the internet for remote data entry. Davies et al. (2007) describe this system which was created for the surveillance of diseases, primarily PRRS, in swine farms in Minnesota, USA, and that it uses publicly available high-resolution aerial photography as a platform for mapping. The system lets authorized veterinarians "edit specific client farm data including location, disease and other attributes (editing limited to one veterinarian to per farm)" and for authorized members of an organization to view farm data related to them (Davies et al., 2007, p. 735).

However, all the above models have been developed putting much emphasis on disease reporting with little or nothing to the provision of timely veterinary service delivery within the pastoral lands. Given the challenges and difficult to access the nomadic pastoral areas, the proposed model intends to avail online veterinary services responding to the farmers request.

3. Methodology

3.1 – Requirement gathering and analysis

The study used Nakasongola district as a case study and this was from June to September 2015. The district has about 20 villages. Due to resource constrains, we gathered data from two villages. We used purposive selection of subjects. Fifty (50) respondents were identified as potential sources of data needed for the study. The respondents were in three categories: (1) five Veterinary officers; (2) five community health workers; and (3) forty farmers. We used both interviews and questionnaire as data collection techniques. From the five veterinary officers we captured data on; common cattle infections, frequency of consultations from the community, and challenges. For community animal health workers we managed to get five subjects. Community health works are society members who have completed at least senior four and have been trained to provide first aid and forward serious cases to veterinary officers. From these we were interested in; common diseases, frequency of visits by veterinary officers, description of first aid they provide, and the challenges faced. Now we went to farmers. These farmers owned 50 to 100 cattle. For these farmers, cattle are taken as reservoirs of their wealth and because of this, they guard their cattle enviously. Unfortunately few farmers could speak English a common medium of communication to Ugandans especially the elite. We managed

to collect data from 20 farmers. The farmers provided information on: (1) common diseases attacking their cattle; (2) how often are they visited to get help from veterinary officer and community animal health workers; and (3) challenges faced. These data were analyzed using descriptive statistics as detailed in the later section entitled Findings from the requirement gathering.

3.2 – Development methodology:

Rapid application development (RAD) was used as the methodology to design the model. The method uses minimal planning in favor of rapid prototyping (Beynon-Davies, 2000). In RAD model the components or functions are developed in parallel as if they were mini projects. The method helps in integration from very beginning to solve a lot of integration issues (Mbaluka & Okeyo, 2016). The model was divided into two, the web application that was developed independently and later mobile applications of which were integrated. For a better understanding, a prototype was presented and examined by the users to prevent misunderstandings and miscommunications between them and us developers.

4. Findings and the proposed system

4.1 – Findings from the requirement gathering

The initial investigation of the study shows that 2 of the 5 veterinarians assert that the method used to report livestock disease outbreak is not sufficient, one of the veterinarians feel that farmers are in places which cannot be easily accessed making it difficult to control diseases and provide timely veterinary services, one of the veterinarians feel that phone calls from the farmer have helped in livestock disease control and one thinks some farmers use traditional medicine rather than reporting which hinder sufficient disease control.

Three of the five CAHWs feel that the current system of veterinary service delivery is not sufficient enough to save livestock while two prefer it.

Further in the study 65% of the animal owners and herdsmen felt that the method in place is poor for veterinary service delivery and disease reporting, and that it requires improvement. 15% (i.e. 3/20) where ok with the current method and 20% of the animal owners and herdsmen gave no answer to this question.

4.2 – Proposed system

The proposed Model architectural design was developed based on the challenges highlighted and opportunities identified as presented in the section entitled *findings from the requirement gathering*. Based on this, A mobile application was developed to allow CAHWs report diseases and receive first aid information to rescue the farmers' livestock before the veterinarians show their way. The CAHW farmer uses the mobile application to report his location, type of infected livestock; symptoms, total livestock and number of infect livestock. The system is able to process the received information and in return the farmer is sent the proposed first aid and the nearby or available veterinarian's contact information. The information is then directed to the database and it is displayed on the veterinarians' phone or desktop using the web interface. Diseases and symptoms are stored on the database for decision making.

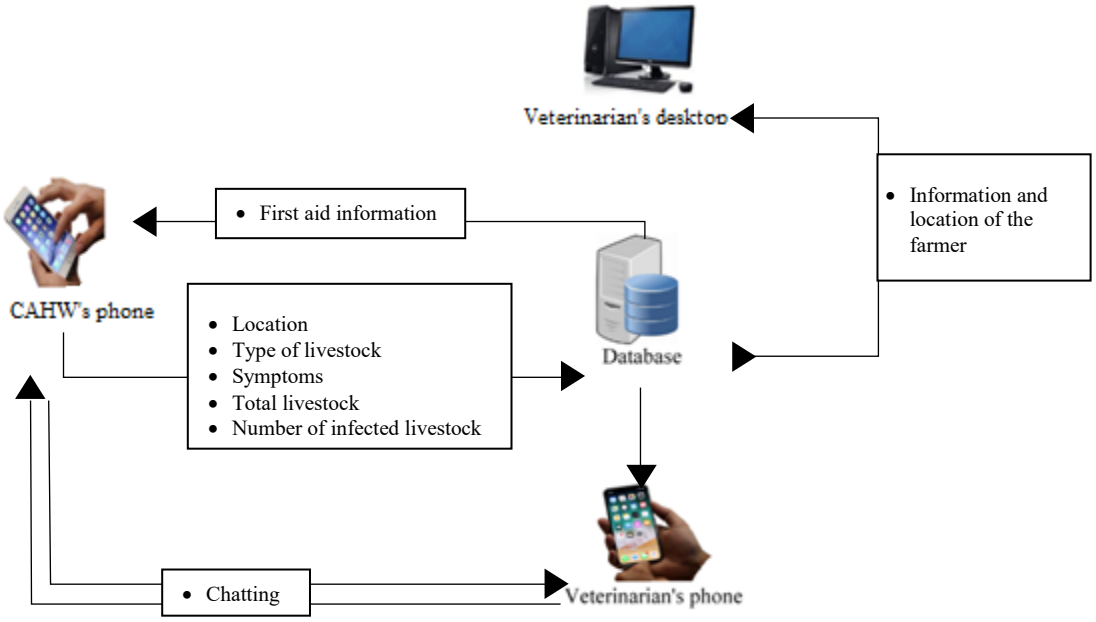

Figure 1: Model architectural design

4.3 – Mobile app

The mobile application is used by CAHWs, field veterinarians and farmers who are able to read and write. The screen shoots present the login interface (Figure 2), CAHW's and farmer's complaint form (Figure 3), and system returned first aid information and available veterinarian's contact details

Figure 2: Startup menu with four login buttons: DVO Panel, CAHW Panel, Field Veterinarian Panel, and Farmer Panel.

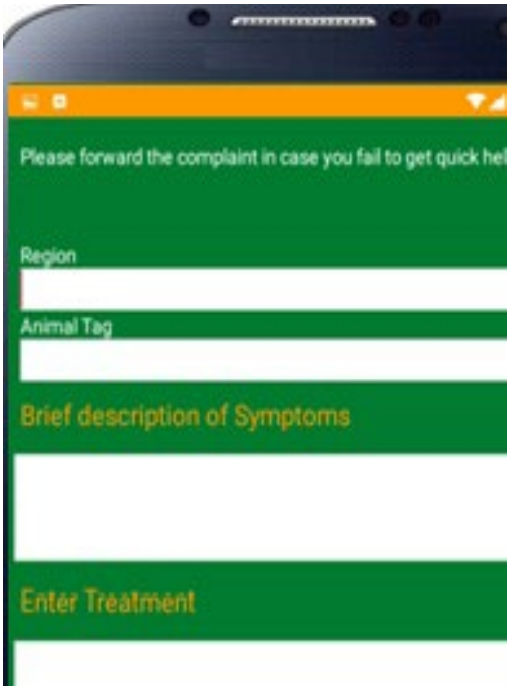

Figure 3: CAHW complaint form

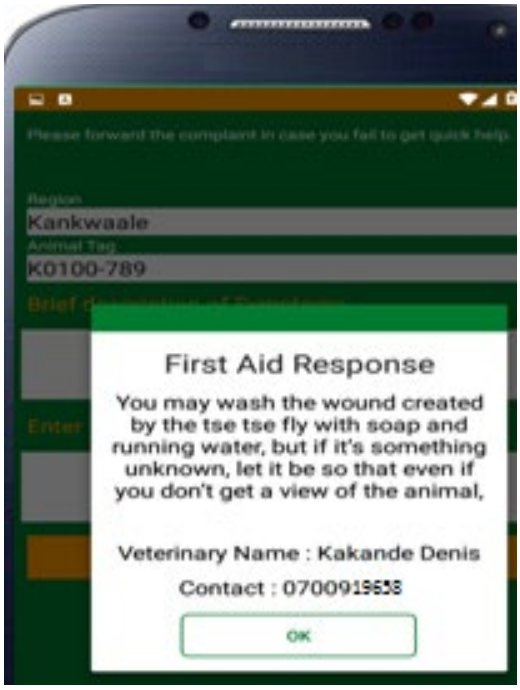

Figure 4: First aid information

4.4 – Validation of design

Due to resource constraints (time & facilitation), the prototype was validated according to the available means.

Three members were involved in solution evaluation and these include: two technical persons and one veterinarians. These were guided and allowed to interact with the prototype. They were asked to assess the system on four aspects: (1) improved veterinary service delivery; (2) fast disease reporting; (3) reducing gap between veterinarian and farmers; and (4) reporting of disease outbreaks.

Finally, they were asked to provide the overall percentage on all these aspects combined: This was given as percentages (75%, 80% and 80%, respectively) of fully satisfactorily; by which an "average" of perceived usefulness could be calculated: 78%.

5. Discussion, conclusion and recommendations

5.1 – Discussion

The study set out to exploit mobile technology to aid in providing first aid and treatment of cattle in rural setting. When the solution was subjected to the technical evaluation, the technical responsible was awarded to over 75% satisfactory. The users scored the system 80%. The average score was 78.3%. This provides some level of confidence that if the system is deployed based on this prototype would help address the observed challeng. This study relates to investigation carried by (Mbaluka & Okeyo, 2016) as highlighted in the related work. Like any other study, the research registered limitations. First due to time and resource constraints, the solution was tested with limited number of subjects. Before deployment of a solution based on this ideology, it is worthwhile to validate the prototype with more subject.

5.2 – Conclusion

This study investigated the use of mobile application in veterinary service delivery and livestock disease management. This was in relation to reducing on animal deaths and controlling diseases in the pastoral areas of Nakasongola district. Findings with developed mobile app demonstrated the usefulness of mobile technology in facilitating disease reporting, recording, monitoring, controlling and giving first aid information to the in animal owners and herdsmen. This is important in this era of increasing penetration of phone and this makes the solution viable to an ordinary man.

5.3 – Recommendations

Stakeholders can consider how this trial can be deployed to the ground. Future work can consider exploring other services which can be brought closer to ordinary man through mobile technology.

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YAY Garden: A conceptual study for a system supporting exchange of agricultural practical experience

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ABSTRACT Farmers encounter unique and useful experiences from the time they prepare to plant crops until harvesting. These experiences can be instrumental in improving agriculture production if shared among farmers that grow similar crops at the same time/ in the same season. There is no documented computerized system to enable sharing of such experiences. The purpose of this study is to design a system, You And Your Garden (YAY Garden) to enable sharing of garden experiences among farmers. We focused on graduate farmers that own 1 to 3 acres of land in Wakiso District Uganda and these farmers are formerly employed in organizations in Kampala city. Requirements of the system were collected using semi-structured interviews. These requirements were transformed into a design for YAY Garden. The design was specified using Unified Modeling Language (UML) use case and class diagrams. When this system is implemented and made to run on mobile phones, it will enable sharing of farmer experiences among themselves and with agricultural extension workers.

1. Introduction

Farmers encounter useful and practical experiences that may not be documented anywhere for others to learn from. These experiences that individual farmers encounter in their gardens are a rich learning experience for other farmers in similar circumstances growing similar crops (Barret, nd). These rich individual experiences remain in the individual gardens of individual farmers without being shared. So, we need a means to share such experiences.

Farmers face challenges during crop growth (in the crop value chain) on which they need advice from fellow farmers growing similar crops. Although such advice could be provided by extension workers who train and visit such farmers, such extension workers are few in developing countries like Uganda. In addition, even if these extension workers were many, they cannot visit farmers' gardens periodically from cultivation time to harvest time because of limited time and money.

Farmers that grow similar crops may greatly learn from one another and address many challenges they face if they form an online community that enables them to share vivid practical

experiences they encounter from cultivation time to harvest time. Similar crops need the same handling for proper growth and if they are attacked by pests and diseases, they need similar care. When information about pests that have attacked crops in one garden is shared among a community of farmers currently growing a similar crop, it may help to prevent similar pests from attacking another garden. If certain methods of farming have yielded better crops such methods can be shared and applied by farmers to their similar crops for better yields in real time.

Despite the value that accrues to sharing of vivid practical experiences among farmers that grow similar crops, these experiences are not shared. We have not found any implemented and documented IT system that enables such experience sharing among farmers. This research seeks to develop an IT system You And Yours (YAY) Garden that supports farmers to share vivid experiences from which other farmers can learn and answer many of their challenges.

In this conceptual study, we claim that an IT application with specified requirements will enhance farmers' sharing of experiences and learning from one another. This study is to lay the foundations for such an IT application through establishing requirements and designing the application. Using this design, other IT specialists can implement such a system.

2. Literature Review

The purpose of this section is to show evidence that there are software applications that have been developed to enable farmer experience sharing and/or learning. These applications, especially web based, are documented, evaluated and their strengths and weaknesses highlighted. We analyse these weaknesses to establish a gap that this research attempts to fill.

"Many small-scale farmers in the developing world learn how to grow crops and raise livestock in a very practical way: by working in the fields and by tending animals. They grow food for their families and sell any extra to visiting traders or at the local market. But they have never studied farming in school." (Ferris et al., 2015). Their fields are their schools. Each farmer has a field as a teaching aid. Farmers can increase their learning experience by learning from their own field and from the fields of other farmers especially those that grow crops similar to theirs. There are software applications that have been developed to aid farmers sharing of field experiences and learn from one another. This section of literature review intends to review such software applications and identify the gap these applications have not yet filled.

Many applications developed are mobile based and these targets sharing of information especially using text messages (FAO, 2012; Oxfam, 2011). These applications are expected to increase farmers' incomes. This is because they provide exchange capital and mobile information services thus enabling access to critical, targeted information on commodity prices, weather, disease outbreaks, etc., and helpline services providing key tips and real-time advice (FAO, 2012; Oxfam, 2011).

Although there are mobile applications that provide real-time advice to farmers, many mobile applications have targeted providing mobile financial services, including mobile money, to small-scale farmers. Such financial applications are Agrinet Uganda and M-PESA in Kenya (FAO, 2012).

In Uganda, there are web platforms intended to support farmers. A collaboration between USTA, UNADA and CropLife have developed a platform in Uganda to help farmers make a choice of high quality inputs (seed, fertilizers and crop protection products) available every

season, reliably and on time (CropLife Uganda, 2018). This platform is essential in providing information about agricultural inputs, but its interactive nature is limited. Interactivity on the web is a feature that is of growing interest today encouraging not only provision of text information but also rich information like pictures, videos, audios and enhanced interactivity.

Radios and Televisions are among other popular ICTs that support farmers' information sharing and learning. Although these technologies are popular and widely used by farmers, they are not fundamentally interactive. Other avenues available for farmer information sharing and learning are regular workshops and annual expos organized for example by Central Broadcasting Service (CBS) radio station and Vision group publishing company. These workshops and expos enable information sharing and learning but they do not enable farmers to obtain perennial support in case they need it. These expos remain at the general level without enabling individual farmer especially farmers growing similar crops to have ad hoc requested support and interaction from fellow farmers. These expos have limited mechanisms of establishing or following up to ascertain if the information obtained is put in practice.

Videos combined with participatory processes have shown great potential in agricultural training and increasing productivity (FAO, 2012). These technologies are influential in information dissemination and peer-to-peer learning. Digital Green's innovation is one such example of these technologies (FAO, 2012). Studies have shown that the practice of using videos is seven times more likely to encourage farmers to adopt new practices compared to conventional agricultural extension systems (FAO, 2012). This same high success record can be expected in farmer to farmer information sharing and learning. Digital Green produces videos that are useful for farmer learning and information sharing in India. This technology is becoming attractive to farmers in Ethiopia and Ghana (FAO, 2012).

There are Community Knowledge Workers (CKWs) in Uganda that provide real-time information on agricultural topics, including market prices, to farmers using mobile phones (FAO, 2012). These CKWs are supported by a call center and they produce and document content in local languages. These CKWs work in connection with TECA ("technologies and practices for agricultural producers"). TECA is an online platform that provides information for smallholder producers around the world (FAO, 2012).

Wang et al., 2016 classified ICT systems that are used in agriculture and came up with the following categories:

(i) Portals: These are collections of links to other resources that farmers may need.

(ii) Voice-based Service: Information dissemination through telephone, i.e. call centers.

(iii) Text (SMS)-Based Service: Information dissemination through text message of mobile phones.

(iv) Self-support online community: This is where a community provides information services to its members. This means of information provision requires stakeholders to subscribe. It involves members sharing and exchanging information through interactive service platforms.

(v) Interactive video conferencing services: This is provision of information using online multimedia technologies.

(vi) Mobile internetbased service: This is provision of information using smart phone services.

(vii) Unified multi-Channel Service Model: This is provision of information using multiple methods or technologies like telephones, computers, and mobile phones.

These methods of providing information as categorized by Zhang et al., 2016 are useful but they (authors) do not follow the same yardstick in categorizing these methods. For example (iii) is based on technology while (iv) is based on who owns the methods of information provision. The system proposed in this study will have elements of self-support online community and web portal.

The different modes of developing, deploying and managing such information dissemination systems and present government led, market driven and community self-support (Mittal and Mehar, 2015).

There are different requirements that Zhang et al., 2016 suggest for information systems intended for farmers. We have focused on those highlighted for web portals and online community for their closeness to the system that this study is to deliver. For the web portal, these requirements or operational features include comprehensive management and maintenance, ability to provide diversified content to meet farmers' needs, and high quality service standards in terms of information quality and security. For the inline community, the operational features include rigorous management in form of hierarchical structure to ensure information reliability, smooth contact system, reliable system with authenticated information, constant improvement of service quality in terms of system improvements to meet the needs of the farmers.

We reviewed a number of ICT applications that provide advisory services to farmers. We review these applications with one focus, ascertaining if they are fine in offering advisory services to farmers. So, we seek for their strengths and weaknesses. Below are some of the applications reviewed and lessons that we obtained.

Table 1: Applications that provide advisory services

Application	**Location/country**	**Main functionalities**	**Strengths**	**Weaknesses**
Agrinet Uganda Ltd	Uganda http://www.agrinetug.net/	-Provides market linkages	-Videos -Audios -Pictures	-No evidence of support to farmer in crop lifecycle. -No evidence of farmer to farmer experience sharing and learning
CafeDirect Producer Foundation (CPF)	International http://producersfoundation.org/	-Farmer to farmer knowledge sharing platform (mobile based)	- Use of pictures	-Little evidence of farmer to farmer interactions. -The interaction is not farmer-led. -Minimal evidence of farmer to farmer discussion
CropLife Uganda	Africa and Middle East http://croplifeafrica.org/	Validating agro-inputs to establish if they are genuine (Uganda)	- Use of pictures	-Does not foster farmer to farmer discussion, experience sharing and learning - No focus on crop life cycle
Digital Green	India http://www.digitalgreen.org	- Trains farmers using short instructional videos.	-farmers share experiences and	- No evidence of farmer to farmer support in the crop development lifecycle.

			stories from the field. -Farmers learn from what they do, and what others do. -Uses videos (community videos)	-No crop development follow up among farmers
e-Arik	India http://www.earik.in	Use of ICT for agriculture extension	-Use of pictures	-No farmer support along the crop development lifecycle.
e-Choupal	India https://www.echoupal.com/	-Links and empowers farmers	-Uses videos -Use of pictures	-No crop development follow up among farmers.
ESOKO	Africa	-Provides weekly advisory services -Uses call centres, audios, and field visits	-Uses multi-media for providing advisory services -Farmer to expert interactions are real	-No evidence of farmer to farmer interactions. -Farmers' fields are not prioritized as learning experiences. -Farmers come to the system "without their gardens!"
Freedom Fone	International	- creates interactive, voice-based communication services	-Uses multi-media technologies - Fosters interaction	-No evidence of farmer to farmer interactions to share experiences -No crop development follow up among farmers.
Frontline SMS	International http://www.frontlinesms.com	Enable farmer use of their ingenuity to craft solutions and create positive change in their own communities using mobile technology.	- Fosters interaction -Use of pictures	-No focus on the field/garden as a teaching aid -No crop development follow up among farmers
Honey Bee Network	India http://www.worldchanging.com/archives/006333.html	Enable local and farmer innovation processes.	- Fosters interaction -Use of pictures	-No focus on the field/garden as a teaching aid -No crop development follow up among farmers
ICAAP	India www.advanceagriculturalpractice.in	- An e-portal that documents best practices at farmer level	-Use of pictures - Evidence of interaction among users of the e-portal	- No evidence of garden presence in the content of the e-portal -No coupling of farmer and garden
iCow	Kenya http://www.icow.co.ke	- Empowers small-holder dairy farmers and helps them to manage their cows to have a greater profit.	-Use of pictures -Interaction between farmers and extension workers	-Takes advantage of only text not video, audio. -No evidence of garden presence in the content. -No evidence of farmer to farmer interaction.
ICTforAg.org/video	International http://ictforag.org/video	A toolkit for practitioners: enables use of low cost	-Fosters creation of extension	-No evidence of use of a garden as a learning aid.

		videos for information sharing.	videos by farmers. -Has multimedia content	-Farmer to farmer interactions are not the focus -No crop development lifecycle follow up
Intelligent Advisory System for Farmers (IASF)	India http://iasf.cdacmumbai.in/ias/jsp/about.jsp	-Expert system answering farmer queries.	-Farmer to farmer interaction present -There is use of pictures	-No crop development lifecycle follow up
KUZA Doctor	Kenya	Enables basic mobile phone based sharing of agricultural information	-Fosters farmer to farmer interaction	-No crop development lifecycle follow up
LifeLines	India http://lifelines-india.net/LifeLines/agriculture	-Provides pedagogical support in rural and remote areas. -Brings agri-advisory services to the field of the farmer.	-Evidence of farmer to expert interaction. -Evidence of farmer-farmer interactions	-Farmers garden is not put to light even if one has a problem in the garden, only textual explanations are used. -No use of a garden as a teaching experience. -No focus on a crop at a time and its life cycle as it grows in the garden.
mKisan	India http://ilriclippings.wordpress.com/2012/06/26/m-kisan-launch	Enable use of mobile technologies to strengthen farmer-extension-expert-linkages in India -Provides agro-advisory service for smallholders using mobile devices.	-Evidence of farmer-farmer interactions -Use of pictures	-No use of a garden as a teaching experience. -No crop development lifecycle follow up
Pasture Promise Tv	UK http://www.pasturepromise.tv/farming.html	Enable posting of videos relevant to pasture management	-Use of multimedia is noted	-Does not enable farmer to farmer interaction based on their gardens
Prolinnova	International http://www.prolinnova.net	Fosters ecologically oriented agriculture and natural resource management (NRM). - Promotes Local innovation	-Uses multimedia technologies -Encourages interactions	-Does not enable farmer to farmer interaction based on their gardens -No crop development lifecycle follow up
Talking Books	International http://www.literacybridge.org/talking-book/#intro-video	Enables agricultural information sharing	-Uses multimedia technologies	-Does not enable farmer to farmer interaction based on their gardens -No crop development lifecycle follow up
Tambero	International http://www.tambero.com	Software that tracks information about land parcels cattle	-Encourages interactions	-Does not enable farmer to farmer interaction based on their gardens

TECA	International http://www.teca.fao.org	A platform that combines a knowledge repository with a tool for discussions.	-Enables discussion among farmers	-No focus on crop development life cycle. -No vivid garden experience sharing.
Ukulima.net	Kenya http://ukulima.net	A mobile web platform that allows farmers to connect and interact on topics of similar agriculture interests.	-Focus on farmers with similar interests -A social network for farmers -There is evidence of sharing ideas among farmers	-No focus on a crop at a time and its life cycle as it grows in the garden.
VERCON	International http://km.fao.org/vercon	A plat form that enables collaborative techniques and innovative methods of communication.	-There is evidence of sharing ideas among farmers	-No focus on a crop at a time and its life cycle as it grows in the garden.
YenKasa Africa (our talk)	Ghana http://yenkasa-africa.amarc.org/en/node/36	A platform that enables knowledge and experience sharing among farmers	-There is evidence of experience sharing -Facilitates dialogue	-No focus on a crop at a time and its life cycle as it grows in the garden.
GADC (Gulu Agricultural Development Company)	Uganda https://www.gadc.co.ug/	Providing market access to smallholder farmers in northern Uganda.	-Evidence of use of multimedia technologies -The firm/garden is present in the system	-No focus on a crop at a time and its life cycle as it grows in the garden.

The reviewed systems have strength of enabling interaction and use of pictures and multimedia technologies. Nevertheless, among the weaknesses of the reviewed systems, the issue of lack of use of the garden as a teaching aid has been recurring. Another important loophole in those systems has been inability to provide extension services, along a crop life cycle, to farmers growing a similar crop in the same season. There are no documented systems that provide such a service.

3. Methodology

The primary purpose of this research was to design a mobile based system to enable farmers who grow similar crops to share agricultural advisory information among themselves based on their own garden experiences and to seek advisory services from agricultural extension workers. This study was primarily a case study where a complex phenomenon is studies in its context (Baxter and Jack, 2008). Our study followed a corresponding participants approach (Gatt and Ingold, 2013). This approach was followed to enable interactivity in knowledge creation which contributes to deeper understanding of phenomena. Data was gathered from graduate farmers who own land between one and three acres in Wakiso district. These farmers formerly employed in different organisations in Kampala city and have just acquired land not more than 15 years ago. We target these farmers because they need extension information since

they studied in towns and are working in Kampala city making them to be with little or no prior experience in growing crops when compared to their counterparts who grew up in villages with farms as conditions sine qua non of their homes.

The researcher conducted semi structured, open ended interviews with 50 respondents. 40 of these were farmers and 10 were extension workers. The interviews were both face to face and on phone. The essence of the interviews was to understand how farmers share information/experiences and to obtain key issues encountered in sharing information with other farmers growing the same crop at the same time. This information provided a foundation for eliciting requirements and then a design for a YAY Garden. Data gathered was qualitative in nature. The data was thus analyzed qualitatively with thematic analysis (Boyatzis, 1998).

4. Findings

One of the key issues the farmers aired out was limited awareness of other farmers that grow the same crops in a given season.

"When I grow a given crop, I have no idea who else is growing the same crop as I grow at the same time or in a given season. Even if I face issues in the process I cannot get advice from such counterparts because I am unaware of them. I also rarely think about extension workers in case I face a problem in agriculture, I do not know them, I have not seen them around my garden …. I do not know how to find and contact them" (Respondent).

One of the other problems highlighted was cost of access to advice in case a farmer faces an issue in the garden, unfamiliarity with seeking for advice from fellow farmers and/or extension workers, a tendency to feel that the farmers have nothing to offer to other farmers (lack of trust in themselves). Extension workers also aired out the issue of awareness as key. Farmers are not aware that they are entitled to obtain services from extension workers. Another issue the extension workers posited was that they are few compared to the farmers they are supposed to offer services to. In addition, these farmers are highly dispersed, growing different crops and the issue of lack of organized farmer groups that can request for advisory services as a group. In a group, farmers get more bargaining power and credibility making it easy to receive advisory services easily. All farmers interviewed had smart phones, ability to buy data and/or had access to internet from their work places and/or at their homes. Table 2 represents the key requirements of the YAY Garden as provided by the analysis of the responses from respondents.

Table 2: A summary of key requirements of the YAY Garden

Actor	**What the actor does with the system**	**System functionality /use case**	**Sub-use cases**
Extension worker, Farmer	Chat	Manage chats	Start Handle-posts Handle-chat-sessions Manage-chat-data Handle-chat-attributes
Extension work	Respond to farmer	Manage response to garden issues	Search-issue Display-issue Enable-response-composition Post-response

Farmer	Make inquiry	Process inquiries	Load-issue Enable-description Categorize-issue Assign-issue Display-issue Archive-issue Retrieve-issue
Farmer, extension worker	Registers	Manage registration	Capture-registration-details Process-registration-details Archive-registration-details Display-registration-details Provide-registration-feedback

Column one of Table 2 shows the external actors that interact with the YAY Garden. Column two shows the task that the actors perform with the system (YAY Garden). This information was sought and obtained from respondents during the interviews. This information (tasks that actors perform with the system) was used to derive system functionalities (which we call functional requirements of the YAY garden). This was done through simple reasoning, for example, if a farmer comes to register with the YAY Garden, the component in the system that will be responsible for that is a registration component whose role is to manage registration (see column three of Table 2).Through the same ratiocination, key class names were derived or obtained (see column four). In all these functionalities of the system, respondents show that farmers need help from extension workers or/and fellow farmers about how to handle diseases that come in the crop development life cycle, advice on how to look for crops for better yields and how to arrest situations on their crops before they can go out of hand. This information is required by these farmers in form of interactive multimedia content.

4.1– System Design

System design is a specification of the system based on requirements. In this research we use Unified Modelling Language (UML) to specify the YAY Garden. The major use cases for the YAY Garden system are: Register, make inquiry, respond to farmer and chat. The major actors are extension worker and farmer. Each of the use cases has a starting and end condition. The actors come to use the system with a goal in mind, which when it is fulfilled, they leave the system. For example, a farmer comes to make inquiry and goes through different interactions with the system until this inquiry is done, then he leaves the system with a submitted inquiry.

Based on the use cases stated, it is clear that farmers are enabled by the YAY Garden to fulfil goals like chat, view responses and make inquiry as indicated in the methods or behavior of the farmer class in Figure 1. In the same way, the agricultural extension workers are able to achieve goals like respond to inquiries from farmers and to view chats.

Issues that were articulated by respondents can be easily addressed by the YAY Garden system. For example, the issue of limited awareness of farmers about the other farmers that grow the same crops in a given season has can be addition addressed through the registration use case. Users of the YAY Garden register and specify the crops they grow at a given time. From this information any farmer can become aware of which farmers grow which crops in what season.

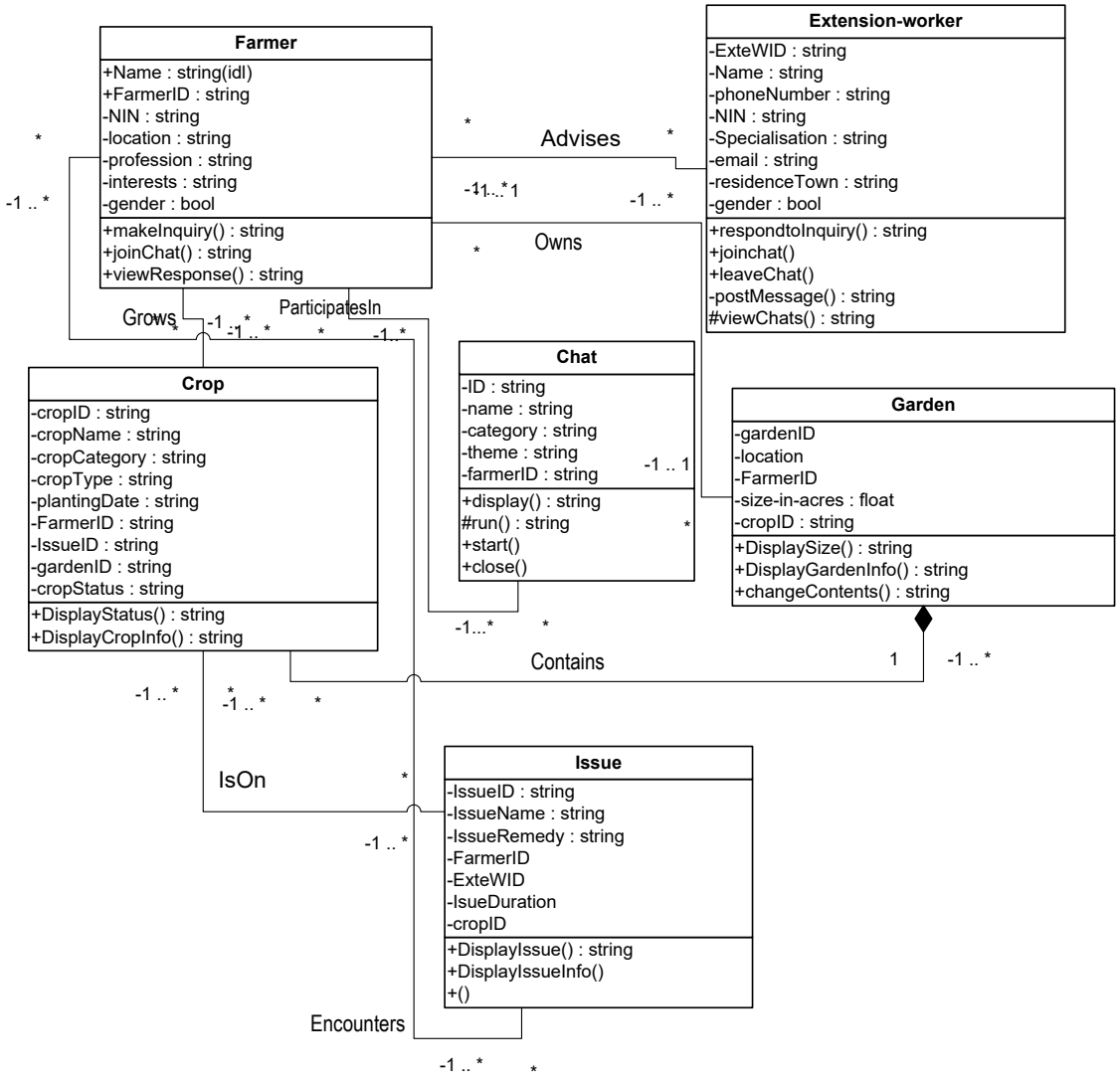

Figure 1: Class diagram of the YAY Garden system

5. Conclusions

The purpose of this research paper was to design a YAY Garden that enables farmers share vivid experiences with their fellow farmers growing the same crop at the same time or in the same season. The design of this system has been presented and what remains is the implementation of such a system in order to run on mobile phones.

6. Limitations of the Study

The design of YAY Garden has been based on farmers in Wakiso District that have formal employment in Kampala. These are graduate farmers that own land between one to three acres having owned it for not more than 15 years. This design can be improved to cater for other farmers in other districts in Uganda.

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Heuristic Evaluation of an Eye-Free Android Application

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ABSTRACT The Android app Eye+ is an eye-free interface designed for visually impaired users. Its second version (V2) is currently available on Google Play Store with 4700+ app downloads and, with music player and multi-lingual support. The development team felt a dire need for usability evaluation six months after the launch of Eye+ V2. The heuristic evaluation method has been selected as it is quicker as well as simpler method to execute, especially for expert from accessibility computing. It is an expert-based summative evaluation method, which also facilitates app redesigning and versioning. The major problems identified include unavailability of app / audio disabling facility, non-compliance of app to accessibility guidelines, unavailability of Internet or Wi-Fi connectivity within the app, no provision of audio instruction repetition, lack of event completion feedback, need for user feedback within app and additional multilingual support needed. These usability problems will be resolved in near-future to design the next version, V3, of Eye+.

1. Introduction

Today, mobile phones are the most vital devices for personal communication as well as information sharing all over the globe. As per report from Telecom Regulatory Authority of India (TRAI) in November 2017, there are about **1162 million mobile phone subscribers** in India [12]. These mobile phone users are of two types - normally sighted or regular users and visually impaired users. A visual impairment can be defined as 'loss of sight', i. e. total visual impairment or reduced vision [2]. The estimates of World Health Organization (WHO) indicate that there are 253 million visually impaired people in the world, out of which 36 million are totally visually impaired people [14]. Almost one third of these people i. e. **12 million blind people** reside in India [6]. These blind and visually impaired people always have tough time in interacting with touchscreen mobile phones.

The visually impaired users cannot provide enough visual attention during their interaction with user interfaces (UI); hence accessibility features become vital. The problems faced by visually impaired users with mobile phones include their struggle in locating interface options / items, difficulty in text data entry, insufficient feedback and inability to read data [11, p. 292]. To provide solutions to these problems, it is essential to design an accessible interface such as an eye-free interface, which enables users to interact with devices without visual attention. Hence, such an Android-based Application (App) named 'Eye+' has been designed by lead

authors**. Eye+ is an eye-free interface designed for visually impaired users and its name suggests that it provides added or extra vision to its users.** Its first version (V1) with messaging and calling functionalities was made available on Google Play Store in 2015-2016. Its second version (V2) was published on Play Store with music player and multi-lingual support around mid-2017 [4]. It has used 'Speech to Text' and 'Text to Speech' converters for user interaction mainly through audio. Figure 1 depicts a sample screen of Eye+ app with four keys in grey scale.

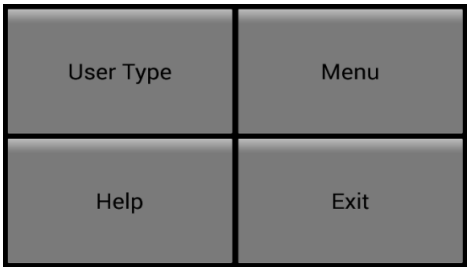

Figure 1: Sample screen of Eye+ app with four-key User Interface (UI)

The important features of Eye+ include:

- 'Phone Shake' feature to start the app,
- Support for both Beginner and Advanced users,
- Simpler UI with four large keys in grey color, (as seen in Figure 1)
- Multi-lingual support in German and French along with English.

The app Eye+ has about **4700+ downloads** [4] **till Oct. 2018**. Related screenshot of world map from Google Play Dashboard depicting number of downloads nation-wise is depicted in Figure 2. One can see that the app has been downloaded across all six main geographical continents of the world. India and United States of America (USA) lead the listing with about 1400+ and 850+ app downloads respectively. Five countries, United Kingdom (UK), France, Germany, Pakistan and Philippines, also have 100+ app downloads. There are another eight countries, Brazil, Indonesia, Canada, South Africa, Bangladesh, Turkey, Morocco and Algeria, completing 50+ app downloads. The average user rating of Eye+ is around 4.6 till Oct. 2018.

The app Eye+ is also useful for normally sighted or regular users who cannot look at the mobile screen due to reasons such as extreme lighting condition (more than 1000 lx) [3, p. 04], protection of private information, constraint of smaller screen, during walking on the street and others [11, p. 292]. This research reported in this paper has discussed the process of usability evaluation of Eye+ using heuristic evaluation method and also, listed the identified usability problems. This evaluation is needed for a rational direction for upgradation of this app to its third version (V3) in near-future.

2. Related Work

The literature work mainly includes the research articles discussing about usability evaluation of mobile apps. These articles focus on expert-based evaluations for identifying usability problems related to mobile apps. There are also articles specifically on guidelines and evaluation of accessibility for visual impaired users [16] [17].

Gomez et al. have proposed a checklist for heuristic evaluation, especially designed for new mobile interfaces. This best-practice checklist has additional heuristics such as skills, pleasurable and respectful interaction with the user and privacy along with more than 150

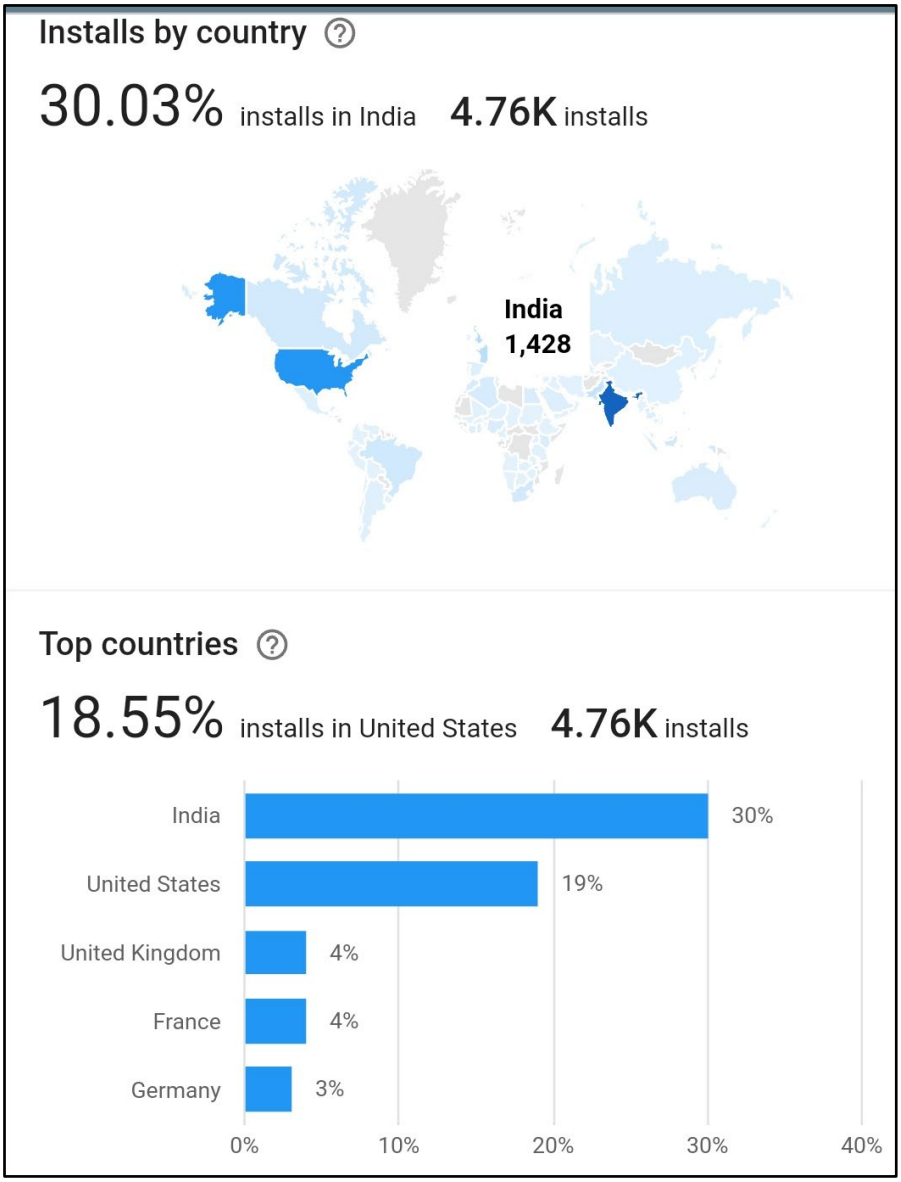

Figure 2: World map from Google Play dashboard depicting number of downloads nation-wise for Eye + along with top 5 countries [4]

related checklist points or sub-heuristics [5]. This is an interesting perspective of heuristic evaluation, but **these additional heuristics have no significant impact in the domain of accessibility computing or on visually impaired users**. Therefore, these heuristics are not considered in usability evaluation of Eye+ along with Nielsen's heuristics.

Watkins et al. have performed heuristic evaluation of Healthy Eating Apps for older adult users. Three experts evaluated five iPad apps related to fruit and vegetable intake using heuristic evaluation method [13, p. 105-127]. Several important problems were identified and they include use of unfamiliar symbols, unnecessary steps required to complete tasks, less accessibility features, small text; insufficient color contrast and unlabeled advertising. This study has approved **the usefulness and applicability of the heuristic evaluation method in identifying design deficiencies and usability problems**.

Georgsson et al. have discussed a study to complete usability evaluation of a mobile health system for diabetes patients using a heuristic evaluation technique of **dual-domain experts i.e. experts from healthcare as well as usability domain** [15]. Major violations are observed with respect to two heuristics – 'Consistency and Standards', and 'Match between System and the Real World'. This study highlights a **need for dual domain experts and for detection of related heuristics with major usability problems**.

Jadhav et al. have performed usability evaluation of messenger applications for Android phones using cognitive walkthrough. These applications include WhatsApp, Skype and GO SMS Pro focusing on primary tasks such as chatting, file transfer, profile viewing and updating contacts [7, p. 9-18]. It has highlighted few usability problems such as lack of provision for multiple smiley selection, no confirmation message for file transfer and ineffective 'Search' functionality. Such **selective task-based evaluation may not be sufficient for summative evaluation targeting design of next version of mobile app.**

These studies of usability evaluations of mobile apps reinforce the applicability of expert-based summative approach of heuristic evaluation in identification of usability problems for app redesign in near-future.

3. Usability Evaluation of Eye+ App

Eye+ V2 app was launched around mid-2017 on Google Play Store. This app had really good response from visually impaired users and other Android users. It had the growth rate of 150+ app downloads per month by late 2017, which has reached to about 500+ downloads per month by Aug. 2018. About 40 users have provided user ratings and reviews on Google Play Store. The user rating stands at 4.6 by Oct. 2018. Though most users have appreciated the app design, few users have raised certain issues related with identification of contacts and voice recognition during making calls through the app. The development team also felt a dire need for usability evaluation and debugging six months after launch of Eye+ V2. Therefore, it was decided that evaluation of app should be done for identification of usability problems and also, to provide a direction for redesign of app to launch its next version V3 in near-future.

3.1 – Inclusion of an Expert from Visually Impaired Community

The development team for Eye+ consists of usability expert, but he has limited understanding in domain of accessibility computing as well as that of visually impaired users. Therefore, it was decided to involve an expert from visually impaired community. The expert involved is one of the co-authors and he coordinates the University Centre for Inclusive Education & Accessibility. He is a visually impaired user himself and also has the required expertise in accessibility computing. He has been there also to help the usability evaluators by sharing expectations, priorities and experiences of visually impaired users [8] during app evaluation process. Two more experts from IT industry, supporting app testing and hosting activities were also included in evaluation team.

3.2 – Selection of Usability Evaluation Method

The evaluation team was interested in identification of major usability problems and design deficiencies in the targeted app Eye+ V2. The prevalent usability evaluation methods such as Cognitive Walkthrough, Heuristic Evaluation and User Testing were studied and discussed by the evaluation team including the expert representative from visually impaired community. The

heuristic evaluation method was selected as it is much quicker and simpler method, especially for expert from accessibility computing. It is an expert-based summative evaluation method, which also facilitates app redesigning [10] and versioning. The blind and visually impaired users at University Centre for Inclusive Education and Accessibility, also were not available due to their examinations and other scheduled activities. The ten heuristics proposed by Nielsen were applied [10] along with 5-point Likert Scale to identify the usability problems as well as their extent [9] affecting design and usage of Eye+.

3.3 – Heuristic Evaluation of Eye+ V2 App

Heuristic evaluation is a method for finding usability problems in a user interface design by having a small group of expert evaluators examine the interface and judge its compliance with recognized usability principles – heuristics [10]. There are ten defined heuristics, which are listed in Table 1. These heuristics are applied on the app Eye+ to identify potential usability problems, which are also listed in the Table 1 along with assigned Likert scale values. A 5-point Likert scale is used for judging severity of heuristics and related problems identified. It has a range of values from '-2 to 2' with '0' in the centre. The value '–2' indicates that the problem severity is high and '2' indicates the high level appreciation for related heuristics. This evaluation was carried out by group of experts. It can be observed in Table 1 that more severe usability problems are associated with two heuristics – 'Consistency and standards' and 'User control and freedom'.

Table 1: Heuristic evaluation table along with assigned Likert scale values

Sr. No.	Heuristics	Usability Problems identified	Likert Scale
1	Visibility of system status	• No provision of instruction repetition, mainly for the beginner users, if required • Invisibility of functionalities provided by the app	**1**
2	Match between system & the real world	• Need for language-support in additional regional and international languages, especially for non-English speaking users	**1**
3	User control & freedom	• Unavailability of Internet or Wi-Fi connectivity within the app • Lack of direct navigation facility to a specific screen or functionality	**-1**
4	Consistency & standards	• Non-compliance of app to Android accessibility guidelines • Unavailability of facility for disabling the app as well as its audio	**-2**
5	Error prevention	• No provision of instruction repetition for the beginner users, if required • Inability of user to detect speech recognition dialog screen	**1**
6	Recognition rather than recall	• Need for recalling four buttons on the app screen due to non-repetition of instructions, if required	**1**

7	Flexibility & efficiency of use	• Unavailability of navigation to recent activities • No provision to record user feedback in the app • Unavailability of functionality to block a particular contact	**1**
8	Aesthetic & minimalist design	---	**2**
9	Help users recognize, diagnose & recover from errors	• No extra analysis done if user's speech input does not lead to any available result • Lack of event completion feedback	**0**
10	Help and documentation	---	**2**

4. Usability Problems Identified in Eye+

Several usability problems have been identified by applying heuristic evaluation method on the app Eye+. An ordered list of the major problems identified is displayed in Table 2 with due consideration to their severity. This list is prepared after a couple of rounds of discussion among the evaluation team related with identified problems and their importance for the next version.

Table 2: Ordered list of major usability problems identified using heuristic evaluation

Sr. No.	Usability Problems identified in Eye+ V2
01	Unavailability of facility for disabling the app as well as its audio
02	Non-compliance of app to Android accessibility guidelines
03	Unavailability of Internet or Wi-Fi connectivity within the app
04	No provision of instruction repetition, mainly for the beginner users, if required
05	Lack of event completion feedback
06	Inability of user to detect speech recognition dialog screen
07	No provision to record user feedback in the app
08	Need for language-support in additional regional and international languages

The usability problems listed in Table 2 are discussed ahead. This discussion includes identification and relevance of each of the usability problems with related screenshots in the app. The solutions are also proposed to deal with these problems, whenever possible.

4.1 – Unavailability of Facility for Disabling the App as well as its Audio

The problem of disturbance due to untimely app activation or related instructional audio and voice communication may disturb the users, who are busy in their work. A few users have reported that this trouble leads to deletion of app. This problem was identified during consideration of one heuristic, namely 'Consistency & standards'. Therefore, the expert from the accessibility computing domain in our evaluation team has suggested that the user should

be able to disable the app or its audio as per the need of time. Many Android apps have such disabling facility; but at present, this facility to disable the app or its audio isn't available with Eye+.

4.2 – Non-Compliance of App to Android Accessibility Guidelines

The app Eye+ is not totally compatible with all of the Android Accessibility Guidelines. It does not follow an important accessibility guideline, 'Create easy-to-follow navigation' [1]. The app does not allow direct navigation to a specific screen or functionality. Also, a few of the options / keys in the app as seen in Figure 3, require complex or multiple touches such as press, or press and hold, which are not easy to execute for most of the visually impaired users. These problems are also identified during consideration of a heuristic – 'Consistency & standards'.

Figure 3: App screen showing options / keys requiring complex or multiple touches

4.3 – Unavailability of Internet or Wi-Fi Connectivity within the App

The app Eye+ requires mobile Internet or Wi-Fi connectivity for its working; especially for providing audio support in multiple languages. If such connectivity is not available, the visually impaired user has to exit the app for connectivity and then, get back to the app. That is a really challenging task for any visually impaired user. This problem was identified during consideration of the heuristic 'User control & freedom'. Therefore, the evaluation team has suggested for Internet or Wi-Fi connectivity within the app.

4.4 – No Provision of Audio Instruction Repetition, mainly for the Beginner Users, if required

The app Eye+ supports two types of users – Beginner User and Advanced User as seen in Figure 4. The beginner users need slow audio communication whereas advanced users prefer much faster communication [11]. The beginner users also need instruction repetition frequently for understanding and executing options or functionalities provided in the app. Such provision for instruction repetition is currently absent in Eye+ V2. This problem was identified during consideration of two main heuristics – 'Visibility of system status' and 'Error prevention'.

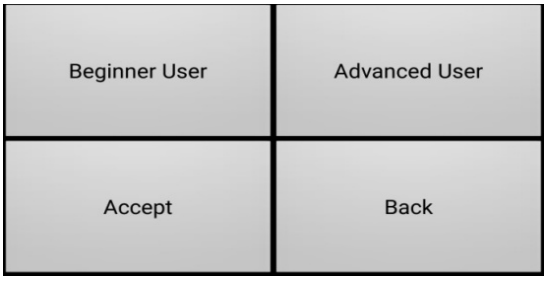

Figure 4: App screen for selection of user type

4.5 – Lack of Event Completion Feedback

The visually impaired users require audio and/or vibratory feedback whenever they take any action. The evaluation team observed that the users occasionally do not get such feedback or acknowledgemnet after an event is completed. This problem was identified during consideration of the heuristic 'Help users recognize, diagnose & recover from errors'. For example, the user fails to get such feedback or acknowledgement during Fast Forward (FF) operation as seen in Figure 3, while using music player.

4.6 – Inability of User to Detect Speech Recognition Dialog Screen

The visually impaired users require to speak up the contact number or message while using Eye+. Once the user selects a particular option for speaking, a speech recognition dialog screen appears as seen in Figure 5 and the app waits expecting the user to speak out contact number or message. The evaluation team observed that users may fail to detect speech recognition dialog screen and wait longer to speak up or get confused as they are not informed to speak up immediately after appearance of dialog screen. This problem was identified during consideration of 'Error prevention'.

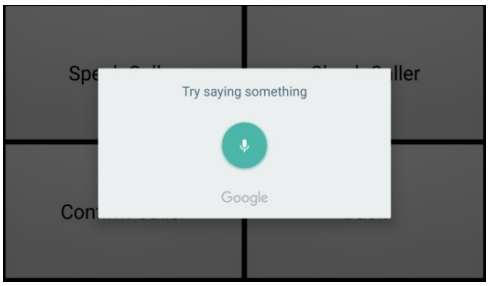

Figure 5: Speech recognition dialog screen in Eye+ V2

4.7 – No Provision to Record User Feedback in the App

The app users can provide user rating (Out of 5.0) along with their feedback on Google Play Store. This feedback may help app developers to improve on app design and its performance. But, it is observed that most visually impaired users rate the app without providing typed-in feedback. Also, some users may come across bugs or usability problems while using the app. The evaluation team felt a need for a facility to record an audio feedback from these users in the app itself. This feedback can be communicated to development team through assigned email account in backend. Lack of such convenient facility for user feedback is seen as notable problem during consideration of one of the heuristics, 'Flexibility & efficiency of use,' by evaluation team.

4.8 – Need for Language-Support in Additional Regional and International Languages

There is a multi-lingual support provided in German and French languages along with English in Eye+ V2 as depicted in Figure 6. It helps the visually impaired users to use the app with audio communication in related foreign languages. So, there are about 150+ app downloads each in Germany and France by Oct. 2018 [4]. The evaluation team has suggested to provide language-support in additional regional and international languages to improve a reach of the app. This suggestion was put forward during consideration of the heuristic 'Match between system & the real world'. There are 80+ app downloads presently from Brazil [4]. To improve on this download count, Portuguese, the national language of Brazil, and Hindi, the national

language of the host country, India, of the app developers, will be added in multi-lingual support for Eye+ V3 in near-future.

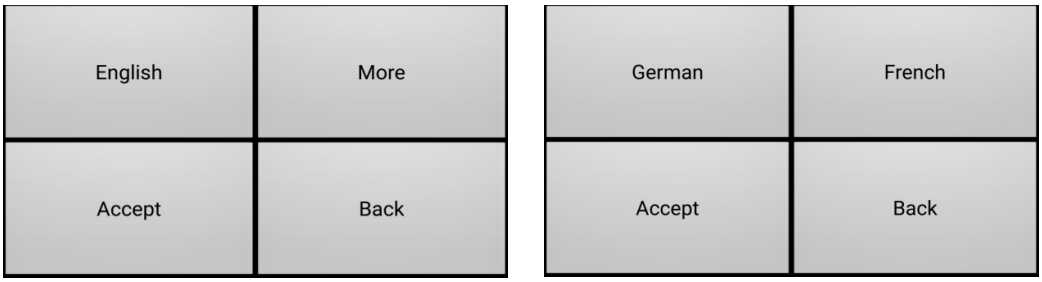

Figure 6: App screens for multi-lingual support in German & French along with English

5. Conclusion and Future Work

The evaluation team observed that the Android app Eye+ V2 needs significant design enhancements in response to major usability problems identified during heuristic evaluation. More severe usability problems are associated with two heuristics – **'Consistency and standards'** and **'User control and freedom'**. There is a need for app / audio disabling facility, compliance to accessibility guidelines, provision of audio instruction repetition, event completion feedback, increased multilingual support, Internet or Wi-Fi connectivity and audio user feedback within the app. The app developers are determined to resolve the identified design deficiencies and usability problems for the next version, Eye+ V3, in the near-future. In future, the findings of this app evaluation could be also used to propose new heuristics for eye-free interfaces.

Acknowledgement

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Assessment of Network Readiness for Telemedicine Services in Uganda

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ABSTRACT Background: There are not very many telemedicine projects in Uganda and Africa at large that have reached scale. One of the reasons for this has been the failure to have a readiness assessment for different factors like cost, technology take-up, and network performance prior to implementation of the projects. **Objective:** To assess network performance of selected networks in selected areas and relate it to minimum network requirements for different telemedicine services and finally use the assessment to recommend readiness of the selected networks in implementing given services in those areas. **Method:** The assessment was classified into bandwidth and latency assessments. Six networks with RIPE ATLAS probes in different locations were used for latency measurements with latencies for a period of two months used while 3G and 4G networks were considered for bandwidth measurements for a period of 9 hours using speedtest by Okla tool. **Results:** All six networks considered for latency measurements showed support for all selected services but showed performance variations with some networks performing better than the others. Also the individual networks showed variation (jitter) with some having high variations while others indicate a rather close to constant performance. 4G showed support for all selected services and 3G only supported a few services at given hours of the day. **Conclusion:** Different telemedicine services have different network requirements and due to the variable nature of cellular networks being the most used in Uganda, an assessment of network performance is very crucial in informing about the possibility of implementing telemedicine in given areas and thus having successful projects in providing health care remotely.

Keywords: Telemedicine, Health care delivery, Uganda, RIPE ATLAS, Speedtest by Okla.

1. Introduction

Uganda's health care system is faced with many challenges some of which include but are not limited to policy matters, distance and mechanism and limited to access to medical facilities and staff [1]. Uganda's health situation is in a bad shape with a ratio of 1.49 core medical doctors per 1000 population which is way below the minimum ratio of 2.3 doctors per 1000 population set by the World Health Organization WHO for achieving the millennium development goals [2]. In addition 70% of qualified medical doctors are in urban areas however the biggest percentage of the population (84.4%) lives in the rural areas of the country as of

December 2014. This means that the biggest percentage of the population when sick is attended to by nurses, aid workers and others sources of healthcare [3] [4].

Telemedicine is an optimal way to bridge the gap between the qualified medical doctors in the urban areas to the sick people in the rural areas. It allows patients to get medical care remotely from their homes using data communications making it very beneficial to people living in hard to reach areas [5]. However technology innovations like telemedicine especially in low income earning countries like Uganda face challenges of sustainability and most do grow beyond the pilot phase [6]. However the benefits of such innovations in health carry great promise in improving provision and reach of better quality health care to people especially in hard to reach thereby answering the objective of Sustainable Development Goal (SDG) number three [7].

Telemedicine is the remote delivery of healthcare services such as health assessments or consultations over ICT communications infrastructure. It allows healthcare providers to evaluate, diagnose and treat patients without the need for an in person visit [8]. Telemedicine has numerous services classified into; telediagnosis, teleconsultation, telemonitoring and telemanagement. Also a classification of the services based on their Quality of Service (QoS) requirements exists where the services are classified as both real-time and non-real-time. For instance in emergency situations remote specialists' diagnosis may require real-time transmission of patient medical data while in non-emergency (delay tolerant) situations, the data can be transferred to a remote location where specialists can analyze it at later point in time [9]. Typical telemedicine applications may involve for instance transmission of patient physiological parameters, transfer of high resolution medical images and such applications generate traffic with diverse network requirements differing in required bandwidth, real-time and non-real-time interactivity and packet loss tolerance. The diverse network requirements make it crucial to have a tool that can provide an accurate QoS assessment of the network and relate it to the different services diverse network requirements to ascertain the possibility of a given telemedicine service on that network in a given area.

Unlike developed countries with proper broadband infrastructure in form of wide spread and cheaply accessible fiber cable, Uganda's broadband connectivity is largely contributed to by cellular network infrastructure from companies like MTN and Airtel [10]. The national backbone infrastructure fiber network is a promising project with fiber connections across the country but has not effectively provided broadband access to many areas especially to the hard to reach areas [11]. The challenge with cellular network performance arises from the random signal propagation impairments like multipath due to reflections and weather conditions that lead to variable network throughput that can affect provision of some critical telemedicine services. Most telecom companies have started rolling out of 4G coverage to some areas in the country with most of central Uganda covered but most rural areas are still served by 3G and 2G network. The only easily available form of network assessment is by use of network coverage maps provided by the telecom companies but these however do not incorporate factors like the variations in network performance and therefore cannot be used to recommend applications pertaining to human health. A reliable and accurate network assessment tool is therefore crucial in determining the available network performance in a given area and what telemedicine service is best supported. The assessment tool can therefore provide informed decisions to medical practitioners wanting to implement telemedicine in a given place on what service to do or not to do depending on the selected network and therefore improving the possibility of telemedicine in Uganda.

2. Methodology

For the assessment, network bandwidths and latencies were considered. Six internet service provider (ISPs) were considered for latency measurements and RIPE ATLAS tool was used. RIPE ATLAS is a platform that assesses global internet reachability with numerous number of probes installed in different ISP networks across the world. The probes are hardware gadgets that keep measuring and storing network information to different server locations across the world [12]. Part of the information stored in the probes is continuous pings to selected server locations. A ping measurement involves sending a packet from one computer to another and awaiting a response. The time taken by the packet to travel to and fro is called the roundtrip time is an indication of the network latency [13]. Six networks were considered because at the time of the assessment only 6 of the 29 probes connected in the country were fully connected and operational. The network locations were obtained and the measurements were to be done in reference to a server (d root server) location in Kampala as shown in figure 1.

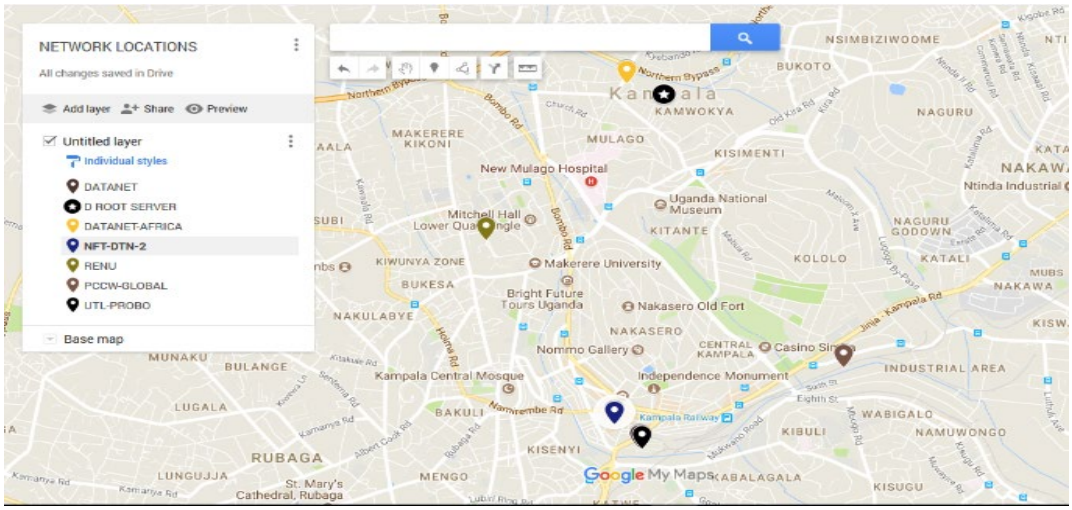

Figure 1: Network locations with RIPE ATLAS probes.

Ping information for a period of 2 months of each of the networks in reference to the d root server was obtained. It was important to have as much data as possible to put into consideration the network variations as highlighted before and this explains the 2 months data used in this work. Data for more than this time would also make the assessment better but the data obtained was already too much for the extraction tools used (python) to handle as the probes do the measurements on a frequency of every after 3 minutes.

For bandwidths, measurements were done using speedtest by okla tool and were done over a period of 9 hours in a one city suburb place called Makerere Kikoni. The choice of place was because it was the author's residence at the time of the assessment and since the measurements were to be done manually, the place would be the most convenient. Measurements were done 4 times each hour and this was done in comparison with a broadband measurement tool used in Italy called "ne.me.sys" that does similar kinds of assessments [14]. 4G and 3G of a selected network were assessed by using a smart phone locked to access either networks for each of the measurements. The phone was used to create a local area network onto which a laptop computer with the tool installed was connected to the measurements.

3. Results and Analysis

The latencies for the six networks were averaged for the two months' time and plotted over a period of 24 hours. Three networks with the highest latencies and lowest latencies were plotted on different axes of different scales because with using the same scale the low latency network plots would not appear at all on the graph. The plots are illustrated in figures 2 and 3.

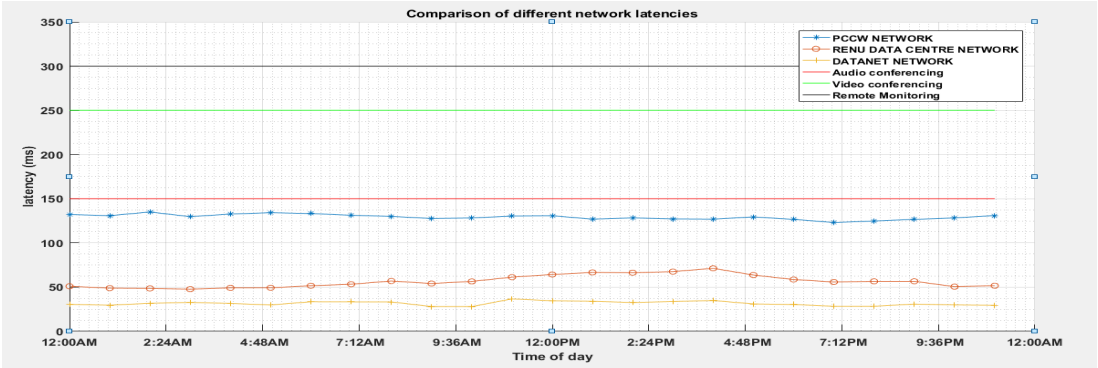

Figure 2: Comparison of latencies for the different networks.

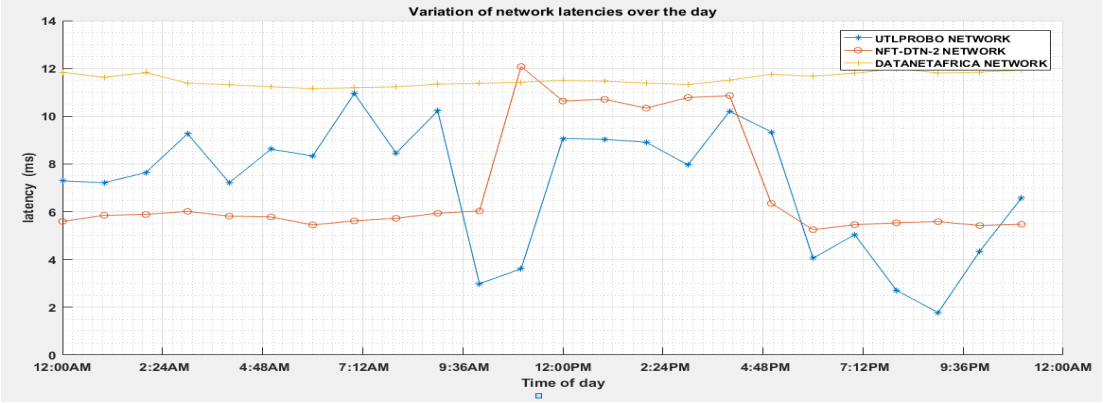

Figure 3: Least network latencies plotted on larger scale.

From figure 2, it can be seen that all three networks support all the selected services and this makes sense because of the close proximity of the network probes and the reference server. However important to note is that all the networks having varying latencies form each other and such variations would not have appeared on the network coverage maps and the maps would indicate all these probes as being in the same place and therefore having the same network performance. This is the reason for the need of such an assessment to give an accurate picture of network performance and before deciding to implement a given telemedicine service in a given region. The networks with least latencies were also plotted on a large scale as in figure 3 and from this it can be seen that the individual network latencies also vary (jitter) over the course of the day. This is very important because with this information sensitive and non-delay tolerant services can be scheduled at times of the day when the latencies are really low and those that are delay tolerant can be scheduled for the times when the latencies are high.

The results from the bandwidth measurements for both 4G and 3G were plotted on same axes plus the minimum bandwidth requirements of selected services as shown in figure 4. The 4G network showed support for all the selected services at all time while the 3G network support of some services varied over the course of the measurements period. The selected services

showed in the graphs i.e. audio conferencing and video conferencing pertain to real telemedicine applications like telesurgery, telediagnosis, telemonitoring etc.

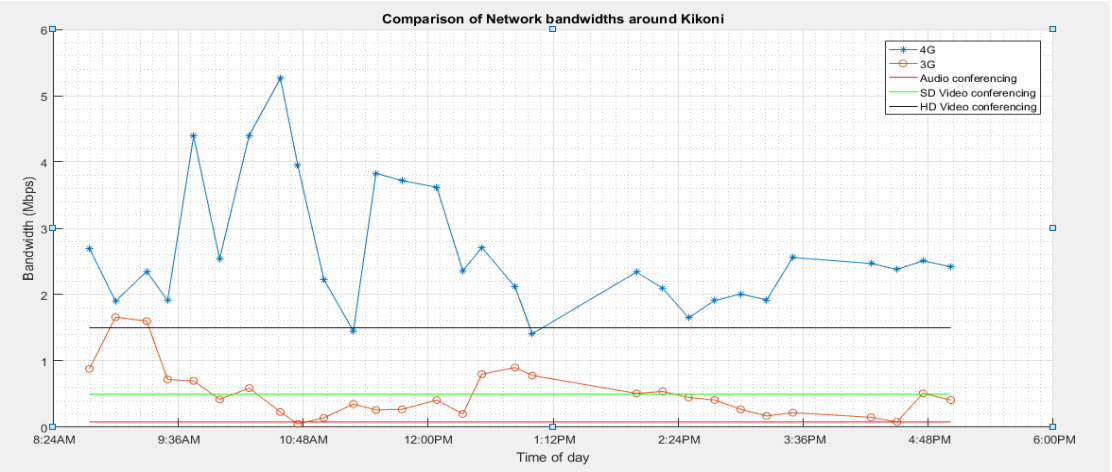

Figure 4: Comparison of bandwidths for the network in Kikoni.

4. Conclusions and Future Work

Network performance is a very crucial factor in any telemedicine solution and therefore a clear idea of the network performance is important in determining the choice of telemedicine service in a given place.

The assessment done in this work gives an idea of the selected networks' performances in the selected regions. Future work will focus on having the assessment packaged in a more user friendly tool like a smart phone application or a computer application that could have the assessment running in the background and after indicating to the user the supported telemedicine services basing on their choice of network the computer would be connected to.

Also focus will be on investigating the possibility of incorporating machine learning in the assessment such that, for instance, the application may only need to extract a few data from the probes but be able to use these data to make predictions of future network performance and also have these predictions included before coming up with a final decision on the best supported service.

Finally, the assessment especially for latencies was done using network probes limited to one location because of the limited number of probes in the other areas of the country. With presence of more probes especially in networks in hard to reach areas, an assessment of the possibility of telemedicine in these area will also be done.

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Towards a maternal and neonatal e-learning mobile aided system for rural health centers in Uganda

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ABSTRACT Knowledge and skills concerning maternal and neonatal healthcare are very vital in preventing and managing complications that may lead to maternal or infant mortality. Currently, there is a scarcity of health workers with adequate expertise to meet maternal and neonatal health care demands in rural Uganda. As part of efforts towards addressing the limitation of maternal and neonatal expertise, this paper proposes a mobile aided e-learning system for providing quick access to maternal and neonatal information or knowledge to expectant mothers and to health workers with limited expertise. An exploratory study was conducted in three sample health centers (Luweero Health Center IV, Lusanja-Kitezi and Nazigo Health Center II) in rural Uganda to establish various issues concerning maternal and neonatal healthcare with regard to the proposed system. The findings from the exploratory study motivated and were the basis for the first prototype of the maternal and neonatal mobile aided e-learning system that is also presented in this paper.

Keywords: maternal health, neonatal health, mobile-aided e-learning

1. Background

Although maternal and infant mortality rates in Uganda have decreased to 43 deaths per 1000 live births and 336 deaths per 100000 live births respectively in 2016 (Uganda Bureau of Statistics, 2016), there is still a need to improve maternal and neonatal services especially in rural Uganda. The Ugandan government has implemented a referral system, but the expertise needed to meet maternal and neonatal healthcare is also limited. While pregnant women can benefit from easily accessible information and knowledge, health workers with limited expertise can also benefit from readily available knowledge and consultation services where critical expertise is needed to make correct preventive or treatment decisions and implement them effectively.

Various forms of Information and Communication Technologies (ICTs) have been proposed and developed for different purposes in resource constrained developing countries (Ariani et al., 2017) including e-learning systems for medical education (Frehywot et al., 2013). As a contribution towards continuous efforts in the application of ICTs in healthcare, this paper proposes a mobile-aided e-learning system for maternal and neonatal healthcare. This proposition is based on the rationale that mobile devices are ubiquitous in developing countries

including Uganda and offer the highest likelihood for adoption of e-learning for maternal and neonatal healthcare. Our proposition also takes into consideration that to increase the validity of the proposed mobile aided e-learning system, it is important to establish the major issues that may affect its adoption and use in rural Uganda. As Frehywot et al. (2013) concluded in their review of e-learning in medical education in Low- and Middle- Income Countries (LMICs), a thorough understanding of appropriate e-learning tools, the practicality and effectiveness of e-learning use, and the feasibility of e-learning is needed to realize the impact of e-learning in improving healthcare. For this paper, an exploratory study was conducted in three sample health centers in rural Uganda to establish various issues concerning the application of the proposed mobile-aided e-learning system for maternal and neonatal healthcare.

1.1 – Key Definitions

Maternal health – is the health of women during pregnancy, childbirth, and the postpartum (postnatal) period.

Neonatal health – is offered to newly born babies until the end of 28 days from birth. During the first 28 days of life, the child is at a high risk of dying and therefore needs appropriate feeding and care.

Mobile aided e-learning system – Is an e-learning system where learners can access learning materials remotely using mobile technologies such as smart phones or tablets (Frehywot et al., 2013).

1.2 – Related work

A number of initiatives concerned with the use of mobile technologies for e-learning in healthcare have been proposed and implemented. For example, Zolfo et al. (2010) presented an innovative approach aimed at enabling healthcare workers involved in HIV/AIDS care in urban and peri urban stations in Peru to access state-of-the-art in HIV treatment and care. In this case, the learning needs for HIV/AIDS healthcare workers are very similar to learning needs for maternal and neonatal healthcare. It is thus plausible to adopt the approach by Zolfo et al. (2010) for maternal healthcare; however, Zolfo et al's (2010) approach was proposed for Peru which differs from Uganda according to several contextual factors.

Apart from e-learning, there are other apps which have been developed in various countries for providing information and facilitating maternal healthcare services and from which we draw inspiration for the work in this paper. The following paragraphs cover some of these apps:

OMama[3] is an app that was developed for families in Ontario, Canada. It connects women and families to trusted, evidence-informed health pregnancy, birth and early parenting information. It is important to note that before this app was developed, over 1,100 women and care providers responded to questions regarding what information the app should contain. Moreover, a follow up on the use of the app was also planned. In this paper, we recognize the necessity to involve pregnant women and healthcare providers in developing and assessing the use of maternal and neonatal healthcare apps.

[3] www.omama.com/en/About-Us.asp

Ada[4] is a health companion app that was developed in the United Kingdom and offers an Artificial Intelligence (AI)-powered health platform that is aimed at helping people to understand their health and navigate to appropriate care. As described in a popular science article by David Nield (2018), AI is used in Ada to spot patterns in a person's symptoms that might otherwise be overlooked. The app feeds a user with simple questions that are personalized to their particular situation; then it lists potential conditions with their symptoms and treatments (Nield, 2018). This app has been adopted by millions of people; this demonstrates the impact AI has in personalizing healthcare services. By the time of writing this article, we could not easily access the details associated with the development of this app. We cannot tell how much the app has for maternal and neonatal healthcare and whether it can meet the e-learning needs for maternal and neonatal healthcare. The main inspiration we draw from this app is the use of AI to personalize healthcare. In a similar manner AI should be suitable for personalizing e-learning for maternal and neonatal healthcare; however, it is not of particular focus in this paper.

GetIN[5] is a mobile app that was developed in Uganda to be used by community health workers and midwives to register and follow up pregnant women so that they can attend antenatal care. The idea behind this app was motivated by the high number of underage pregnancies that for obvious reasons are likely not to be recorded and followed up and in turn are at a danger of maternal mortality. This is a significant innovation towards reducing unattended pregnancies and maternal healthcare complications. Such an app can definitely benefit from additional functionalities including provision of information and knowledge as is the case for the work in this paper.

Beyond the functionalities provided by the systems above, we identify a number of properties that would be associated with an efficient and effective mobile aided e-learning system: provision of timely maternal and neonatal expertise to prevent unnecessary complications and deaths; provision for capabilities for users to access and express their health status; the ability to access as much maternal and neonatal information and knowledge as possible, at any time, and without any limitations; easy localization of the functionality and content of the system to meet information and knowledge needs of users with varying natural language capabilities; the possession of a user friendly interface for effective interaction.

2. Conceptualization of the proposed mobile-aided e-learning system

The proposed system is expected to enable pregnant women, new-born baby mothers, village health teams and health workers in rural areas to access maternal and neonatal information and knowledge. In this paper, we envisage this access to be achieved via a suitable user interface on a mobile device such as a smart phone. The proposed system must also contain appropriate information and knowledge that can be used for maternal and neonatal healthcare. For e-learning purposes, we have identified a number of learning modules that would be essential for maternal and neonatal healthcare. The following is a list of some of these modules from the United Nations Population Fund (UNFPA-UK) that are especially targeted for use by health workers: Pregnancy danger signs; Management of prolonged and obstructed labor; Family

[4] https://ada.com
[5] https://getinmobile.org/

planning; Management of post abortion care; Management of pre-eclampsia and eclampsia; Control of bleeding after birth; and Managing puerperal sepsis. We believe that in addition to an e-learning component, the proposed system can be a more complete healthcare support system with more functionalities including: having the functionality for locating nearest antenatal care services; providing information about birth attendance services and stages and signs of labor; providing information for requirements preparation for labor and delivery; providing information about nutrition and dieting during and after pregnancy; providing information about hypertensive diseases (such as heart diseases, stroke, peripheral arterial disease) in relation to pregnancy; and providing information of approved drugs and immunization for expectant mothers. Based on this conceptualization, we set out to determine the current experiences in accessing maternal and neonatal healthcare information and knowledge in rural areas and perceptions about the proposed system.

3. Exploratory study

In order to inform the requirements of the proposed system from expected users, we conducted an exploratory study from three purposely selected health centers that are located in areas which to a great extent are comparable to rural Uganda. The three health centers are: Luweero Health Center IV, Nazigo Health Center II, and Lusanja-Kiteezi health centers. We use the term comparable because these health centers are not so remotely located but the health facilities can be associated with those found in most of rural Uganda. The choice of these locations was also based on a number of limiting constraints and one of the author's easy access to health workers, pregnant women, and mothers for new born babies. In total, 55 expected users were interviewed (15 healthcare providers from Luweero Health Center IV, 10 healthcare providers from Nazigo Health Center, and 30 pregnant women and mothers from Lusanja-Kiteezi). The interviews aimed at establishing the current status of maternal healthcare and collecting feedback on the proposition for a mobile-aided e-learning system for maternal and neonatal healthcare. From the exploratory study, we found out that many rural based health centers lack supporting technologies that could stimulate quality maternal and neonatal health services. Both midwives and expectant mothers need knowledge so as to enhance the lives of mothers and their newly born babies. It was also discovered that health providers need to expand their knowledge on handling situations around labour and delivery by mothers.

3.1 – Feedback about the proposed mobile-aided e-learning system

- Most of the respondents appreciated the proposed provision of maternal and neonatal healthcare information and knowledge via mobile devices. This can be associated with a willingness to adopt the proposed mobile-aided e-learning system by expected users in rural Uganda.
- Language issues. Most of the respondents indicated to use local languages that they easily understand alongside English. This is true considering that most of the people in rural Uganda are likely not to comprehend the English language which is used in these kinds of apps.
- Most of the respondents also recommended that the proposed system enables access to information about maternal and neonatal healthcare providers including their contacts.
- Most of the pregnant women and new born baby mothers also recommended that the proposed system should provide a component where they can communicate their status and about the kind of treatment and support they receive from their spouses. Here, it was noted that pregnancy complications can also be associated with lack of support from spouses.

3.2 – Feedback about factors that may cause failure of mobile aided applications to improve maternal healthcare services

- Resistance (this includes unwelcoming attitudes of the health workers). They feel these systems would just waste their time and thus rely on personal understanding.
- Inadequate resilient hardware to support the software enabling the functionality and sustainability of the systems
- Lack of appropriate guidelines/regulations on the utilization of these systems.
- Lack of quality evidence on their outcomes and impact. Some health providers may not have faith that the new system will work consistently over the long term and may find ways to avoid switching to using them.
- Financial pressure of running these systems. So, health providers pay ongoing costs of Internet and mobile network access over the years.
- Inadequate training and supportive supervision. Limited training availed to health workers thus poor quality of care in the health units. Thus, need for extensive training. On the side of supportive supervision, limited follow-ups keep midwives from expanding the range of their tasks using these systems.
- Language. Most of the service providers and expectant mothers are not familiar with the language as used by the programmers, so they tend to ignore using the system. They prefer their local languages.

4. Implementation of the mobile aided e-learning prototype

4.1 – Functionalities implemented in the prototype

- SMS texting component for appointment reminder. With relevant information that relates to the phase of their pregnancy. For example, they receive a reminder when it is time to visit the clinic again and to take malaria pills, proper care for their health.
- Training / learning component (mainly for midwives)
- Feedback to allow interaction between the health providers and the expectant mothers as well as amongst midwives themselves.
- Sufficient health related data from prominent sources of expert health workers and organizations worldwide. For example; ministry of health, AMREF, health insurance companies.
- Open data (information/knowledge component)
- Text message component (as an added advantage for expectant mothers with difficulties to directly access the system).
- Live recordings component.
- Site map for easy navigation through the system.

The tools and software used to implement the above functionalities include: presentation tools and validation tools (enabling the back-ground support, color) like PHP and HTML; Swift (for mobile compatibility); Sublime text editor and note pad; Java script; and Bootstrap. Paper sketches were also used to enable capture a broad view of the system before it is put into use.

4.2 – The flow of interaction within the system

Figure 1 summarizes the interaction within the mobile aided e-learning prototype. A user has to sign in to access the different functionalities of the system. Most importantly, users must have already registered necessary details including all their names, usernames and passwords; some details such as email are optional. Registration details enable tracking of the use of the prototype by the different types of users (including patients and health workers). As figure 1 shows, the mobile aided e-learning prototype is expected to provide a number of services

including consultation; access to learning modules, healthcare provider locations; and a feedback interface for comments from users.

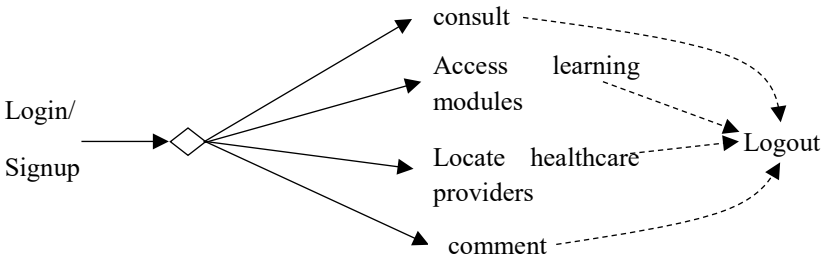
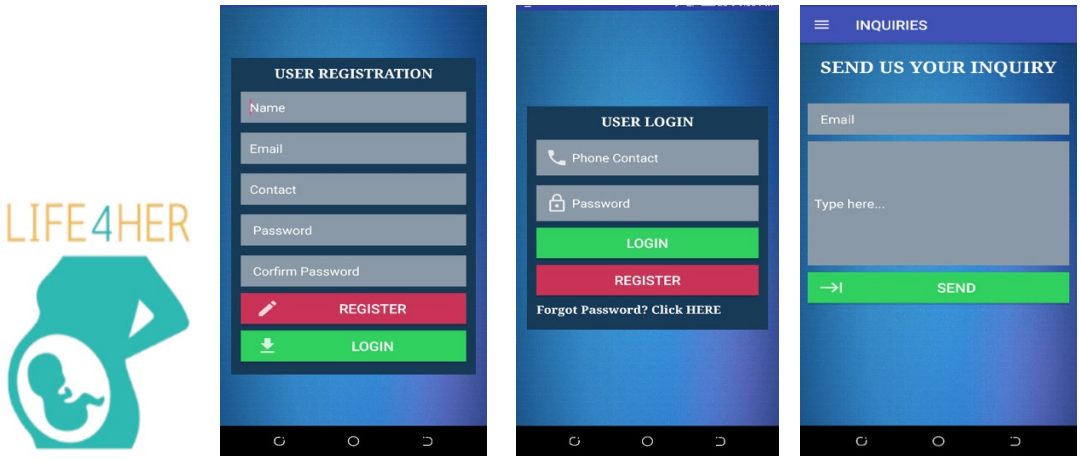


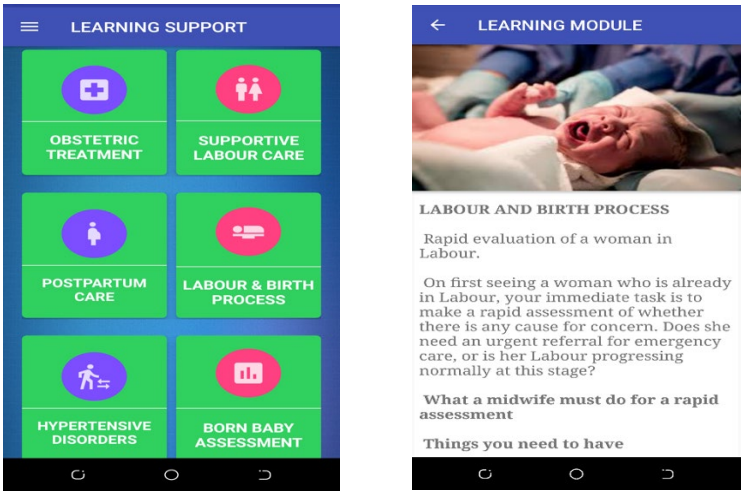
Figure 1. High level summary of interaction with the system

The homepage of the app enables expected users (pregnant women, mothers, and health workers) to access key information about the prototype and links for registration and login. Figure 2 (a) shows the app splash screen on start-up after installation on a mobile device; the user registration interface; the user login interface; and an inquiries interface.



(a) (b) (c) (d)

Figure 2: app splash screen on start-up (a) Registration (b) Login (c) and Inquiry (d) interfaces



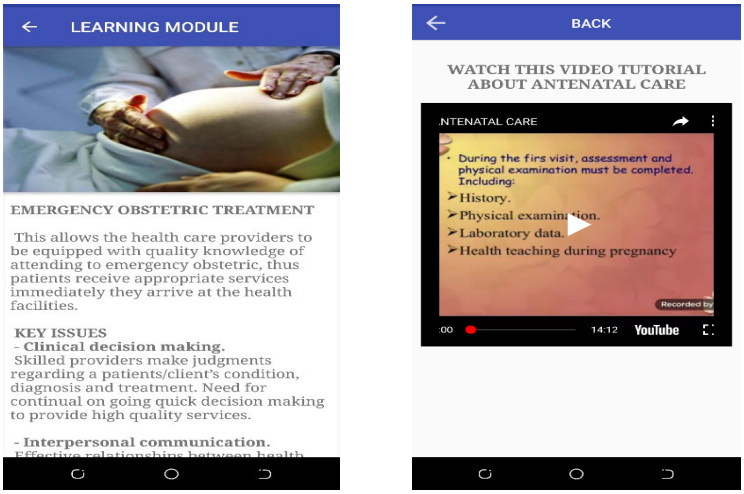


Figure 3: Examples of Learning support interfaces

Figure 3 shows examples of learning support interfaces that enable access to different learning modules including video presentations of learning material.

5. Testing and validation

The prototype was tested to remove different forms of errors. This involved testing the functionalities of the prototype to determine whether the interactivity involved was free of errors.

The prototype was also validated by expected users including twenty pregnant women from Luwero health centre IV and health workers from two health centers. Remarks from expected users included; the mobile app will provide them more understanding on maternal and neonatal health services, thus they highly recommended it. Need for internet to access all sessions when using the app could sometimes be a challenge in remote areas.

Expected users also appreciated the ease of use of the mobile app. However, they suggested integration of local languages where possible.

6. Conclusion and Future work

This paper proposed a maternal and neonatal mobile aided e-learning system to provide expectant mothers and less experienced health workers with easy to access knowledge and guidance. An exploratory study was conducted to establish the perceptions towards the proposed system from expected users including factors that may challenge the use of the system. Based on findings from the exploratory study and literature on similar systems, key requirements for a mobile-based application were identified; a prototype was developed, tested and partly validated. Although the mobile-based prototype covers key functionalities, some concerns from expected users as voiced in the exploratory study are yet to be realized; an example is the need to access maternal and neonatal knowledge in indigenous languages which are the main mode of communication in rural Uganda. Such unaddressed concerns actually require their own committed research; we recommend that this research should be part of future work.

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Bridging the information gap among expectant mothers in Uganda by use of USSD

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ABSTRACT Over the years, mobile phones have developed into one of the best ways of providing reliable access to information to people in low and middle-income countries. With the increase in the number of mobile phones, there has been a corresponding increase in the number of mobile applications which can be used as a new medium for the dissemination of information to people. In this paper, the authors focus on the Unstructured Supplementary Service Data (USSD) application to provide information about and report danger signs during pregnancy to pregnant women and medical practitioners respectively. The USSD application is used in the project since it is a technology that can be used by everyone including the rural population where the prevalence of smartphones is not so high, and many rely on the more cost-effective traditional phones.

Keywords: USSD, SMS, pregnancy, healthcare information system, e-health.

1. Introduction

Maternal death is caused by many and variable factors and the risk rises in the case of risky pregnancy or during a premature birth. According to the World Health Organisation (WHO) [1] about 830 women die from preventable causes related to pregnancy and childbirth and 99% of all maternal deaths occur in developing countries. Uganda, in particular, has a high maternal mortality rate of 368 deaths per 100,000 live births [2]. This is an alarming figure since all of these deaths are preventable. The deaths are mainly caused by the delay in seeking medical care due to inadequate information about danger signs during pregnancy.

The leading cause of death among pregnant mothers is postpartum haemorrhage. Most pregnancy complications for rural mothers are a result of lack of or poor maternity care while in urban centres, mothers are often affected by hypertensive disorders. Bleeding among pregnant women could be due to the womb's failure to contract properly.

Fatality due to loss of blood occurs when an individual loses 40 percent of their blood. The other serious causes of death among pregnant women are represented in Table 1.

Table 1: Fatal medical conditions during pregnancy

Haemorrhagic complications	Hypertensive disorders	Other complications
Postpartum haemorrhage	Acute fatty liver of pregnancy	Urinary infection
Placental Abruption	Severe preeclampsia	Pulmonary oedema
Ectopic pregnancy	Hypertensive encephalopathy	Sepsis
Placenta Previa/accreta	Eclampsia	Seizures
Ruptured uterus	Severe hypertension	Postpartum endometritis
Severe haemorrhage due to abortion	HELLP syndrome	Post-abortion endometritis

Women are not informed about all these conditions including signs and symptoms plus the kind of care needed to treat these medical conditions. This causes a delay in seeking medical care due to ignorance.

Poor infrastructure, inadequate literacy, availability of technology and socio-cultural settings are a few factors in the myriad of challenges facing the development of rural areas in developing countries [3]. Healthcare is one of the most important sectors where governments of developing countries strive to enhance the situation by utilizing affordable ICT solutions. However, unlike developed regions, in rural areas within a developing context, issues are intertwined. This requires truly innovative solutions that are affordable, robust and above all sustainable. The reported work is still a research in progress. Nonetheless, this first fully functioning prototype allows for significant reflection on the research and practical challenges we focused on.

2. Background

This project is aimed at providing information about danger signs during pregnancy to pregnant mothers through the use of USSD for all GSM enabled mobile devices. The absence of accurate and timely patient information at the clinic implies that the patient cannot be monitored on a frequent basis, meaning that the medical practitioner cannot take actions as promptly as desired. Patients cannot assess the severity and criticality of situations and try to postpone transport to a clinic or hospital as long as possible due to high travel costs and efforts. In the eyes of caregivers and sisters, deaths can potentially be prevented when medical practitioners are aware of patients' health conditions at an earlier stage.

UCC mobile subscriber report [4] reported a total of 23,993,111 telephony subscriptions from Uganda. The current population of Uganda [5] is 44,126,577 as of Wednesday, May 30, 2018, based on the latest United Nations (UN) estimates. Assuming a fairly distributed population, it is fair to assume that in every home there is a mobile phone of either Global System for Mobile communication (GSM), 3G Universal Mobile Telecommunications System (UMTS) or 4G Long Term Evolution (LTE).

The solution presented in this paper will also be able to advise these women accordingly in case they encounter problems during pregnancy. The motive of the proposed mobile

application is to connect all expectant mothers and their new-borns under one umbrella by keeping track of their weekly/monthly health records, health issues while also localizing them to make any health- driven actions faster and effective in developing countries.

The solution will also provide awareness to people in developing countries which aims to prevent deaths due to superstitious myths and beliefs that prove unhelpful and can increase the risk during pregnancy both to the mother and her unborn child. There are a number of pregnancies that result in deaths due to lack of awareness of the severity of a given condition. Mobile [6] services have been proven as a reliable means of conveying information, but the question of cost and financial sustainability is one that should be considered. For our solution, we shall start by working with government bodies such as the ministry of health so as to offer this information for free to the citizens especially those in rural areas.

2.1 – Definition of terms

Mobile Application: A mobile application is defined as software designed to take advantage of mobile technology. In this paper, we refer to USSD and smart phone application as mobile applications.

Short Message Service (SMS): SMS is a text messaging service component of phone, web, or mobile communication systems. It uses standardised communications protocols to allow fixed line or mobile phone devices to exchange short text messages. SMS are sent to mobile phones via the SMS Gateway.

Unstructured Supplementary Service Data (USSD): USSD is defined as a communication protocol used to send to send text messages, i.e. SMS messages, between a mobile phone and applications running on the network.

Medical Practitioners: These include doctors, nurses and care givers at the different stations of the health care hierarchy.

Patients: In this paper, this term is used to refer to expecting mothers.

3. Overview of USSD

As Kassinen et al. [18] explain, “The USSD protocol is supported by every GSM or UMTS phone. The USSD version in GSM Phase 1 specifications does not have the “push” mode that enables network-initiated USSD connections; only mobile-device initiated connections are possible in Phase 1, as pointed out in [7] and [8].” They also explain that the pushing of messages from the network-side to the handset was introduced in GSM Phase 2, which is also broadly deployed and has been in use since the 1990s.

“The USSD protocol has no store-and-forward support; the connections are always session oriented. The typical user interface to USSD services is either through dialing commands using the phone’s numeric keys or with a menu-based browser.” [18]

USSD is being used for different information services, telecommunications services like voucher airtime recharge, mobile money cash transfers, mobile banking and so on. [18]

“USSD carries messages of up to 182 characters in length (7-bit characters: 160 bytes). As an additional plus, the load caused by USSD on the operator’s networking resources is very light. USSD operates in the same SDCCH signaling channel as SMS does.” [18]

Finally, Kassinen et al. also point out that USSD is better than SMS for implementing Network-Assisted P2P Invocation (NAPI), because:

- USSD is session-based: the radio channel is reserved until the end of the USSD session which yields shorter delays (in addition, SMS could cause unwanted storing of NAPI messages in the message center when the target device is offline); and
- roaming with USSD is free of charge – even the non-roaming use of USSD is often free, unlike SMS.

4. The Proposed Technical Solution

4.1 – Overview of the proposed system

We follow the assumption that frequently providing health care givers with patient information that is relevant, easily accessible and accurate during the whole pregnancy period will benefit patients in multiple ways. Earlier diagnoses can be made, better treatments can be started, but also travel costs and effort can be reduced for both patients and caregivers.

This will result in better life quality and expectancy for patients, but we also expect that providing such information to the medics has a positive effect on the workload and joy for both doctors and nurses attending to the pregnant women.

Facilitating the transmission of patient information by technology operates in the field of telemonitoring (remote monitoring) which is a branch of e-health. Telemonitoring includes the collection of clinical data and the transmission of such data between a patient at a distant location and a health care provider through electronic information processing technologies [9].

4.2 – Research Approach

In this section, we discuss the starting points for the design process: the social context and the related design challenges, followed by the requirements engineering approach.

Social context and design challenges

Physical, financial and skill accesses [10] are tangible boundary conditions to successful ICT implementations. However, acceptance of communication technologies for health care systems is itself a challenge in developing countries and especially in culturally diverse countries [11]. The high rate of failure in ICT programs is explained by Heeks [12] as a 'mismatch between Information System design and local user actuality.' Some of the social and cultural circumstances specific for our research, which have been embodied in the design process are described below.

Originating from many forms of inequalities and experiences with corruption and political mismanagement, the rural population has a low esteem of government actions. Furthermore, many projects that have taken place, started by the government or non-government organizations have resulted in failures. This has resulted in a certain reserve towards new projects, and it affects caregivers' and pregnant mothers' motivation and willingness to share information with the researchers. Some other aspects make it difficult to gather valid information: informality of business processes, 'yesnodding,' and stigma around some diseases like HIV/AIDS. Burdened with more fundamental problems, caregivers and pregnant mothers are tended to disagree about the proposed problem to be solved (lack of communication) and the proposed solution (ICT). Caregivers have limited professional training and are of semi or low literacy level. This limits the extent to which system requirements can be elicited.

Furthermore, a substantial part of the patients doesn't have faith in western medicine and more traditional medicine is practiced. Also, Uganda being a multi-lingual country, language barriers in certain parts of society leads to reliance on interpreters who don't always convey accurate gestures to verify the quality of the information passed on.

Elicitation of requirements

The system requirements were shaped by the "three phases of delay" model as discussed by Thaddeus and Maine [13]. Phase 1 delay: delay in deciding to seek care on the part of the individual, the family, or both. This phase of delay is the main focus of this solution. Our model seeks to provide patients with an ease of taking western medical solutions rather than traditional medicine which has proven ineffective over the years. This is done by reducing distance barriers, financial costs, and opportunity costs and improving the perceived quality of care.

To develop a sustainable system a key requirement is that the community adopts the system, maintains the system and has a sense of ownership with respect to the system. To achieve this, user involvement in all stages of the development process is considered very important. To develop commitment from stakeholders in using and maintaining the system we can refer to [14] who found that there are three components of commitment; (1) affective or emotional commitment, presented in the patient-caregiver relation, (2) continuance commitment, based on the benefits or utility people obtain from participating, and (3) normative commitment, a felt obligation to continue, strengthen by the sense of community and being needed. Normative commitment has in our context a critical additional factor, the tradition and informal ways of working in the current system are valuable to the community and should not be thwarted.

Given these constraints, we took the following steps to derive the requirements for the system and to develop a prototype that meets these requirements. At the start of the design process, the problem, the solution, and its technology were flexible and depended on stakeholders' input. Informal semi-structured interviews in small groups were held during the first two visits to assess users' needs. A workshop attended by all relevant stakeholders was organized at Resilient African Network (RAN) to define problems they encounter and how they could be solved. A secondary goal was to achieve consensus and build commitment. Also, the first basic requirements were elicited and ranked by importance. During the third visit, more detailed requirements were again discussed in small groups and participants could state their technology preference (call centre, Smart phone app, SMS or USSD) after simulating interaction with these technologies. Here medical doctors and engineers gave their opinions about the simulations. Visits were made to pregnant mothers in remote societies of Kikube (Luweero), Kasebuuti (Masaka), Muyomba (Wakiso) and Kikoni (Kampala). These were intended to get user views of the proposed system and find out if it could fix the problem stated, also for usability and usage observations. Questionnaires were administered during these visits for evaluation purposes.

5. Prototype Design

In the previous section, we elaborated on the design approach, the social context, and its challenges. The goal was to design a robust and affordable ICT enabled system through which patients or family members can submit vital patient information to the medical practitioners through the USSD system. The prototype, which is currently tested, meets its functional and technical requirements for the most part. Therefore, the proposed solution and the prototype are jointly discussed in this section.

5.1 – USSD Code Format

According to Akram, R. [15] USSD communication is initiated by dialing a special code known as USSD code or short code. It usually has an asterisk (*) at the beginning and ends with a hash (#) and has digits 0 to 9. The code for our application is *130*45#.

5.2 – Technical Architecture

USSD stands for Unstructured Supplementary Service Data. USSD allows for the transmission of information via the Global System for Mobile communication (GSM) network. USSD is best explainable as 'interactive SMS.' Text messages are sent to and received from a caregiver's mobile phone through a real-time connection to the GSM network. A wireless service access provider (WASP) routes the messages from the mobile network to a server with the application and database. Medical practitioners and information officers have web-based access to the application and personal health records (PHR) via a 3G modem and a desktop computer. A big advantage of the use of USSD is that it is easily accessible (by simply dialing a number) and easy to use (simple menu structure). USSD works on almost all mobile phones, and it is generally used in Uganda, for example, to load airtime on a mobile phone. A drawback is that the open connection is disabled after three minutes.

To simplify the description, the USSD architecture basically comprises of:

- The network part which includes the Home Location Register (HLR), the Visitor Location Register (VLR), and the Mobile Switching Centre (MSC)
- Simple Messaging Peer-Peer (SMPP) interface for applications to enable services.

5.3 – Designing the client application

The system is designed for use by all GSM phones and subscribers will access information through USSD messages on these phones. The user enters USSD code (*130*45#) to access the information. Accessing the system, the user will be asked to subscribe by sending messages to a special number (registration could be free).

The user can then choose to proceed or quit. Language options are displayed so the user can choose a preferred language. Upon choosing a given language option, the user will be notified in this language, and all message interaction will remain in that language. The application has been developed with the main languages spoken by people across the main regions of Uganda. Figure 1 shows a sandbox simulation of the application being used to subscribe to SMS alerts in the "Luganda" language.

After reaching to the last subcategory, the user will receive a USSD SMS informing him that information will be sent to his phone as an SMS or as an audio message.

5.4 – Patient Interaction with the system.

After a patient subscribes for continual alerts of the danger signs using the code (*130*45#), the user can set their preferred language and means of communication, i.e. either voice or SMS alerts. We discovered from talking to various mothers that while taking the messages to their local languages was engaging, it was not sufficient as many could not read the SMS in their local languages. Even those who could actually read, many could not tell when a new message had arrived on their devices and therefore could not navigate their devices to SMS. Therefore the need for Interactive Voice Response (IVR) which is faster than reading an SMS but requires

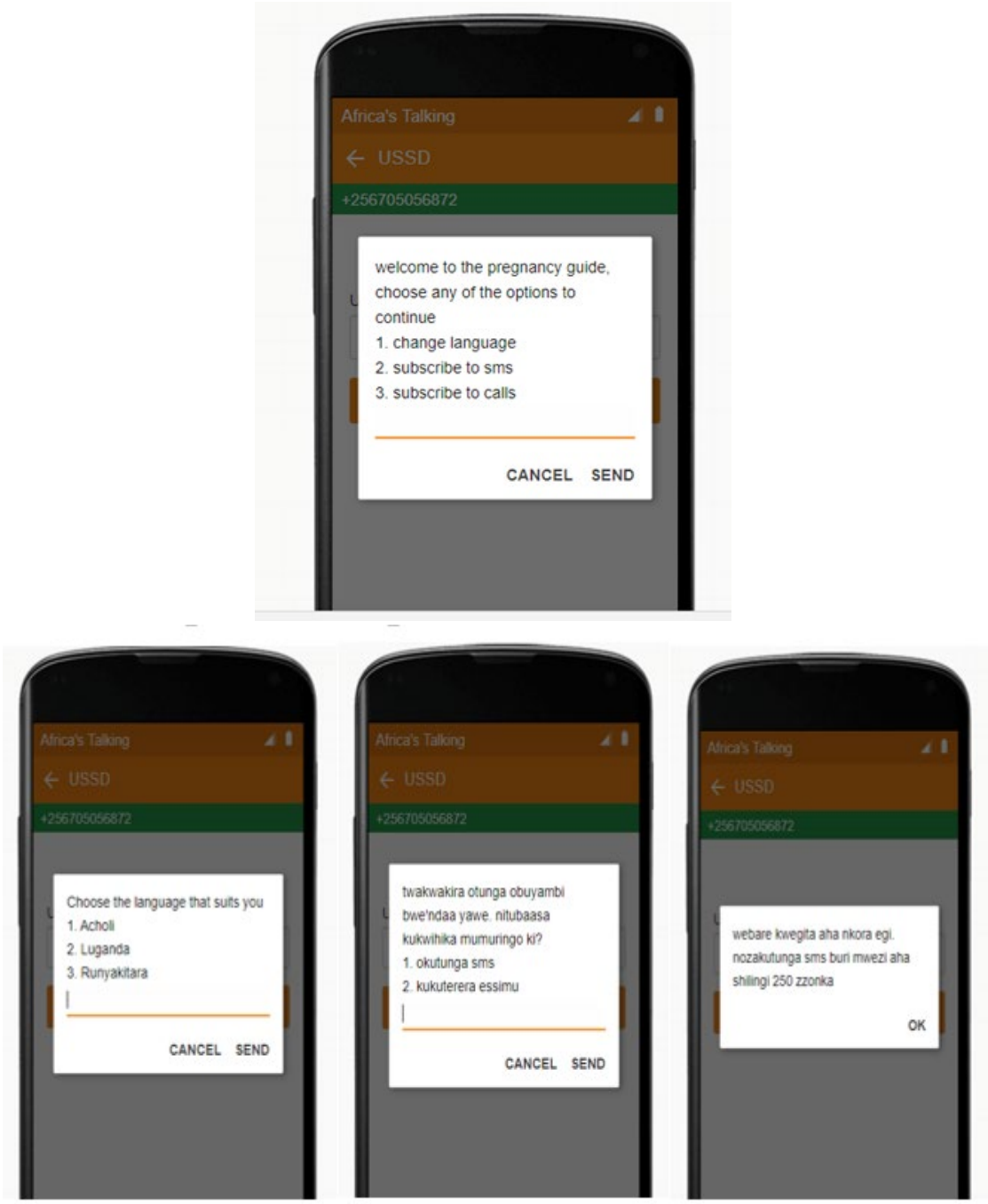

Figure 2: Maternal health USSD application running on the Sandbox Simulator

a specialised team to leverage information to address patient needs, streamline development and control operational costs.

It is normal for a patient to ignore the problem in early stages when they feel fine [16]. The disability arising at the onset of the illness, like extreme fatigue and depression, is managed by the adoption of a healthy lifestyle which includes healthy eating and regular physical activity, oral medication and weight loss.

This is the phase when doctors should care to communicate to patients to avoid long-term complications that could lead to miscarriages or death. The patients can then initiate the USSD

menu to report a danger sign once it is realised to the system which in turn raises a flag to the doctor depending on the danger rate of the sign and the stage of pregnancy. Effective dissemination of health information allows patients to engage with the healthcare system to follow recommended advice, adhere to treatment and cope up with the psychological consequences of their illness.

5.5 – Medical Practitioner interaction with the system

The medical practitioners provide information about the danger signs and health eating habits that is fed in the system's database by the Information officers. This information is relayed to the mobile subscribers depending on their registered stage of pregnancy. The medical practitioners also get a desktop computer interface where they receive alerts of danger signs reported by the pregnant women and can make a judgement on how to respond to these alerts.

6. Evaluation – intermediate results

Evaluation is in progress, but we will briefly discuss our intermediate results.

The goal of testing the prototype is to determine its success and to investigate its potential in comparable areas. Some general preliminary findings are; The stakeholders were all happy and enthusiastic about the solution and the attitude towards it was generally positive. The medical practitioners seemed happier about having the system than using the system. The cases sampled proved that using the system was not as easy as anticipated because users who could not read found it hard to subscribe to the system. However, after a few unsuccessful trials, all users successfully subscribed to the system. Still, some of the users completely failed to report the warning signs and ended up recording false signs to the system.

Submitted patient information (by patients) and login data (from medical practitioners), questionnaires and user observations will be used to disentangle factors that led to high or low user acceptance. Factors that possibly determine user acceptance [3] are for example referent power, years of professional experience, experience with a mobile phone or computer, age, education, learning curve, technology aversion, availability of airtime and network coverage. By investigating these underlying factors and by profiling comparable communities, future behaviour and potential can be assessed.

7. Conclusions

The number of women who die in preventable deaths during pregnancy continues to rise in developing countries. There is a wide gap between what people know and the facts when it comes to pregnancy and hence the requirements to bridge this information divide.

This paper has discussed the design and simulation of USSD applications that can be used as an information tool for disseminating information to pregnant women both in urban and rural settings in developing countries. If this technology is implemented in practice it has the potential to reduce the time delay between an expectant mother having a problem and seeking medical care. This time-reduction can save lives and reduce mortality rates.

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MOBICAP – A mobile app prototype for detection of criminals at country borders in low resource contexts. The case of Uganda

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ABSTRACT Uganda is a land locked country bordering Democratic Republic of Congo and South Sudan that are fairly characterized by political and social instability resulting into large numbers of refugees that continue to flock the country for safety. In some instances, criminals take advantage of inadequately manned remote border posts through which they are able to traffic humans and drugs,and move both small and large ammunitions hence contributing to more instability. This paper proposes a mobile-based solution for aiding the detection of criminals at remote border posts. The paper discusses alternative cost affiliated mobile technologies that require affordable resources to capture bio-geographical information of travellers and to ascertain their legibility from forged documents, criminal history and associates, and to monitor continuous movements of travellers and ascertain their motive. The paper then presents a prototype of a mobile application that is designed according to these properties while aimed at providing the necessary aid for criminal detection.

1. Introduction

Uganda has porous borders that are poorly manned by informal (paper based) verification checks of travellers; some criminal elements are taking advantage of failure to track their travel history and criminal record to cross these borders. Ntezza (2015) say that "The Uganda 2012 Overall Crime and Safety Situation (OSAC) report noted that while the country is "generally viewed as a safe, secure and politically stable country within the region, its extensive and porous borders are inadequately policed, allowing for a robust flow of illicit trade and immigration""(Ntezza, 2015). In a report by the USA Bureau of Counterterrorism and Countering Violent Extremism it is said that "Border security remain a persistent concern for the Ugandan government, with especially porous borders between Uganda and both South Sudan and the Democratic Republic of the Congo. Uganda used the U.S.-provided Personal Identification Secure Comparison and Evaluation System (PISCES) to conduct traveller screening at the country's major ports of entry. The use of PISCES led to the late-November 2016 arrest of one individual allegedly linked to the al-Shabaab bombings in Kampala in 2010; the individual was attempting to cross the border from Kenya to Uganda and was flagged by the PISCES system" (Bureau of Counterterrorism and Countering Violent Extremism, 2016).

IFRC say that "Since January 1, 2018, 77,429 people fleeing from interethnic violence that erupted in the Ituri and North Kivu Provinces of the Democratic Republic of Congo (DRC) arrived in Uganda" (International Federation of Red Cross and Red Crescent Societies, 2018).

It is hard to verify whether some of these people are not fleeing from crimes or not involved in rebel activity. In other instances, ADF training camps like Miba in the Mwalika area, 30km south-east of Beni. It is alleged that recruits come from the DRC and neighbouring Rwanda and Uganda. They are either enrolled in ADF by force or attracted by the promise of a better life **(**World Watch Monitor, 2017**)**, these elements bypass porous border points undetected.

On the night of June 9, 1998, the Allied Democratic Front (ADF), a Ugandan rebel force of Islamic extremists based in the Democratic Republic of Congo (DRC), infiltrated Uganda on its western border and attacked students at Kichwamba Technical Institute by setting dormitories ablaze. Between 50 and 80 students were burned to ashes, others where abducted (Human Rights Watch, 1998). The porous, mountainous Uganda-Congo border facilitated the terrorists' ability to infiltrate Uganda, attack the institute, and retreat to their safe havens in the eastern DRC.

On July 11, 2010, during the World Soccer Championship in Kampala, Al Shabaab launched a suicide terrorist attack. During the attack, several people were killed, including 60 Ugandans, 9 Ethiopians, one Irish woman, and one Asian; some 85 were wounded (Al Jazeera, 2010). Investigations revealed that the terrorists exploited the porous Uganda Kenya border to infiltrate items used in the attacks. Recently, a number of Muslim clerics have been assassinated in Kampala; senior security officials have linked these targeted killings to the ADF terrorists, who are still operating across borders **(**Radio One, 2014**).**

However, the threat remains real and constant—in large part because of the situations on Uganda's borders. The Lord's Resistance Army (LRA) makes the South Sudan–DRC–Uganda border insecure (Weber, 2012). While Uganda has pacified the north-eastern region after a successful disarmament exercise, its northeast border remains vulnerable because Kenya has not conducted a similar disarmament exercise.

In this paper we propose the use of mobile technology to aid crime detection at Uganda's border points that have limited capacity. In Uganda, mobile technologies continue to offer commercial solutions to both individual consumers and companies. Uganda also currently lacks the capacity and finances to establish effective infrastructure and surveillance and control mechanisms at all border cross points. The necessary border security infrastructure includes physical barriers (such as fences), roads, lighting, cameras, integrated fixed towers, remote video surveillance systems, mobile surveillance systems, agent portable surveillance systems, thermal imaging devices and unattended ground sensors among others but mobile applications to capture traveller details.

Currently, the country is estimated to have about 22 million mobile phone subscriptions and over 18 million Internet users (Uganda Communications Commission, 2018). Because of the proliferation of mobile technology users in Uganda, we argue that the use of mobile technology is a very suitable alternative for detecting criminals at resource constrained border locations. Mobile technology can be used in areas where there is limited or no grid power supply; instead, solar power can be used for charging purposes. Remote Border Posts can be equipped with a mobile application for accessing traveller history and details, and for exchanging security information with law enforcement agencies. This paper presents MOBICAP, a prototype of a mobile application intended to capture travellers' bio-geographical information, identity, country of origin and destination, dates and occupation / reasons of travel while at the same time offering capabilities for exchanging information with other security agencies. MOBICAP

has been developed for installation on mobile devices that use the Android operating system. It is hoped that such mobile applications are a cheaper and affordable mechanism of identifying criminals who usually exploit remote un-digitized border posts.

Uganda has two main border management systems, Personal Secure Comparison and Evaluation System (PICES) donated by the American government, and Migration Information and Data Analysis (MIDAS) managed by the Uganda Immigration Services (International Organization for Migration, 2016b*).* These systems collect, process and store travellers' information/details however lack country wide coverage, they operate at busy border posts of Malaba and Entebbe International Airport, most remote border posts rely on paper based information capture making the process complex especially tracing false identity and forged papers, international criminals take advantage of these loopholes to cross between countries smuggling weapons and elicit trade activities. These gaps can be reduced by adopting mobile application systems to capture digital information that can be searchable to identify whether the entrant has been recorded in any other border posts for criminal suspicion, also keeping track of the number of entrants visa-vi the reason (Trade, humanitarian, Instability or even disease outbreak). This helps government make policies that can effectively scrutinize trans-border crossings without compromising privacy, controlling the flow of criminal activities while addressing strategies to limit humanitarian instability driving forces.

Mobile applications run on basic phones mostly on android platforms, the economic advantage is their low power consumption, they can be charged on small solar system especially in remote borders where Government power lines have not yet reached, illegal immigrants usually exploit such border posts to cross undetected, mobile application recording bio data details can help in trace backs and investigations.

1.1 – Existing Ugandan immigration systems

Uganda has two main border management systems: Personal Secure Comparison and Evaluation System (PICES) introduced by the American government and Migration Information and Data Analysis System (MIDAS) introduced by the European Union and managed by the Uganda Immigration Services. These systems collect, process and store travellers' information or details. These systems are only used at busy border posts like Malaba, Busia, Katuna and Entebbe International Airport. IOM say that "The PISCES project was initiated by the United States Department of State, Terrorist Interdiction Program (TIP) in 1997, initially as a system for countries to improve their watch list capabilities by providing a mainframe computer system to facilitate immigration processing. It was supplied to a selected group of countries in Africa. Foreign authorities used the technology to monitor the watch list and exchange information with the United States Department of States regarding suspected terrorists appearing at their borders. The information is used to track and apprehend individual terrorists, not for the wide-ranging analysis of terrorist travel methods, according to the Government of the United States report. It matches passengers inbound to the United States against facial images, fingerprints and biographical information as they depart from airports in high-risk countries. A high-speed data network permits US authorities to access advanced information concerning inbound passengers. PISCES workstations installed in participating countries are linked by wide area network to the nation's Immigration, Police or Intelligence headquarters" (International Organization for Migration, 2016b).

Most of the remote border posts rely on manual based information capture and processing which is complex especially when tracing for false identification and forged documents. International criminals take advantage of these loopholes to cross such borders from where they smuggle weapons and conduct illegal trade activities.

1.2 – Possible solution

Empower border staff in remote locations with a mobile application to capture traveller information for possible comparison among other post to assess the truthfulness of the traveller. Mobile application can run on basic phones with android platforms. The economic advantage is their low power consumption and that they can be charged on small solar systems especially where Grid power is non-existent. Mobile technologies are also portable and can easily be connected to post and access information to and from servers via wireless networks.

2. Literature review on border management

Today scholars argue that globalization, which is characterized by internationalization of production, liberalization of trade, and development of communication technology, has led to the erosion of borders**. (**International Organization for Migration, 2016b**).** Andreas (2009) observes that, contrary to conventional wisdom that in the new world of globalization borders have become irrelevant, instead the state intervention through border policing has increased due to the rising risks emanating from clandestine cross-border criminal activities..

In Uganda, while there are systems in place for the identity management of nationals and migrants at a number of BCPs, their use is inconsistent. There is an obvious weakness in Uganda's border control because of the prevalence and acceptance of insecure temporarypasses (not passports) and in some cases allowing travellers to bypass the Border Management System (BMIS) in the name of traditional trans-border movements. There are occasions when no biometric registration or other checks are done on the departing migrants, some of whom might have been on wanted lists. (International Organization for Migration, 2016b, p. 59). "East Africa has been a volatile region, facing numerous challenges from political, military and economic instability. Such conditions have placed great strain on the border management of Uganda, exposing its borders as being vulnerable to irregular movements and mass migrations. The pressures on Uganda's borders are also a major contributing factor to other cross border issues such as trafficking in persons and smuggling of precious materials which fuel conflicts" (International organization for Migration, 2018a).

IOM reports that during the opening of the South Sudanese Government High Level Expert Meeting held in 2018 towards the protocols on free movement of persons and transhumance in the IGAD region, South Sudanese Foreign Affairs Minister Martin Elia Lomuro "urged the experts to tackle various sticking issues, including nomadic pastoralism and belligerent asylum seekers. He said many South Sudanese live in capitals of neighbouring countries, where they own property inappropriately acquired from South Sudan, and reportedly use their wealth to finance instability back home." He urged "these cannot be treated as ordinary asylum seekers". Further IOM say that Mr Ali Abdi, Chief of Mission of IOM Uganda, "urged IGAD member states transition from restrictive to facilitative border management strategies, promote free movement of persons, and unlock the region's intra-regional trade potential" (International Organization for Migration, 2018b).

In a press release from May 2016, IOM claims that "Uganda's porous borders make it extremely challenging to counter transnational organized crime, including terrorism, trafficking in persons and smuggling of migrants. As a country fully engaged in regional integration, Uganda must also ensure the legitimate cross-border flow of people and goods" and that the Japanese Ambassador to Uganda Junzo Fujita is providing funds to IOM to help the Ugandan government improve its border security. According to IMO, "Fujita said that the project will contribute to the security of all Ugandans by enhancing the country's capacity to respond more effectively to various migration and border challenges. 'We cannot allow transnational crime to take hold because of porous borders. Also, we must ensure that Uganda's borders are contributing to enhanced trade, investment and tourism'." (International Organization for Migration, 2016a)

Lack of strong, established and well-facilitated structures along Uganda's borders to effectively conduct surveillance and monitor border activities provides transnational criminals with an opportunity to violate the national borders. However, this situation can only be remedied by a regional effort between Uganda and its neighbours through joint border operations and information sharing. Though some improvements in this regard are underway, the development is ad hoc and needs improvement.

Land border crossings constitute obstacles to regional integration and facilitating the movement of goods and persons across borders ranks high in the priorities of Regional Economic Communities in Sub-Saharan Africa. These obstacles are common to gateway corridors serving the landlocked countries and also hinder regional trade and international transit, thereby adding to the importance of addressing this challenge (Fitzmaurice and Hartmann, 2013).

Papademetriou and Collett states that "Governments are beginning to place greater emphasis on the need to collect data on people who wish to enter their country before their arrival at the border. The data collection ranges from biographical information contained in the passports […] to more detailed information on travel plans (collected through Passenger Name Records [PNR]) and the purpose of an individual's visit […] This information historically collected through visa applications and at ports of entry, is no longer used just for immigration enforcement and the prevention of visa overstay, but also assess potential security risk" (Papademetriou & Collett, 2011).

3. Requirements gathering: method and result

3.1 – Sampling

Through sampling, a number of border posts were reviewed to assess how the immigration information process is handled, it was observed that Entebbe Airport and Malaba Border post with Kenya have the highest number of entrants and the digital approach to digital processing and storage was highly emphasized, Many entrants satisfy requirements like passports and authentic travel documents although depending on the expertize of the illegal entrant, some elements have managed to bypass the virtual fence, for example the 2013 Westgate attackers managed to bypass Entebbe and Malaba check points to Kenya undetected. The Mpondewe – Bwera border post between Uganda and DRC lacks the necessary equipment to control the busy border characterized by individual trans-border crossing basing on same ethnic backgrounds of the indigenous border community, criminals work with these communities to

bypass a poorly managed process to cross elicit weapon accessories and counterfeits between Uganda and Eastern DRC which has recorded a long era of security instability.

3.2 – Interviews

During the Interaction with immigration officials at Malaba border-post they hinted one the system being slow and freezing during peak hours where traffic is at its highest, officials attribute this to limited finances allocated to them especially for IT maintenance and Upgrading, this limits their capacity to add strong and high speed/memory machines that can capture, store and retrieve information faster in real time.

Immigration Officials expressed concern about remote border posts that continue to rely on manual information processes not only because of small budgets but also poor geographical terrain and overall national infrastructure challenges like absence of power lines, roads, water for employee's wellbeing and operational activities. They urged that remote borders are not frequently bypassed with bulk illegal merchandise but small bits of ammunition pass through such borders in parts and soft target for crossing high classified criminals like wanted terrorists and rebel structures.

Immigration officials give credit to the MIDAS system and PICES so far operating on main entry/exit points where individuals with pending court cases have been intercepted trying to escape through use of electronic verification and information exchange, other criminals on the Interpol hit list have also been intercepted, counterfeits and human trafficking offenders have also been intercepted. Officials continue to emphasize on the need to train and recruit IT skilled personnel to learn the proposed system to cover other remote borders, this comes at a dollar cost on top of the limited budget at the moment.

In consultation with security officials, they expressed frustration about lack of prior information about individuals on Interpol's hit list and wanted criminals from neighbouring countries who enter the country from remote borders with fake travel documents that cannot be tracked by the manual processes at these borders hence limiting their efforts in combating international crime. Security personnel further hinted at the laxity of IT equipment personal where international traffickers and wanted criminals have bypassed the digital fence at these major Airports and border posts, they hinted that the PICES system is accurate and so far the best but does not serve the host government it instead benefits the American government more in efforts to track the movement of their political and military rivals from Asia and Middle East who travel to other states less hostile to the West where PICES system has been installed

4. Proposed System Prototype

4.1 – Conceptual Design for the criminal detection prototype

The proposed application is conceptualized to help immigration staff go mobile in their data processing since digital data can be verified and easy comparisons between different border posts done in a minimal time lag. Conversely, the application is also supposed to furnish Headquarters and other stations with information about all travellers who have been registered through that specific border point. Figure 1 illustrates this conceptualization.

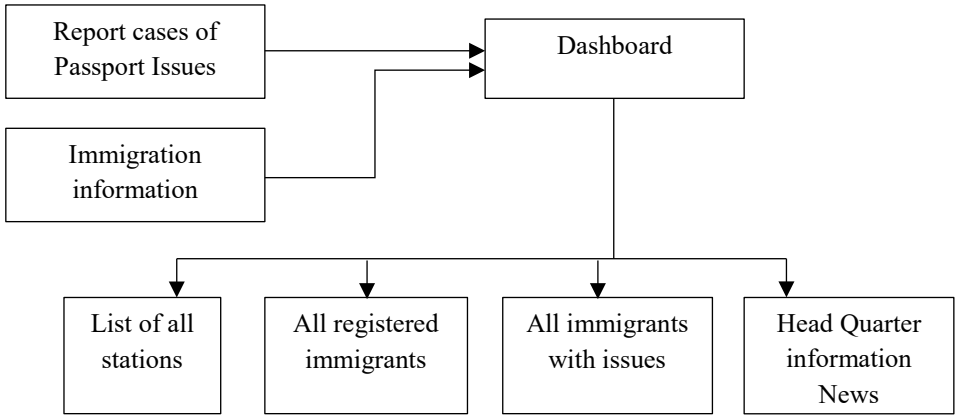


Figure 1. Conceptual design of MOBICAP

4.2 – Use Case Diagram for the criminal detection prototype

To represent the functionalities of the system, a use case model is used. A use case model describes a function provided by the system that yields a visible result to the actors. In the proposed system, the following use cases are identified in Figure 2.

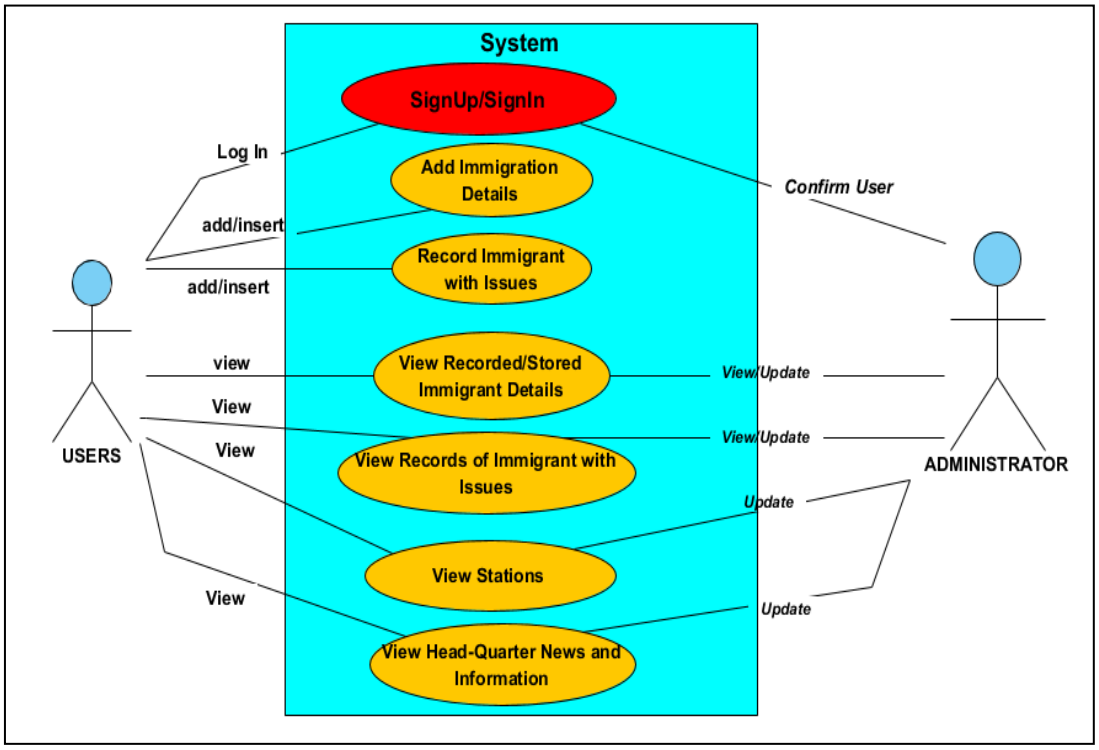


Figure 2. Use case diagram for MOBICAP

User actions and their descriptions

Users are border post officials that capture travellers' information. In the proposed application, the users are required to authenticate themselves before they can use the application. This is

achieved through a Sign up/Sign in functionality where border control officials are capable of logging into the application or creating an account that is used for granting them access to the application.

A traveller's details can be added using the Add immigration details functionality. This ensures that a specific traveller's details are captured and recorded for future reference.

The View Recorded/Stored Immigrant Details functionality enables a border control official to access stored information about a traveller.

The View Stations functionality enables a border official to view details of available border stations in a country.

The View headquarters news and information functionality enables users to view headquarter notice board for information updates.

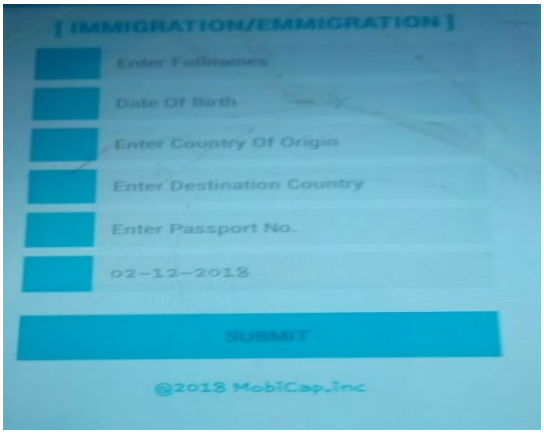
Administrator actions: is a system administrator of the database system, can view, update, edit, insert and delete immigrant information, stations and news depending on the need.

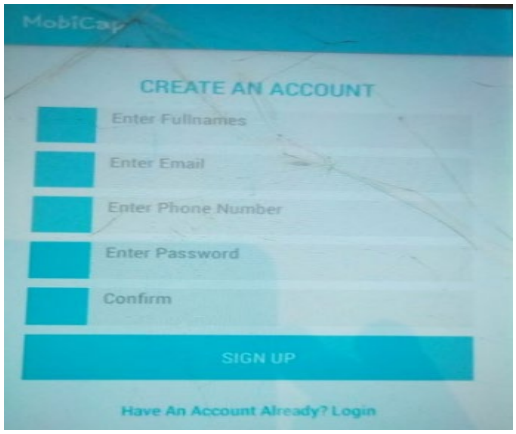
4.3 – Implementation of the criminal detection prototype

MOBICAP is installed on android operated mobile phone devices and can be given to immigration officials in remote border posts. The official can create accounts and log on the application which is backed by an SQL Database store that is accessed by a central administrator who generates comparison reports, monthly assessment summaries, and can also grant privileges, edit and update the database in cases of corrections.

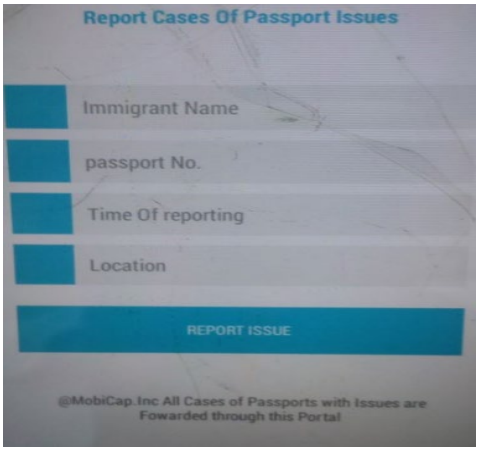
Immigration officials record bio-geographical particulars of a traveller, and also are capable of querying the database and other sources of information to resolve issues surrounding fake / expired travel identities and wanted criminals / smugglers. The officials can view the recorded information on phone screen for reference purposes. The images below are a sample of screen shots of the mobile app.

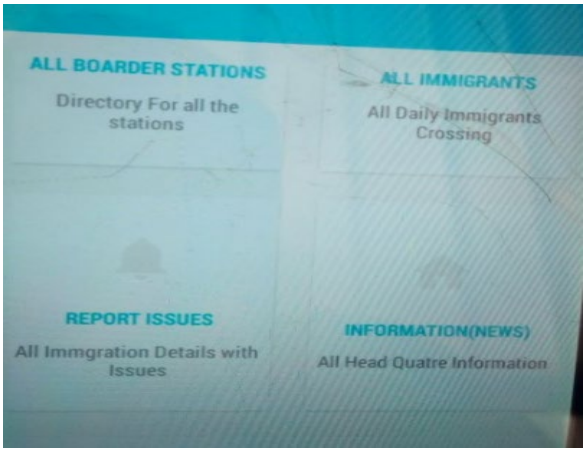
Prototype screen shots[*]





[*] One screen with personal data has been removed by the Editors.





5. A first validation

Port Bell Luzira is one of Uganda's main cargo ports with a sizable number local and regional human traffic connecting Uganda's most industrial town of Jinja, Kisumu in Kenya, Musoma and Mwanza in Tanzania. Port Bell is not as remote as other border ports on the northern and western borders; it was selected as an interview site because of its closeness to the capital city Kampala, assessing the increasing population of business community offloading and loading merchandise not withholding the number of travellers that use the ferry to cross borders. Despite the port being in close proximity to the Capital City with all the infrastructure, it still lacks digital data capture of traveller's details and instead travellers details are recorded in counter books manually. Thus, this could be a site which need an enabling technical solutions like the proposed mobile application.

The following brief is extracted from the Interview Report which was generated after consultations with Immigration staff at Port Bell during the presentation of the MOBICAP mobile application showing the functionality of its information capture and retrieval of traveller bio-geographical Information.

The staff decried instances of forged identities, human trafficking, illegal trade and lack of verification mechanisms to ascertain whether a traveller is avoiding the other digital border posts like Malaba, Entebbe, Katuna for various reasons.

Staff appreciated the mobile application claiming it would revolutionize their information capture process. The European Union and World Bank have offered the government a helping hand to revamp the pier, remodelling the entire port, including design for capacity augmentation of the existing berths, dredging, reclamation of lagoons, and massive expansion which will increase human traffic and as a result the mobile application based information system will be of great importance in capturing traveller details.

The Immigration staff hinted on the need for a full scale development of the Mobile Application with additional automatic analytics in the application for easy and quick generation of reports for daily, weekly and monthly summaries of travellers and their details to enable fast decision making and predict forecasts at the stations

6. Conclusion and Future work

The implementation of MOBICAP fairly fits the financial capacity of Uganda Immigration Services to purchase android phones, wireless adapters and storage facility / servers. This system satisfies the demand for low developed countries to use basic systems to capture, store and retrieve information of both security and intelligence value in the fight against trans-border crime. The prototype presented in this paper is however, still basic as it lacks many functionalities beyond just matching structured database information. Future work on the app includes equipping it with state of the art data mining capabilities to use even unstructured information in detecting criminals.

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Panel Abstract

Panel Abstract

The Impact of Shrinking Civic Space on Technology-Based Initiatives for Democratisation

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As reliance on technology grows, so does the immense opportunity for its use in enabling civic agency, social innovation, financial inclusion and improved governance. Uganda's decision to tax the use of social media applications and mobile money transactions is among the first of its kind. The country's technology market is relatively small and costs of such a taxes on the citizens' political, social and economic rights, therefore seem to outweigh the potential benefits. But other countries, including Tanzania and the Democratic Republic of Congo, have this year introduced regulation on social media / online content creators, which requires payment of annual fees including for licences. Zambia has proposed a daily tax on calls made over the internet.

These developments mirror the overall shrinking civic space in some Africa countries, where governments are getting more hostile to the political opposition as well as to activists, critical media reporting and to criticism by social media users. This session will therefore present different perspectives on the impact of recent developments in the ICT and governance sectors in Kenya, Tanzania, Uganda and Zambia; discuss the implications for the rights of citizens, democratic engagement, women's participation in governance, social accountability and human rights monitoring.

Moderated by Dr. William TAYEBWA, Head of the School of Journalism and Media, Makerere University, Uganda.

Poster and Demo Extended Abstracts

Poster Extended Abstract

Improving information quality in healthcare, the Malawian context

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In sub-Saharan Africa, the management of timely and accurate response to communicable diseases still is an overwhelming burden. In order to correctly assess diseases, decide and act on assessment, healthcare workers need complete, timely, valid, and consistent information – i.e. a need of high information quality.

In the case of Malawi, there are several challenges to improve information quality to and from remote healthcare workers in the field. Most health records are paper-based and manually managed. With paper-based patient registers, incomplete filling of records and illegible handwriting are known problems. Particular problems were identified with laboratory testing and medication supply chain logistics. For example, referral lab samples can take up to 21 days for results to be returned to a clinic (Wu and Mumba 2016). Combined, these challenges inflict information quality. However, mobile technologies have gained momentum in healthcare in both low and middle-income countries and high-income countries thanks to improvements in network coverage, cheaper transmission fees, and widespread penetration of mobile devices. There also evidence that mobile technologies can improve information quality, aspects of pivotal importance in healthcare (Adokiya, Awonoor-Williams et al. 2016, Hardy, O'Connor et al. 2017).

However, established in interviews with local stakeholders regarding the effects of mobile apps for assessment of diseases, such as D-Tree, and SL-CCM App, there are still issues with information silos, insufficient alignment to national health records and lacking accessibility of information for healthcare workers. These issues are mainly caused by autonomous applications, not connected to other systems.

In agreement with stakeholders and authorities in Malawi, there is an evident need and a wish to connect these isolated applications so information can be accessed and shared. Furthermore, an initiative that must be compliant with Malawian healthcare systems. With the modification of existing systems and a middleware, information sharing and sufficient accessibility can be achieved. "A Medic" (amedic.org) is an initiative to study further and develop a sustainable, locally adaptable information system that connects remote healthcare workers in the field, hospital doctors and national health records. Essential components are:

- an assessment tool,
- an on-demand communication channel,
- a generic patient record database.

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Poster Extended Abstract

Supporting Mothers of Premature Infants Using Social Network Sites: Kenya Case Study

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In Kenya, the rate of preterm births is estimated at 12% annually [11]. The preterm infants are admitted to the Neonatal Intensive Care Unit (NICU) where they receive specialized care [12]. Studies show that most mothers of preterm infants suffer from stress due to the uncertainty of the infant's health condition [2,5,12]. Some mothers feel guilty for not carrying the pregnancy to term and in some cases, they are condemned by the society for giving birth prematurely [6]. These mothers are vulnerable to stress during the infant's hospitalization and they need constant support to help them manage the stress related to prematurity.

In this study, we focus on exploring how Social Networking Sites (SNSs) such as Facebook, Twitter, and YouTube can be used to support mothers of premature infants through information sharing [9]. In public health and health promotion, SNSs are increasingly being used to disseminate health information because they remove geographic and physical access barriers [8]. In addition, people facing communication barriers in the health facility—which is common among new mothers, often use the internet to obtain health and psychological support information [1,7]. Choudhury et al. research prove that participation in health-related online communities and support groups have been associated with significant reductions in anxiety and other psychological distress [3].

Building on this premise, we focused on exploring the use and implications of SNSs in spreading health information and educating mothers of preterm mothers on their health rights as they take part in the care of the preterm infants. To explore the feasibility of SNs in supporting mothers of preterm infants, we created Facebook [6] and Twitter [7] groups and used these platforms to share parental support information. On Facebook, we screened members before giving them access to the group. We included health organizations and medics as members of the groups to provide clinical information as well as to authenticate the shared information. We educated mothers on low-cost intervention (such as Kangaroo Mother Care (KMC) and the importance of exclusive breastfeeding for infants' development. Furthermore, we shared encouraging stories of infants who survived after premature birth.

This research is ongoing and preliminary findings show that mothers frequently visit the groups to access psychological support information. They expressed their satisfaction by liking and adding appreciative comments on the motivating and encouraging posts. This resonates with Shin et al. findings that prove users frequently visit SNSs when the information shared is relevant and useful [10]. However, no mother shared their story/queries on the timeline. They preferred using private chats for inquiries

[6] https://www.facebook.com/groups/180103339214809/

[7] https://twitter.com/PreemiesMumKE

and to share their current motherhood ordeals. This echoes Farfan, G result which shows that SNSs users only share information with people they already know rather than with strangers [4]. Nevertheless, Heldman et al. provide a list of key principles that can be used to enhance interactive communication with the audience who access health information on SNSs [6].

These results reveal that SNSs play a critical role in the transmission of health information and can successfully be used to support and educate mothers of premature infants if they are fully engaged in communication. These findings serve as a foundation for more in-depth empirical research on how best to leverage SNSs, specifically the ability to engage with our audiences, to improve premature birth outcomes.

Acknowledgment

We are grateful to the Collaboration on International ICT Policy in East and Southern Africa (CIPESA) for funding this research, as well as the participants who form part of this Project. We would also like to thank Ashnah Kalemera for guidance and insights throughout this research.

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Poster Extended Abstract

Optimising Placement of Baseband Unit Edge Clouds in Cloud Radio Access Network

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Cloud Radio Access Network (CRAN) has been deployed to improve cellular network performance as well as reducing costs which Mobile Network Operators (MNO) face while trying to meet the increasing subscriber demands such as high data rates. The key feature of CRAN is that Base Band Unit (BBU) functions maybe pooled at a location or locations removed from the Remote Radio Head (RRH) functions. They are centralised and virtualised at a BBU pool. The front-haul link between the BBU and RRH maybe long (over 40km) thus high front-haul link latencies which in turn leads to higher overall network latencies. This is a major challenge for technologies such as 5G which aim at providing near zero network and user latencies. The long front-haul link lengths also affect the synchronisation between the RRHs and the BBUs [1].

This project introduces a novel way of addressing this challenge. It considers running the virtualised BBU pool in optimally placed Edge Clouds (ECs) such that virtualised BBU functions are extended closer to the RRHs. This reduces the front haul link length and likewise the front haul link latencies in CRAN. The key feature of CRAN is having several RRHs sharing the same BBU pool. In this proposed idea, at the cell sites still remain only RRHs that will be sharing a BBU pool but located in an EC. *In terms of implementation, an already virtualized BBU pool is considered; therefore, orchestration of all functions in the BBU pool remains as it was at the centralized locations. The virtualized BBU pool can be instantiated at the* EC co-located at the antenna site or at the EC at an aggregation site. Since the aim is to reduce front haul link latency to as low as possible, locations closest to the RRHs are preferred given that the constraints are fulfilled.

Position of the BBU pool in CRAN is crucial as it determines the overall front-haul link latencies. In placement of BBU pools in CRAN, researchers have been focusing on minimising number of BBUs, substrate links, energy, actual Virtual Machines (VM) required and actual network set up costs. To the best of my knowledge, no work has been carried out so far as regards to placing BBUs in optimally placed ECs with an aim of minimising overall front-haul link latencies. In this project, the network model under consideration consists of Voronoi cells with RRH and candidate EC locations placed in it using Poisson point process. The cells are clustered using fuzzy c-means clustering algorithm. General formulation of the problem leads to a constrained nonlinear optimisation problem that is solved by genetic algorithm in MATLAB. Optimal locations for the BBU ECs are determined to further achieve proper resource utilisation, reduce cost of ownership as well improving user quality of experience.

Numerical results demonstrate that the proposed idea greatly reduces the overall front-haul link latency, improves EC and BBU utilisation, front-haul link utilisation improves and user delays are reduced thus improving user Quality of Experience (QoE) as well as reducing CRAN cost of ownership. The

algorithms used are not specific for a given network but can be used for different networks and under changing network conditions.

Keywords: Baseband Unit, Cloud Radio Access Network, Edge Cloud, Latency, Remote Radio Head.

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Poster Extended Abstract

The Anthropology of Smartphones and Smart Ageing

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The Anthropology of Smartphones and Smart Ageing is a multi-sited research project based at UCL Anthropology and funded by the European Research Council. The project employs a team of ten anthropologists, who have been conducting simultaneous 16-month ethnographies in Uganda, Cameroon, Ireland, Italy, Brazil, Chile, Jerusalem, China and Japan since February 2018. Findings will be widely disseminated in open access books, regular blogs, videos and online education materials.

The aim of this collaborative five-year project is to understand the impact of mobile technologies on the experience of mid-life around the world, with the intention of assessing practical implications for the field of mobile health. Despite best intentions, mHealth interventions may often fail to align with existing mobile phone practices and therefore to appeal to users' preferences. We aim to demonstrate how anthropological insight can lead to more culturally appropriate mHealth interventions and more effective improvements in people's lives.

In the case of the Uganda fieldsite, primarily based in a low-income area in Kampala, and secondarily in participant's home villages in rural Northern Uganda, it is evident that people already use mobile health in various informal ways. For example, older adults often use their phones to support elderly relatives' health in the village, giving advice and sending mobile money. This may suggest that the communicative nature of existing popular mHealth usage in Uganda would be the most beneficial approach for a new or existing initiative.

In this way, a holistic ethnographic exploration of the new opportunities or challenges of connectivity afforded by mobile phones can supplement the work of digital and health practitioners in Uganda. We are currently seeking partnerships in order to contribute our contextual insights and help to improve accessibility of health information and services.

Poster Extended Abstract

Deaf in India

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Technological advancements try easing the life of people around the world. People, who are differently-abled, are getting more attention for easing their lives. There is around 2.21% differently-abled population in India, which is the second largest contributor to the world's population [3]. Among various disabilities, deaf is somehow overlooked. This needs attention as around 19% are deaf in the disabled population of India [3].

Deaf in India faces challenges as illiteracy, parent awareness to special education and lack of communication with the world. To address deafness, hearing aids and cochlear implant as shown in e.g. [4] and [2] are promoted in India by giving subsidy.

But these aids contribute little hearing sense to the deaf. Also wearing such aids whole day is a little painful. As a result, the deaf have to rely on a special way of communication - sign language (SL). There are very less Educational organizations in India educating sing language. So, deaf find difficulty communicating with ordinary people around them. This has minimized at very low extent because of the smartphone. In India, smartphone (Android) cost starts from $80, which is an affordable price to have a smartphone. As deaf are also comfortable with the smartphone, many Android apps are developed to address special needs [1, 5, 8], but didn't achieve popularity. This seeks more research in this area.

This motivates to look more into effective use of such a device to ease the life of deaf in India. Children, first educate to speak mother tongue from their parents. Deaf Children are not exception to this. Parents of deaf children find difficulty in teaching mother tongue. But this can be minimized by providing e-learning platform to these parents for enabling effective duplex communication with deaf children. The areas for research can be an effective interpretation of SL to local language and vice-versa, interpretation of digital media to SL and converting a book to SL. There is also a scope for research in sensing non-speech sounds around deaf [6].

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Demo Extended Abstract

Footomo Kit

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Problem. Livestock production has been confronted with several epidemics over the last decades. 25% of Livestock in sub-Saharan Africa die due to contagious diseases like East Coast Fever, Mastitis, and Foot-and-Mouth disease. 65% of livestock in Uganda predominantly cattle are susceptible to Foot and mouth disease leading to huge losses in terms of livestock productivity and trade. [1, 2]

Foot-and-mouth disease (FMD) is one of the highly contagious diseases of domestic animals. Effective control of this disease needs sensitive, specific, and quick diagnostic tools at each tier of control strategy. [2-4]

Outbreaks with devastating economic consequences still occur and remain a terrible threat to countries that have eradicated the disease and to those that never had the disease. [5]

The main concern nowadays is in case of an outbreak how to prevent spread of the virus. [6]

Solution. In recent years, compact wireless sensor network devices have made animal health monitoring, disease detection and diagnosis increasingly smart. However, detection of contagious viral diseases – specifically Foot-and-Mouth disease – is still complicated and inconvenient due to the nature of the virus in an animal's body. But, proper diagnosis and detection of the disease is very important and accurate results need to be displayed. In order to overcome FMD in any animal, we propose a wireless sensor network based model for detecting this disease in livestock.

A complete integrated information and communication technology is desired for FMD disease detection system to identify the animal health during the livestock disease diagnosis [7]. The answer to the new detection model is to use the WSN (Wireless Sensor Network) based technology. The key features of the WSN technology is the low power consumption [8].

The Footmo Kit is a hand-held device that diagnoses FMD in livestock with multiple vital parameters in one test in hard-to-reach and remote areas. The device is put in the mouths of a cattle and it detects the disease against the antigen content in the saliva and body temperature. This is done to assess the specific antibody responses in saliva. The results in real time are then displayed to the farmer on the screen. When the animal is found infected, the farmer reports to the nearest animal scientists or veterinary doctors. The antibodies are detected correlated between the rate of decline of the antibodies titres and the presence of virus in probang samples.

Future outlook. Our technology and approach will allow for scalable, affordable and dynamic growth in the future

Mission. To Power Livestock Production, increase household income and Strengthen food Security by controlling foot and mouths disease in Uganda and entire world.

Vision. To be the most dependable tool for diagnosing Foot-and-Mouth disease.

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Workshops Abstracts

Workshop on 'Mobile Accessibility'

Organizers

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Target Audience

App Developers, Usability Experts, University Teachers, Research Scholars, Engineering / Science Students, Physically Challenged People, and Older People.

Objectives

1. To explain the importance of mobile accessibility for people with disabilities and older people
2. To list common barriers experienced by people with disabilities and older people
3. To apply basic principles of accessibility during the preparation of mobile content
4. To carry out preliminary checks of mobile apps for accessibility and communicate the results
5. To present case study that influences mobile usage by people with disabilities and older people

Workshop Outline

- What is accessible computing?
- How people with disabilities use computational services?
- Difference between Accessible & Inaccessible User Interfaces
- Various accessibility standards & guidelines
- Mobile accessibility standards
- Various Laws, policies, directives
- Accessibility myths
- Approaches for accessibility implementation
- Design considerations
- Development tool accessibility
- Accessibility of rich Internet applications
- PDF accessibility
- Android accessibility
- IOS accessibility.
- Windows mobile accessibility.
- Approach to accessibility testing
- Demonstration of accessibility testing tools
- Testing with screen readers

Duration: 1 Day (5-6 hours) – 3 Sessions on Accessibility, Accessibility Perspectives, and Case Study of Eye+. Held the day before the conference, 14th of November 2018.

Graduate Students Track

Organizers

Edgar Napoleon ASIIMWE
ipid *— the International Network for Postgraduate Students in the area of ICT4D*
edgar@dsv.su.se

Target Audience

Master students and PhD candidates.

Objectives

This track is organised as a workshop to provide a forum for PhD students and Master students in the area of mobile communication technology in and for development to present their works and receive feedback. The goal of the workshop is to provide professional development in M4D with critical, but constructive, feedback and advice to graduate students on their ongoing research from senior researchers.

Workshop Outline

Student participants had prior to the workshop submitted their work plans. These had been reviewed and the more mature had been accepted for presentation and discussion at the workshop. The conference fee was waived for accepted students.

- Start: an IPID social event between 9am-12pm
- Arriving from the social event by 12 to have lunch at 12pm-1pm
- Short lecture followed by Q&A: 1:10-2pm (On Academic writing and publishing or something else) by John Sören Pettersson. 40+ students are attending.
- Presentations from the selected 5 Ph.D. students and feedback 2-3pm in 3 groups. Mentors: Asiimwe, Nabende and Pettersson.
- Closing followed by evening tea and cross-group presentation by speed dating after 3.30pm.

Duration: 1 Day (7-8 hours). Held the day before the conference, 14th of November 2018.

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