Information Needs and Communication Patterns of Rural Uganda: Implications for Mobile Applications

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Abstract: In light of the growing ubiquity of mobile phones within the context of developing countries, there is a gap in understanding the information and communication needs of rural users. Using the backdrop of Uganda, this work reports on a detailed study, of rural users of various information and communications technologies (ICTs). It explores how rural users prioritise various information needs, identifies their current methods of information access, their frequency of information access as well as their satisfaction level with the information that they do receive. The study discusses priorities and gaps in current access to information that may highlight opportunities for mobile applications. The study sample includes an urban component that is used for purposes of contrasting differences between rural and urban information practices as well as exploring the communication linkages that do exist between the two sides.

1. Introduction

There is growing enthusiasm about the potential of leveraging the mobile phone as a tool for social and economic development. This is motivated by the rapid expansion of networks in the developing world coupled with the growing number of subscribers. To date, the mobile has been exploited primarily as a communication device to talk, contributing to tremendous profitability of mobile operators in sub-Saharan Africa. As competition intensifies thanks to deregulation and new entrants seeking for ways to benefit from the mobile boom emerge, operators are looking to diversify their revenue base. One potential avenue is offered by mobile applications that can be used by a wide range of subscribers in a variety of ways to compliment the voice side of the business. Promising progress is being made towards leveraging mobiles as a platform for addressing financial needs of the poor (Hughes and Lonie 2007; Mendes, Alampay et al. 2007; Mas and Kumar 2008; Duncombe and Boateng 2009). The catch is that current models tend to lock-in customers, while excluding other potential players in the sector (Ndiwalana and Popov 2008). The donor community on the other hand, has funded a variety of forays exploring socially related aspects of leveraging mobiles, ranging from agriculture, education to health.

Despite all these initiatives, there has not been a documented effort to study the general information needs and priorities of rural communities coupled with their current use and attitudes towards different communication media as an avenue to explore potential mismatches and hence new mobile application opportunities. It is towards this gap in the literature that this study seeks to contribute. To set the stage, the next section provides a background, which encompasses an overview of prior work related to the study and presents its methodology. Section three explores how rural users prioritise their information needs and

how they seek information to satisfy them. Finally, the conclusion summarises the study findings, and highlights some of the critical issues that we need to keep in mind as we strive to develop new mobile phone applications.

2. Background

In Uganda, there are now over 9.9 million mobile phone subscribers spread across 5 networks (MTN, Orange, UTL, Warid and Zain) and the percentage of the population covered by mobile phone networks has increased to over 90%. While the number of mobile subscribers is soaring, fixed line subscribers are merely 244,455 coupled with 96,890 payphones countrywide, bringing the national tele-density to 32.2 only. As expected the traffic is largely dominated by voice, logging about 2 billion voice minutes in the first quarter of 2010, of which 89% is in-network traffic, thanks to discounted in-network tariffs, which help explain multiple-SIM ownership strategies adopted by many subscribers. About 175 million SMSs were sent in the same period, a growth of 28% (Uganda Government 2010).

Internet is still largely a luxury for an insignificant few. Initially only available in a few urban locations (Mwesige 2004), it can now be accessed via a large portion of the GSM infrastructure. In fact with over 460,000 active accounts, more users access the Internet using mobile connectivity compared to any other means of access. This has been primarily the result of many operators adopting 3G in upgrading their networks as competition intensifies in the data segment as well as the arrival of cheaper bandwidth from undersea cables that have become operational on the eastern coast of Africa (Uganda Government 2010).

2.1 Related Work

Understanding the role of information and communication within the context of a rural community is a big challenge. Information needs tend to be explored through a sectoral approach. For example, in health we might want to identify information requirements to help people avoid contracting some disease, while from an agricultural view the concern might be to equip farmers with information about pesticides to increase yields or fishermen with accurate weather information to facilitate better catches (Ikoja-Odongo and Ocholla 2003). Research on the use of mobiles has also tended to follow a similar approach with a particular bias towards economic sub groups like informal urban entrepreneurs (Donner 2006; Esselaar, Stork et al. 2007), fishermen (Njoku 2004; Jensen 2007), and craftsmen (Molony 2006). The recognition that development (and the strategies that people adopt to cope with poverty) depends on a range of interrelated factors has resulted in more holistic approaches, such as the sustainable livelihoods approach. Only relatively recently, with the advent of development communications as a field of study in its own right have people started to advocate for the role of information and communication in a more integrated context (Donner 2008).

Based on household surveys in three countries (India, Tanzania and Mozambique), Souter, Scott et al. (2005) identified priority types of information and ranked them according to perceived importance. They showed that people leverage different media channels to access different types of information. Zainudeen, Sivapragasam et al. (2007) conducted larger surveys in Asia (Pakistan, India, Sri Lanka, the Philippines and Thailand), but with limited set of indicators. Besides highlighting the latent demand from potential users and issues of affordability, current phone owners indicated that their greatest benefit from owning phones was perceived ability to be able to act in an emergency.

Donner (2008) decries the lack of studies focussing on rural users compared to their urban counterparts. While he justifies this trend from the point of view that services usually start in urban and spread to rural areas as connectivity improves, he contends that ignoring rural areas might result in researchers overlooking emerging usage patterns given the difference in contexts. He makes the case for appreciating and capturing the needs and

motivations that influence rural people and understanding how these differ, are influenced and interrelate with those of urban people.

In our study the focus is on the individual, because we assume that as mobile phone ownership rapidly increases, phone usage will tend to be more individualised. One weakness of a user-centric approach is the focus on information "pull", where a user seeks information or a service to meet a perceived need. This may overlook the inherent potential offered by a shared platform used by a growing proportion of rural users in developing countries. Mobile phones now offer the ability to engage with large proportions of the public, and may be of value in information "push" issues (Heeks 2008).

2.2 Methodology

This study draws on extensive desk research on information needs and communication patterns across the developing world (Ikoja-Odongo and Ocholla 2003; Donner 2004; Njoku 2004; Souter, Scott et al. 2005; Molony 2006; Skuse and Cousins 2007; Zainudeen, Sivapragasam et al. 2007; Dutta 2009) and a range of discussions with different stakeholders in the communications industry in Uganda. These shaped a questionnaire and interview survey of 406 individuals from across the country, selected for having experience with using telecommunications services. Most survey questions were structured and included both single-option and multi-option variables. The 5-point likert scale was used for questions that required responses on an interval level. The survey instrument was in English, but definitions and translations into local languages were agreed upon during enumerator training. Actual data collection occurred between January and February 2008.

"Information" is a concept that respondents have difficulty in dealing with, so the survey explored the relative importance of a range of development issues in 3 categories business and financial, health and education, as well as those related to social and civic endeavours. For each issue respondents also indicated means of access to related information to identify current information sources and existing gaps; frequency of access that impacts on sustainability and business models of any potential application ideas; and level of satisfaction as a way to gauge respondents' willingness to seek alternative sources.

Besides information needs, the survey explored current use of communication channels, looking beyond the mobile to capture interaction with radio, TV as well as newspapers. How people accessed phones and used them beyond making calls was given special emphasis. Intention to use a range of potential mobile-based applications was captured using a list of potential applications drawn from literature, focus group discussions as well as brain storming sessions within the project team.

The focus of our interest was on the rural part of the sample, although an urban component was included for juxtaposition because earlier research hints at differences in information needs and information seeking behaviour between rural and urban dwellers (Donner 2008; Dutta 2009) and the fact that from earlier focus group discussions in the rural area, it emerged that most communication in rural areas generally has some link to urban areas. Please note that the selected sample is not nationally representative.

2.3 Description of Sample

The survey covered 406 respondents from different parts of the country to provide a mix of livelihoods. Respondents were randomly selected from Kampala (central), Mbarara (west), Lira (north), and Mbale (east). The sample had a 290:116 rural: urban split, where urban refers to Kampala city centre and district capitals, with the rest of the areas classified as rural. The bulk of our subsequent discussion revolves around the 290 rural respondents, with the urban portion of the sample used only for comparisons.

The rural sample of 290 respondents had a gender balance of 56:44 (male: female ratio) with a mean age of 31.1 years old. Roughly one third of respondents claimed to be the head of household. The sample had a good balance of educational levels as illustrated in Table 1. Based on claimed literacy in own or other language, literacy is 95.5% among the rural

sample, and 97.4% among the urban sample. This is much higher than national levels (overall literacy rate of 69% among persons aged 10 years and above for 2005/06 (Uganda Government 2008)), reflecting the relatively high status of the sample. The importance of English as a national language is reflected in the high levels of English literacy 72% amongst the rural sample, and 90% among the urban sample.

Table 1: Demographic characteristics of survey respondents

		Rural		Urban	
		Frequency	%-share	Frequency	%-share
Gender	Female	127	43.8	37	31.9
	Male	160	55.2	78	67.2
	Missing data	3	1.0	1	0.9
	Cumulatively	290	100.0	116	100
Age	16 - 23 years	87	30.0	16	13.8
	24 - 29 years	80	27.6	44	37.9
	30 - 49 years	96	33.1	52	44.8
	50 years and over	26	9.0	3	2.6
	Missing data	1	0.3	1	0.9
	Cumulatively	290	100.0	116	100.0
Education	No formal schooling	21	7.2	3	2.6
	Incomplete primary school	37	12.8	5	4.3
	Complete primary school (P7)	41	14.1	4	3.4
	Incomplete secondary school	74	25.5	20	17.2
	Complete secondary school (S6)	45	15.5	18	15.5
	Post secondary e.g. certificate, diploma	53	18.3	50	43.1
	Degree and above	19	6.6	16	13.8
	Cumulatively	290	100.0	116	100.0

The average household size is 7.2 people with an average of 3.3 children. Interestingly, 78.6% of respondents reported members of their immediate family living in other cities in Uganda and 24.8% of respondents with members of their immediate family living abroad. Urban demographics amongst the sample indicated a male bias with gender balance of 68:32 (male:female ratio), higher educational status, smaller households (average of 5.7 people) and more-dispersed households with 82.8% reporting members of their immediate family living elsewhere in Uganda and 46.6% living abroad. This dispersion across both rural and urban families has implications for familial communication patterns as they attempt to stay in touch with each other.

3. Information Needs and Access Channels

Information and communications technologies (ICTs) within the context of this study refer to the various ways people use to organise and disseminate information in the developing world. Thus technologies like radio, TVs, newspapers, etc. are unconventionally considered within the realm of ICTs. In this section, we provide an analysis of the results. It begins by looking at the current access to various information and communications technologies (ICTs) by respondents. We then explore the importance that respondents attach to various types of information, the means and frequency with which they access this information, and their level of satisfaction with the current modalities at their disposal.

3.1 Patterns of ICT use

Radio is still the most dominant form of ICT used to access information in rural areas, followed by the mobile phone as highlighted in Figure 1. TV as a broadcast media is growing as more private broadcasters get licensed and coverage expands to rural areas. 39% of respondents owned a mobile phone, with an additional 5.9% owning only a SIM card. 9.6% of all respondents own more than one SIM card and prepaid plans are ubiquitous, with only 2

respondents claiming to own post-paid contracts. In comparison, 83.6% of urban respondents own a mobile phone and an additional 4.3% own only a SIM card.

Phones are primarily used for making calls, with incoming calls accounting for about 35% of all calls. About 50% of survey respondents report using SMS, although many do so infrequently. As with calls, most SMS are outgoing messages, with incoming messages accounting for about 31% of all messages. In contrast, for the urban sample both voice and SMS traffic is roughly balanced 54% of voice calls incoming and 46% of SMS messages are incoming.

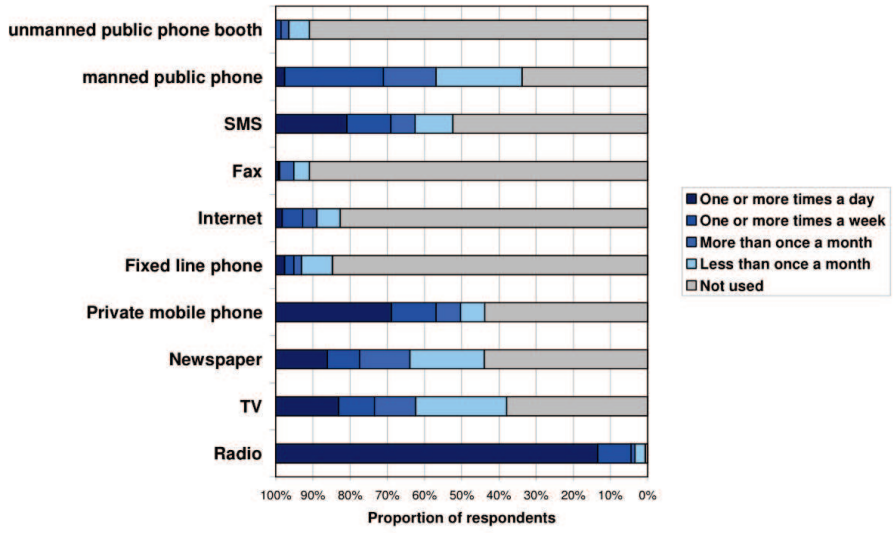

Figure 1: Breakdown of frequency of use of different ICTs in rural areas (N=290).

Although a slightly higher number of people make use of manned public phones (with an operator) compared to private mobile phones, private mobile users appear to be more intensive users. In reality, more mobile phone owners (74%) use manned phones compared to those without a mobile phone (54%). The high cost of across-network tariffs is given as the most common reason for this, making use of manned public phones cheaper for occasional calls. Other reasons included lower denominations or call cost compared to top-up credit and call management features provided by phone operators like timing calls for users to ensure they spend a specified amount of money. As a result, mobile phone owners tend to spend more on communication than non-phone owners who rely exclusively on public phones.

3.2 Importance of Issues

Issues related to health (HIV/AIDS, family planning, finding a medical expert, finding drugs, first aid) and social wellbeing (keeping in touch with family and friends) are ranked as most important. Interestingly, issues related to agricultural production (e.g. agricultural advice, modern farming ideas, weather information) are ranked higher than those relating to finance (e.g. credit, cash transfers). This might imply that respondents regard their lack of knowledge of good practice as more of a problem than infrastructural issues. Amongst infrastructural issues though, transport is ranked as most important and this appears not to be restricted to transporting only agricultural products, reflecting the importance that respondents attach to transport infrastructure.

Governance issues are ranked with low importance (e.g. learning about local government, awareness of human rights, compliance with legal requirements and participation in political debate). While this contrasts with the current importance attached to governance issues by the donor community, it might reflect respondents' perception of the minimal influence they have on political issues. Ranking local governance as highest amongst governance related issues seems back up this view, as people tend to participate more in local governance.

Preliminary fieldwork seemed to indicate that making cash transfers was important, but remittances were not ranked as highly as expected. Most of the agriculture and business related issues are given higher importance by economically active age groups (24 – 49); this is also the case for some political issues e.g. engaging in political debate, awareness of human rights.

Amongst health issues, importance attributed to knowledge on health matters tends to be consistent across age groups with the exception of the oldest (over 50 years), who regard many issues as less important e.g. HIV/AIDS, family planning, diseases. However, there are no differences in issues relating to health treatment e.g. finding a doctor or drugs.

Table 2: Information needs ranked according to importance.

Rank	Heading level	Rural Mean score (N=290)	Urban Mean score (N=116)
1	Understanding HIV/AIDS	2.73	2.74
2	Contacting people in an emergency	2.71	2.80
3	Keeping in touch with family & friends	2.64	2.82
4	News	2.58	2.70
5	Understanding family planning	2.40	2.24
6	Finding a medical expert	2.38	2.69
7	Finding drugs and what they cost	2.35	2.49
8	Learning about first aid, disease prevention & treatment	2.32	2.53
9	Transport	2.24	2.60
10	Entertainment	2.23	2.15
11	Crime & insecurity	2.18	2.46
12	Getting agricultural advice	2.18	1.63
13	Getting market information	2.17	2.47
14	Introducing modern agricultural ideas	2.16	1.78
15	Job opportunities	2.13	2.47
16	Remittances to/from family	2.12	2.24
17	Weather	2.10	2.14
18	Fake drugs	2.08	2.42
19	Expanding markets	2.06	2.23
20	Finding the right school	2.04	2.39
21	Learning more about my local government	1.98	2.10
22	Sport	1.92	2.27
23	Availability of savings, credit & other financial services	1.88	2.30
24	Raising awareness of human rights	1.87	2.15
25	Compliance with government & legal requirements	1.80	2.20
26	Adult education	1.66	1.59
27	Having your say in political debates	1.65	1.57
28	Making cash transfers remotely	1.45	1.95
29	Finding a boy/girlfriend (dating)	1.36	1.35

(Scale: 0 = n/a; 1 = not important; 2 = important; 3 = very important)

3.3 Level of Satisfaction

Generally, urban respondents expressed higher levels of satisfaction with information they receive than their rural counterparts, which is expected given the wider choice and quality of sources. Despite radio's dominance, it is not clear that satisfaction ratings are higher overall wherever more people use radio to access information. It is apparent though that, satisfaction ratings are lower where a large proportion of people claim not to get information. This latent demand for information might portend opportunities to serve them. Figure 2 shows a weak correlation between importances attributed to information on one hand verses satisfaction with current sources used to access this information. Some highly ranked information needs for which satisfaction levels are low are indicated in Figure 2. They include:

1. Introducing modern agricultural ideas;
2. Fake drugs;
3. Getting agricultural advice;
4. Learning about first aid, disease prevention & treatment;
5. Raising awareness of human rights;
6. Expanding markets;
7. Job opportunities.

These indicate issues for which people might be inclined to consider alternative means of accessing information.

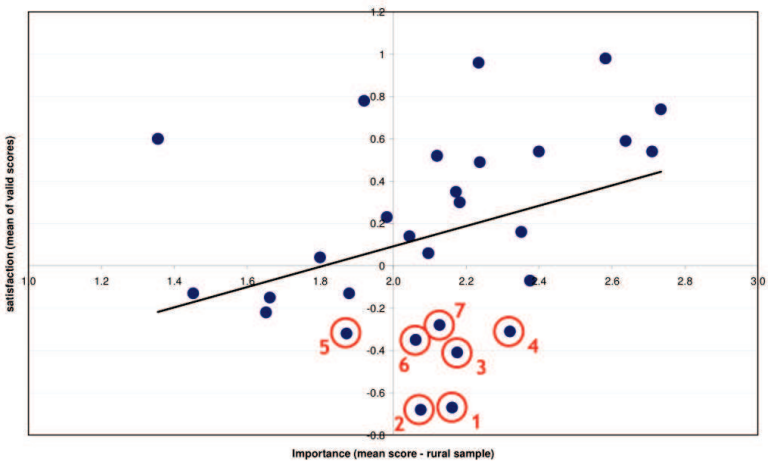

Figure 2: Correlation of Satisfaction scores with importance of issue (N=290).

3.4. Frequency of Information Access

The frequency with which respondents' access information tends to reflect the importance attributed to those issues. Figure 3 shows a distinct relationship between importance and access that compounds the potential value of being able to provide information services related to important issues, particularly for top-ranked issues like understanding HIV/AIDS, keeping in touch with family and friends, news as well as contacting people in emergencies.

The high frequency with which respondents claim to access HIV/AIDS related information begs the question of whether this information is "pushed" (e.g. radio and TV programmes) or "pulled." The answer lies in the main channel for accessing this type of

information, which is radio, reflecting the high profile of HIV/AIDS issues in radio broadcast scheduling.

There are some issues rated as important, but for which respondents access information only infrequently. Highlighted below the line in Figure 3, some of these issues include:

1. Contacting people in emergencies
2. Finding a medical expert
3. Expanding markets
4. Fake drugs

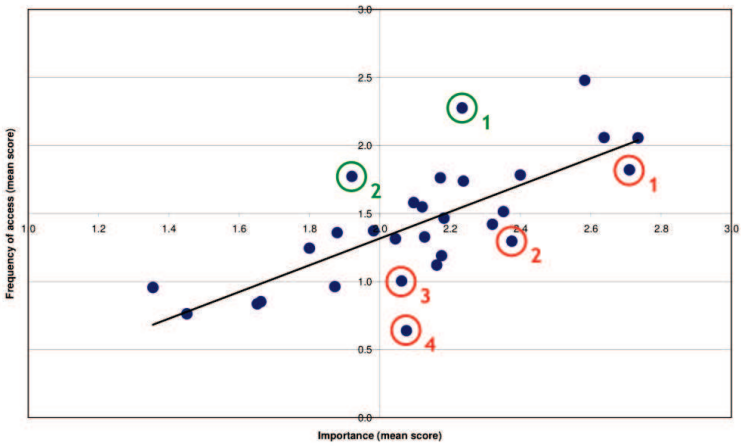

Figure 3: Correlation of frequency of accessing information with importance of issue (rural; N=290).

Other types of information people access regularly that might not be regarded as particularly important are also highlighted above the line in Figure 3. These include:

1. Entertainment
2. Sport

While urban respondents claim to access information more frequently than their rural counterparts, issues for which differences in frequency of access are not significant mirror those for which there is no difference in importance. Getting agricultural advice is the only issue for which rural respondents access information more frequently than their urban counterparts.

3.5 Means of Information Access

Radio and Face-to-face are still the dominant means through which people access information. Radio is particularly used for information relating to News and HIV/AIDS information, two of the most important issues while Face-to-face contact is commonly used to access information relating to many other issues. The phone also accounts for two of the other highly ranked issues contacting people in emergencies and keeping in touch with friends and family. Newspapers on the other hand play an important role in urban areas, where they are most common sources for information on job opportunities as well as government and legal issues.

Although over 60% of respondents watch TV (Figure 1), only a modest proportion of the respondents around 15% (note that this corresponds to the number of respondents watching TV frequently) regard it as the most important means of accessing information. TV is primarily used as a source of information on entertainment, sports, news, and the weather.

Taking into account the dominance of radio and face-to-face, *location of the information source* tends to play an important role. Information that originates locally tends to be accessed via face-to-face, while that which originates remotely (nationally or globally) tends to be accessed via radio. *Information urgency and its shelf life* also tend to play a role with face-to-face better suited for information needed with a given *timeframe*. Although learning about HIV/AIDS is recognised as important, it tends not to be a matter of immediate urgency, unlike, for example, the need to find a doctor.

Where an issue involves a *personal transaction* (even as an outcome of the issue itself) face-to-face tends to be best suited e.g. finding a medical expert, job opportunities (employers will generally want to meet the person they employ); finding schools (similarly, parents will probably want to visit school and meet staff before committing to a school). On the other hand, information suited to the radio tends to be "impersonal" information e.g. weather, information on disease, etc.

Some information needs do require multiple pieces of information that are related that may require interpretation and sorting, which introduces two related challenges *complexity* and *interaction*. Consider a job opportunity, it will include start date, duration, tasks, skills and experience required, and wage all of which tend to be negotiable. Interaction relates to the ability to drill down through large amounts of information to find what you are looking for while getting feedback throughout the process. Face-to-face might be expected to lend itself best to complexity and interaction, although radio, augmented with say mobile phones can be used to communicate complex ideas and provide opportunity for users to give feedback. It is over such issues that the Internet has a clear advantage, but its use is currently almost non-existent. For most issues that involve actively seeking specific information (e.g. finding the right school, job opportunities, getting market information, finding drugs) it is face-to-face that is the dominant means of access.

There is a good deal of similarity between the predominant means of information access between rural and urban respondents. Differences highlight a preference for TV as a means of entertainment among the rural population, wider availability of newspapers, and more widespread use of phones for personal contacts.

4. Discussion

There are a number of expressed information needs for which people seem unable to get the desired information. Issues for which 10% or more respondents claim not to get information include health (finding a medical expert, learning about first aid, fake drugs), agricultural matters (advice, weather), and economic matters (job opportunities, markets). For many of these issues, people tend to seek information (information-pull) and face-to-face contact is currently the predominant way to access this information.

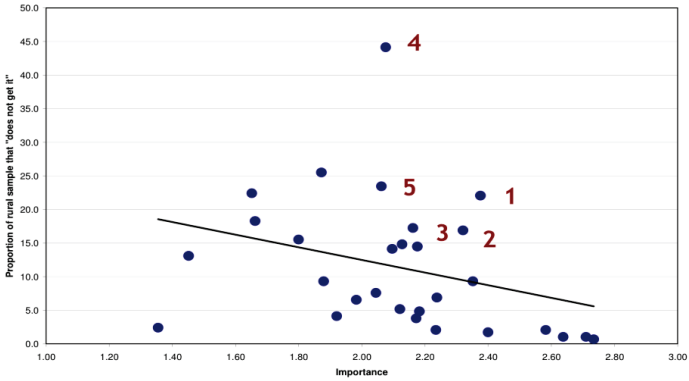

Figure 4: Proportion of sample not getting information against importance of issue (N=290)

The relationship between importances attributed to an issue or information need and proportion of respondents that report it as unmet is illustrated in Figure 4. Given that respondents try to find sources of information relating to issues that they regard important, this does indicate latent demand for information that could be filled by potential services. Some of the emerging information gaps highlighted in Figure 4 include:

1. Finding a medical expert
2. Learning about first aid, diseases etc
3. Introducing modern agricultural ideas
4. Fake drugs
5. Expanding markets

Compared to other means of accessing information, one advantage of the phone is its interactivity communication (using voice or data) is two-way. In this respect, it's an obvious substitute for face-to-face communications. However mobile phone applications need to take into consideration other aspects that can influence channel selection, some of which may include:

- *Content origin*—allowing users to easily access information generated remotely (nationally or globally), which currently needs to be broadcast. The challenge then becomes one of cost as most broadcast media are currently free
- *Content publication*—empowering mobile phone owners (and public phone users) to publish information, particularly about their local context, whether explicit (such as voting on different TV programmes) or implicit (such as tracking the spread of disease through enquiries about the disease)
- *Content timeliness*—enabling users to access information whenever and wherever they might require it. Some situations might require on-demand responses, while time-lags between requests and responses might be acceptable for others
- *Specificity*—relevance of information is often related to geographical location and context. For example face-to-face discussions are a great way for farmers to share agriculture tips and experience that are local in nature. Thus to capture such information for later dissemination would require accompanying context. Phones can make it easier to target a user with content using a range of criteria (e.g. location and language) much more easily than other channels
- *Navigation*—databases are good for organising and sifting through large amounts of data or complex information, but how do you provide an interface that allows users to

easily navigate such information with a good user experience within the constraints of mobile phone while minimising operator intervention at the backend?

- *Personal interaction*—some transactions like visiting the doctor sometimes require face-to-face communication and contact during interaction to facilitate examination and diagnosis. How can we emulate or compliment such personal interactions? Or better support transactions that require discussion or dialogue before a solution can be identified

5. Conclusions

As a communication medium, mobile phones now have a wide reach into rural communities in Uganda. The rapid increase in phone penetration thanks to falling handset costs coupled with the good coverage across the country, indicates that handset ownership is likely to increase within poorer sections of society. TV audiences are also increasing and, as coverage increases, this is likely to emerge as a viable alternative to radio, which is still currently the only medium with universal coverage. Complimentary interaction between mobile phones with both radio and TV is an aspect that we did not cover in this study, but one that warrants further investigation (Donner 2008). As mobile handsets acquire more processing and beget open source operating systems like Android and Symbian, they are spawning application development efforts that are more responsive to local needs.

One of the implications of public phone use is the difficulty of receiving calls in rural areas only about one third of calls and SMS messages are incoming or received. This implies that the poor are bearing a bigger burden of the costs of communication. Given that phones are primarily used for calls to family and friends, this has implications for the development of social types of applications. It would be attractive to explore ways to support shared use of devices as well as the cost of services (much like a collect call, or reverse charge call). This will require some ingenuity, as the concept of collect call services has not been widely adopted in Africa and we have not encountered research in this area.

Phone applications as a source of information might tend to be more accurate and less susceptible to distortions for example compared to face-to-face. While face-to-face communication is common and plays an important role in building social capital, people have to use more judgement to assess the accuracy and relevance of information they pick up. A good deal of this also depends on the recipient's relationship with the information bearer and perception of their credibility. All of this implies that preliminary effort has to be invested to create credibility and trust for any mobile application amongst its potential users.

Literature has indicated that mobile phones tend to result in cost reductions rather than increased income for small business operators (Souter, Scott et al. 2005; Donner 2007). It is likely that mobile applications will in the same way enable people to access information more cheaply. Mobile applications that provide information may also reduce vulnerability, especially where they facilitate access to services (e.g. finding medical experts). They can also build the capacity of the individual to cope by providing access to education materials (e.g. family planning).

There is still need for more research to explore viable business models for mobile applications. For starters, some of the most important information needs that also align with developmental themes like health services tend to correlate with less frequency of access (see Figure 3), complicating normal commercial avenues to provide such information. Where there is a tangible benefit, it is likely that the poor will pay for a service as the mobile market has demonstrated. Although there is some reluctance to pay for services offering potential or future benefit (e.g. introducing new crop varieties) as they tend to be risk averse. It is difficult to assess willingness to pay for services, but it would be useful to gain an understanding of how users make decisions to use or not use services.

A related challenge emanates from the tension between accessing information for private gain verses for public good. Rural communities tend to work collaboratively together on certain matters and certain types of information may fall into this category or people tend to

share one household member will pay and then share information with rest. How such characteristics influence the success of some mobile applications is not entirely clear. Conversely, NGOs have a track record of paying for media programmes in line with their work (e.g. health awareness campaigns) and might be interested in subsidising some of these applications. Government institutions might also subsidise services that provide an element of public good (e.g. tracking spread of the disease, monitoring insecurity, detecting fake drugs). This raises the possibility of interesting public-private partnerships that fulfil the interests of various stakeholders.

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Blacknoise: Low-fi Lightweight Steganography in Service of Free Speech

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Abstract: Censorship of communications is a widespread, current practice in various countries with repressive governments in order to prevent or restrict speech; political speech in particular. In many cases state-run telecommunications agencies including those providing internet and phone service, actively filter content or disconnect users in defense of incumbents in the face of widespread criticism by citizens.
In this paper I present Blacknoise, a system which uses commodity low-cost mobile telephones equipped with cameras, and takes advantage of their low-fidelity, noisy sensors in order to enable embedding of arbitrary text payloads into the images they produce. These images can then be disseminated via MMS, Bluetooth, or posting on the Internet, without requiring a separate digital camera or computer to perform processing.

1. Introduction

Regimes such as China [1,2] are actively censoring content across various communications channels used by their citizens under the auspices of an effort to curb "offensive" materials, often with full cooperation from state-run agencies such as China Mobile [3]. However, reports in [4] indicate that this censorship also cracks down on political speech including satire, and is triggered by, for instance, any mention of the names of political figures.

In addition, nations as varied as France and India [5] prevent encryption of SMS by regulation, ostensibly in order to ease monitoring of communications along this channel, while Iran [6] disabled the transmission of SMS entirely in the hours leading up to its 2009 presidential election in response to SMS' role in organizing protests and mass rallies as well as transmitting news outside of the country via channels such as Twitter [7].

A litany of other nations conduct routine censorship of internet traffic, including but not limited to Turkey [8], Saudi Arabia [9], Pakistan [10], and many others, which follow the pattern of limiting speech and consumption of speech on the grounds that they are protecting their citizens from harm.

2. Steganography

The aim of steganography (from the Greek *στεγανός,* for 'covered' and *γράφειν*, 'to write') as a technique is to conceal a message within some 'cover medium' in such a way that the fact that a message is being sent at all is difficult to detect and harder to prove, and recovery of any such message is harder still.

A popular historical example of such a technique is noted in Herodotus' account of Histiaeus, who shaved the head of a trusted slave and tattooed a message on his scalp, sending the slave to deliver the message once his hair had grown back in, obscuring the message. The modern interpretation of this technique involves embedding message bits into some digital cover (most typically in images, although embedding in video, audio, and text are also practiced.) One of the most basic steganographic techniques is known as Least

Significant Bit (LSB) replacement, wherein the message bits are written over the least significant bits of the carrier medium, e.g. the lowest intensity bit in each pixel in a raster image. These bits were initially assumed to contain random Gaussian noise.

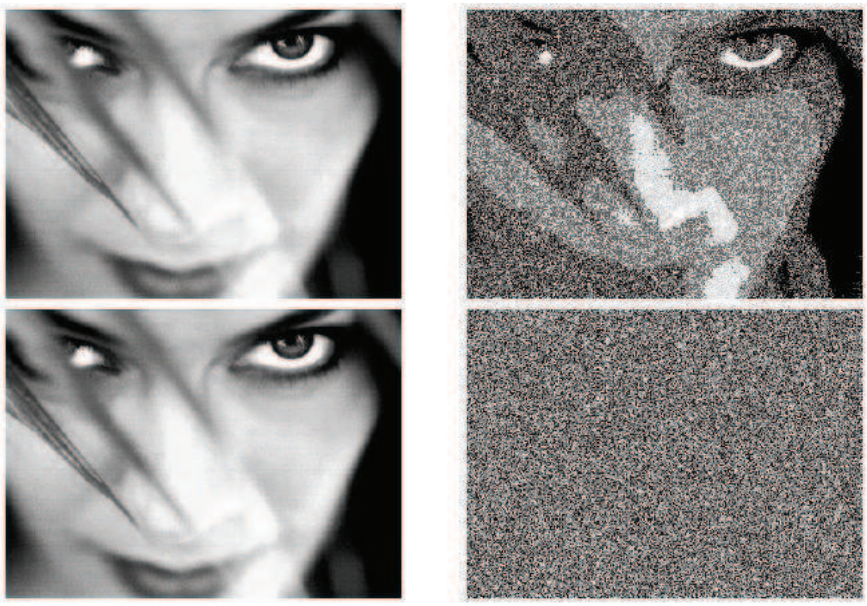

Figure 1: LSB plane example using two images. Upper left image is the original photograph, and upper right is its least significant bit plane with 0 set to black and 1 set to white. The lower left image is a message embedding with S-Tools and the lower right is its LSB plane. Images from [11].

Subsequent analysis [11] indicated that the LSBs of cover images were not, in fact, random, but statistically correlated. The outworking of this was that naive embedding of message bits was easily detectable using straightforward χ^2 analysis and, depending on embedding style, could also be detected using a "Visual Attack" [11] in which the bit plane assumed to contain the image was extracted from the cover image and visually inspected.

A somewhat more advanced technique than LSB replacement is called LSB matching [12], wherein the pixel values are modified at random by ±1 if the bit of the cover does not match the bit of the embedded image, which preserves image statistics better than the earlier method.

3. System Overview

We make the observation that low-cost embedded imaging sensors of the type typically found in early or inexpensive cameraphones exhibit high noise floors in both luminance and chrominance due to their small size, artificially increased sensitivity/ISO, and typically the lack of a flash.

Using 150 samples of images taken with a Nokia 3110c, a Chinese-made Amoi E72, and an Indian-made Micromax X280 at the default resolution for MMS (120x160 pixels), it was observed that the LSB plane did, in fact, more closely resemble random noise than image content illustrated in Section 4). Significantly, this also held true for each of the four least significant bit planes of each color channel, leading to significant visible noise in the resultant images.

The design of Blacknoise makes use of this fact and makes the novel contribution of extending the LSB matching technique across all three color channels of a PNG bitmap image taken with mobile phone cameras, across the four least significant bits. The result is that the embedding rate on any given bit plane is 1/12 what it would be on an equivalent grayscale bitmap image using conventional LSB matching.

Blacknoise operates, at a high level, as follows: Users Alice and Bob each have a cameraphone handset with the Blacknoise software installed. In a face-to-face encounter, the software establishes a symmetric key for communication between the two parties over Bluetooth or some other near-field communication method, e.g. Infrared, NFC. This key is used until the two parties meet face-to-face again and optionally establish a new key.

After the two parties separate, if Alice wants to send Bob a message, she takes an arbitrary, innocuous snapshot using her cameraphone, and enters the message. This message is encrypted appropriately with the symmetric key and a stream cipher, and the message is embedded into the image in a pseudorandom manner, using a pseudo-random number generator (PRNG) seeded with the last *n* bits of the key. When embedding the message, the system makes use, as noted above, of the four least significant bit planes of each color channel. The alpha, or transparency, channel is left untouched as it is unlikely that a mobile phone will produce an image with variable alpha, and as such images with alpha channel noise would immediately become suspect. The encoded image is then sent as a PNG bitmap using some carrier medium (MMS, Bluetooth, email, Internet posting, etc.) to Bob.

Upon receipt of the message, Bob opens the application and uses the established key to seed his own PRNG, selecting the correct bits to read values from, and uses the key to decrypt the ciphertext, recovering the message.

Eve, a party at the telecom or Internet provider observing the MMS message or image, may perform statistical analysis on messages passed between parties, and ideally should not be able to detect the presence of a message in the cover.

4. Implementation

A proof-of-concept implementation of Blacknoise was created on a pair of Nokia 3110c handsets in J2ME. The 3110c has the requisite J2ME APIs: JSR 205 [13] for MMS, JSR 82 [14] for Bluetooth connectivity, JSR 177 [15] for cryptographic APIs, and JSR 135 [16] for access to multimedia devices, including onboard cameras. In addition, as noted previously, the 3110c has a poor-quality image sensor which produces a high noise floor.

The software creates an RFCOMM Bluetooth connection between the two handsets using a custom UUID to distinguish the application. It subsequently establishes a symmetric key for the Salsa20 stream cipher. The implementation of this cipher is provided by the BouncyCastle [17] cryptographic library for J2ME.

A file selector is provided to load images which have been saved to the phone, allowing images to be received via any of the various communication methods the phone supports, including MMS, Internet, Bluetooth, and Infrared.

As the 3110c unfortunately does not support capture of images into a bitmap format (despite specifications indicating otherwise) a custom PNG encoder using the open source JZlib [18] library was implemented.

Once a key between two parties is established using the J2ME PRNG, the application allows capture of images via the 3110c's onboard camera, at the 120x160 pixel resolution standard for minimal MMS. After the image is captured, the user specifies a message to embed, with the same 160 character, 140 byte payload limit as an SMS message. This limit is artificial but is designed as a sensible first-cut payload size and will increase as further evaluation about the embedding capacity of these images is performed. Larger captured images also clearly offer greater embedding capacity.

The input message is encrypted using the Salsa20 cipher and the established key (with a static, predefined 64-bit initialization vector for the purpose of this proof of concept) and embedded at random using LSB matching to preserve statistical properties. The resulting

image is then either saved for transmission using WAP/GPRS/EDGE/UMTS or Bluetooth, or is embedded into an MMS/SMIL message. In the latter case the user is prompted to enter any additional descriptive text, such as a caption, and the message is transmitted using JSR 205 APIs.

The message is appropriately extracted and decrypted upon receipt when the user selects the received file in the file browser and selects the symmetric key he has established with the sender, and the decrypted message is displayed to the user.

5. Dissemination Methods

5.1 – MMS

The Multimedia Messaging Service (MMS) is a service which works analogously to the better-known SMS, but can carry multimedia content (e.g. images, video, and audio) as well as text. As a result, the payload size of MMS can be much higher, albeit at a somewhat higher cost to the subscriber.

The popularity of MMS is on the increase in areas with limited data connectivity, with China Mobile, for instance, reporting a volume increase of 130% to 33.1 billion messages, representing an 83.7% increase in revenue to approximately $421 million USD in its 2008 earnings report [19].

MMS is supported on every modern cameraphone handset and has widespread API support via J2ME JSR205 [13] and lower-level phone operating systems.

This widespread and growing acceptance of MMS, its larger payload as well as its own and well-understood specification make it one of the natural choices as an obfuscated data carrier.

The use of Blacknoise over an MMS carrier is straightforward. Once the shared key is established and an appropriate message is encoded in an image shot by the cameraphone, the image is then embedded in an MMS message and conveyed to a target user, and the message extracted and decrypted on the other end using the shared key.

5.1.1 – MMS Caveats

While MMS is a natural channel for information such as this, there are certain drawbacks which must be considered.

Firstly, MMS, depending on the country, can carry a significant cost, often three to ten times that of SMS or data via GPRS, EDGE, or UMTS, which can represent a major cost burden in developing nations.

Secondly, MMS messages are routed from handsets to servers controlled by the mobile service provider known as MMSCs, or Multimedia Messaging Service Centers, which then route the messages onward to their destinations. Because this carrier-controlled bottleneck exists, carriers can put filters in place which either resample or compress images in bitmapped formats, destroying the data contained within. While techniques exist to embed bits in similar ways into audio and video rather than images, these media are also susceptible to the same type of resampling or compression and offer no advantage against this bottleneck, while offering significantly increased complexity to encode on a computationally restricted mobile handset.

Finally, as in the Iranian example, during periods of dissent, mobile carriers can simply be instructed to turn off communications entirely, completely blocking this channel of communication.

5.2 – Bluetooth/Infrared

Bluetooth or Infrared file transfer, also known as OBEX, or Object Exchange, offers another channel through which Blacknoise images can be conveyed. This technique requires the communicating parties to be in very close proximity to one another - 30 meters in the case of

Bluetooth, and mere centimeters in the case of Infrared. In order to perform the exchange, the properly encoded Blacknoise image merely needs to be sent, as any other image file, to the recipient which is set to receive it.

This proximity makes widespread interception and analysis difficult, as the information exchanged never spreads beyond the immediate vicinity of the sender and receiver. In addition, there is no cost associated with this transfer mechanism, as there is with MMS.

Finally, Bluetooth supports a technology called 'Piconets' in which one master can communicate with up to 7 other devices, and 'Scatternets' which are bridged Piconets, which have no effective size limit. While the exact implementation of a communication channel using these techniques is outside the scope of this paper, it's clear that in some cases, particularly where many people are massed together, (e.g. a protest) this represents an economical and secure method for dissemination of information.

5.2.1 – Bluetooth/Infrared Caveats

Again, certain drawbacks apply to this communication channel, aside from the distance restriction inherent to the technology.

Bluetooth, as a standard wireless communications medium, is susceptible to jamming on its standard frequencies. While Bluetooth uses channel hopping in order to counteract narrowband interference, a sufficiently powerful broadcaster could energize the entire Bluetooth band and prevent any communications from occurring.

Additionally, only certain payloads and scenarios make sense for Blacknoise communication with those who are already nearby vis-a-vis passing a piece of paper or having a conversation in person. However, in these specific scenarios (e.g. where the parties communicating are under direct visual observation), Blacknoise can prove indispensible in, for instance, providing plausible deniability that any communication occurred.

Finally, in the case of Piconets and Scatternets, the problem of key dissemination and control adds a significant degree of complexity to 'broadcast' type messages. While these challenges are straightforward to overcome, they do require careful redesign of certain elements of the protocol, as well as potentially imposing a larger infrastructure burden compared to the current lightweight implementation of Blacknoise.

5.3 – Internet

The Internet, for those who have access to it, is easily the most robust and simplest method of conveying Blacknoise images. While nations which carry on censorship can and do selectively block sites, it is nigh well impossible to block every site on which a Blacknoise user might post an image, and even more difficult to resample every candidate image to make it unusable, given the sheer volume of images transmitted through the Internet.

Aside from dedicated photo-sharing sites such as Flickr [20], Blacknoise images can be posted anywhere in innocuous forms from personal blogs (though Blogger [21], Tumblr [22], Livejournal [23] and Wordpress [24] are all blocked in China, myriad other services exist), and the nearly limitless number of discussion forums on the internet which support .PNG images in 'Avatar' icons or user signatures.

Use of the Internet as the medium for conveying these messages carries with it all of the advantages entailed in other Internet use, including (relative) anonymity, encryption when using TLS and, typically, low cost.

Finally, unlike either the MMS channel or Bluetooth, it is impossible for a regime to completely cut off Internet access without both incurring significant negative global publicity and crippling elements of its business mix which rely on the information economy.

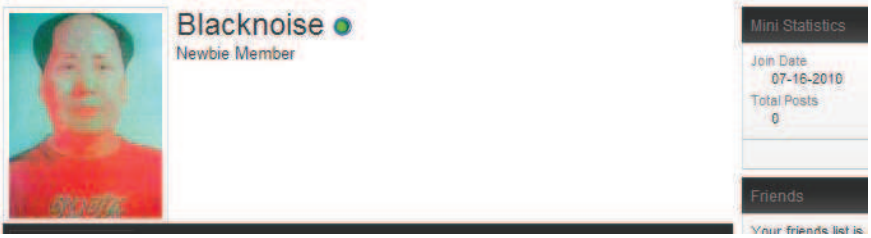

Figure 2: A Blacknoise image used as an avatar on an arbitrary web discussion forum.

5.3.1 – Internet Caveats

The Internet may be a preferred medium for dissemination of Blacknoise images, but there are obvious drawbacks to using it for this purpose. Countries which have an interest in controlling the flow of information have developed extremely sophisticated methods for tracking and tracing these flows and, while Blacknoise offers a significant degree of deniability, the burden of proof in such regimes typically lies with the accused. Thus, should an image be suspected of carrying hidden information, it is possible that the poster could be tracked and prosecuted.

In addition, it is important to note that Blacknoise images posted on the Internet as opposed to shared directly on handsets have the property that they can be accessed by anyone, a negative property if the goal is information control and a positive one if the goal is broad dissemination.

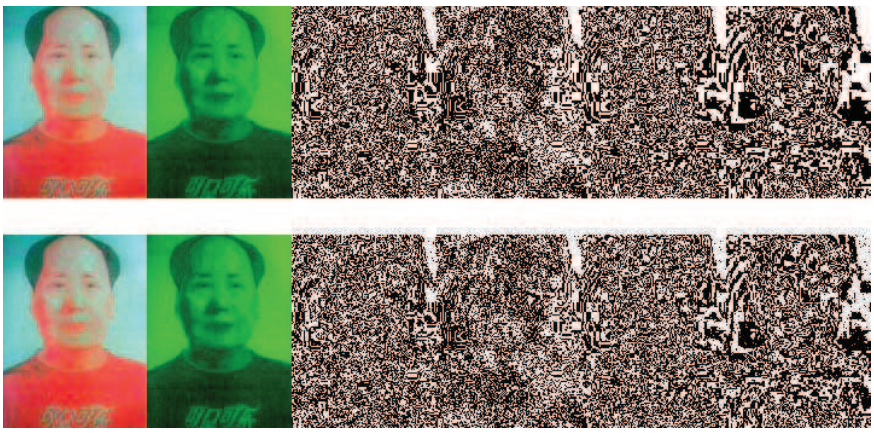

Figure 3: Examples of an image captured with the 3110c camera. The top row from left to right consists of the full color image, the green channel (selected as representative and containing the least visible noise) and the bit planes of the four least significant bits of the channel (1,2,4,8) before encoding. The bottom row contains the same images after encoding 1 message bit per pixel, a total of 19200 bits, or 2400 bytes. This represents more than 17 times the data payload of an SMS, and was selected as a reference only.

6. Analysis

We examine the results of embedding a message at a rate of 1 bit per pixel; in other words, an average of 1/3 bit per pixel per channel, or 1/12 bit per pixel per channel per bit plane. The resultant images of the bit planes can be seen in Figure 3.

It is clear to see that visual attacks will be difficult to execute without access to the original, unembedded cover image, as the qualitative noise pattern in the embedded and unembedded images on each of the four bit planes is very similar due to the high noise floor of the sensor masking the embedding. While differences are perceptible, particularly in fields of high intensity such as that in the upper right of the image, even these would be difficult to pick up in the absence of the original image for comparison. In addition, measures can be taken to avoid embedding 0 bits in such saturated areas during the embedding phase, or additional procedural noise can be introduced to mask saturation.

Initial attempts to classify stego and cover images using standard χ^2 techniques as well as Westfeld and Pfitzmann's sliding window [11] technique have failed to provide significantly better than random detection due to the low effective embedding rate per channel per bit plane. Histogram analysis to detect greater-than-normal symmetry in least bits due to LSB replacement is defeated by using LSB matching instead. The small image size (and therefore the small number of pixel samples) and high noise floor also contribute to creating high degrees of statistical variance between images and a difficulty in accurately characterizing a given image.

Because existing techniques for bitmap images rely upon the assumption that all bits are embedded in the LSB plane, effectiveness is reduced. It is currently unclear whether there is a simple augmentation that could be performed on these tools which would allow more robust detection of LSB matching among the 12 different bit planes used.

While there exist commercial tools to detect embedding in bitmap images, (e.g. [25]), their effectiveness is unclear as it is unknown what principles they work on. There are free and open source steganalysis tools available, but the best among them, StegDetect [26], only operates on JPEG coefficients, not bitmaps. StegSecret [27], an open-source contribution which detects various LSB schemes on bitmap images, failed to identify a single embedded image.

7. Related Work

There is a great deal of work surrounding the topic of steganography. Jessica Fridrich at Binghamton University leads a group that has produced several important papers on steganography and steganalysis [28-33].

Andreas Westfeld and Andreas Pfitzmann [11] contributed some early seminal work on steganalysis including some of the first statistical attacks on contemporary steganographic systems. Westfeld also contributed one of the first LSB encoding systems resistant to basic statistical attacks, F5 [34] for JPEG images.

Niels Provos created OutGuess [35], which used selective pseudo-random number generator seeding to deterministically offset statistical aberrations caused by steganographic embedding in JPEG images, and also created StegDetect [26], an application which detects various steganography schemes in JPEG with a high degree of reliability.

While there has been research into steganography on mobile platforms, notably by Agaian et al [36], most of the corpus consists either of implementations of 'naive' LSB or orthogonal research on algorithms which work well with constrained image sizes and low-powered processors without taking the advantages of naturally occurring noise into account.

Blacknoise builds upon various facets of the existing work, particularly making use of LSB matching and pitted against several of the published statistical steganalytic methods while contributing the underutilized principle of high-noise sources and using multiple bit planes to limit statistical perturbation of any given bit plane. In addition, the fact that Blacknoise operates preferentially on low-cost phone handsets brings steganography within

practical reach for many in the developing world who own such phones but have little or no access to computers of their own.

8. Future Work

Future work on the Blacknoise system will proceed in several directions. Of primary importance is more robust analysis of the statistical properties of the cover images produced by small sensors, and how they differ from images which have been embedded. This analysis will help ascertain tight bounds for embedding capacity, allowing greater freedom in embedding text.

Orthogonal to this but of similar importance is research into generating procedural noise which carries similar statistical and visual properties for use with phones with better cameras, including smartphones.

Finally, more rigorous steganalytic tools will be brought to bear upon the images which result from Blacknoise, including RS [28] and Difference Image Histogram [37]. The standard statistical tools used in the analysis performed to date will also be examined for ways in which to augment them to detect the multiple bit plane embedding used in BlackNoise.

9. Conclusion

In this paper I have presented Blacknoise, a simple, lightweight steganographic system which takes advantage of the significant noise present in image sensors in typical inexpensive cameraphone handsets. The properties of the images produced by these cameraphones combined with contemporary embedding techniques defeat known existing first-line detection of message embedding in bitmaps.

Properly implemented, the system should allow the transmission of arbitrary text within and outside the borders of nations governed by restrictive regimes while maintaining plausible deniability and making both detection of message transmission and the recovery of messages difficult for parties not in possession of the appropriate keys.

The advantages of the Blacknoise system are clear, but significantly include a vast reduction in the amount of infrastructure required to send a hidden message: one $30 USD cameraphone as compared to a digital camera, memory card reader, computer, image editing software, etc. It is my hope that this will democratize the sending of truly private communications and increase free speech in otherwise repressive environments.

While this implementation is academic and stills a work in progress, it is my hope that future development will allow for both more definitive security guarantees and practical use in China and elsewhere around the world.

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"Ten Seeds": How mobiles have contributed to growth and development of women-led farming cooperatives in Lesotho.

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Abstract: The potential for mobiles to contribute to development has been widely heralded, but evaluations tend to be technically-oriented and not framed by development theories, and thus empirical evidence on their actual developmental impact is limited. This paper attempts to address this gap by building on 4 follow-up evaluations over the 4 years since mobiles were provided to women-led farming cooperatives in Lesotho. Using theories of development as economic growth, empowerment and choice, the paper highlights how, in these women-led farming cooperatives, development has certainly been achieved against all of these elements.

1. Introduction

Information and Communications Technologies (ICTs) have widely been heralded as a mechanism for promoting development (UNDP, 2001; Saunders et al, 1983). This is particularly the case in Africa, where there has been a rapid growth in both mobile ownership and signal coverage in recent years. A number of academic communities have turned their attention to the developmental impacts of ICTs, resulting in such terms as M4D (mobiles for development) and ICT4D (ICTs for development), and the growth of a development informatics discipline. However, the dominance of technical specialisms in development informatics, relative to development studies, means that impact assessments have been poorly informed by conceptual frameworks on which to truly assess the effects of mobiles on development. By association, it also raises the question of how to define development. This paper presents a qualitative and longitudinal examination of the impact of ten mobiles ("ten seeds"), provided by a development programme to women-led farming cooperatives.

2. Growth in the availability and uptake of mobiles in Africa

In 2008 58.5% of the population of Africa was covered by a mobile signal, with some countries, including South Africa, Botswana, Mauritius and the Seychelles, approaching 100% coverage of inhabited areas (ITU, 2009). A number of African governments, such as South Africa, Kenya and Uganda, have obliged mobile operators to provide certain population coverage as part of their license conditions and/or require them to install community service telephones, thus ensuring that coverage is not solely restricted to urban areas (Gray, 2006). By the end of 2008 there were over 246 million mobile subscriptions in Africa (out of a population of just under 700 million), and between 2003 and 2008 the rate of growth was more than double that in the rest of the world. Estimates suggest that actual

usage might be twice the subscription rates, due to the shared usage of mobiles (Heeks, 2009). Even vulnerable groups that are typically targeted for development interventions, such as the elderly and women, are embracing the technology and learning how to use mobiles (Vincent et al, 2009; Vincent and Freeland, 2008).

3. Theories on the linkages between mobiles and development

Whilst the increased diffusion of ICTs is undisputed, more questions have been raised about the actual impact of these on development. In a recent policy arena of the Journal of International Development Studies, Richard Heeks argues that the development informatics community has been informed much more by academics with a technical bias (for example those from the information sciences, information systems, communication studies and computer science disciplines) than those with a development studies focus (Heeks, 2010). The consequence has been that the impact assessments of ICT4D have typically been descriptive rather than analytical, lacking in methodological rigour and, crucially, not linked to development studies-informed conceptual frameworks around which to structure and analyse findings. Perhaps even more fundamentally, undertaking impact assessments around ICTs requires epistemological questions to be asked concerning what development actually is?

The policy arena presents three papers in which different perspectives on mobiles and development are shown. Donner and Escobari (2010) use models of enterprise value chains first proposed by Porter (1985) to define how mobiles contribute to development. They find that mobiles improve the quality and depth of existing trading relations, by allowing small and micro-entrepreneurs to build trust by keeping in closer contact with their suppliers and customers, and also to reduce their costs by removing the need for physical journeys. This is defined as progressive change, but not transformational. Donner and Escobari (2010) find less evidence of transformational change, with few signs that mobiles alter the market structures, or create new livelihoods but they cite other studies which found that found evidence of the "digital provide", namely that the existence of mobiles tends to change the operating environment to the benefit of all in it, whether or not they themselves have direct access to mobiles (the reverse of the argument proposed in the 1990s and 2000s on how a "digital divide" would arise between those with access to ICTs, and those without it (van Dijk and Hacker, 2003; Norris, 2001).

A study on fisheries in India showed that, after the introduction of mobiles, profits for small-scale fishermen in Kerala increased, whether or not those fishermen owned mobiles. For those that did, profits rose by an average of US$4.50 per day, more than offsetting the costs of phoe ownership and use; but even the profits of those fishermen without phones increased by US$2 per day, as market efficiency improved for everyone, meaning fishermen were able to sell more of their catch, and thus reduce wastage. The actual price per kilogram for fish dropped, as less wastage meant the market was better supplied – but this, of course, provided benefits to all consumers (Jensen, 2007).

Whilst economic growth is undoubtedly one aspect of development, there are other, less tangible, elements that are equally important. The second element addressed in the policy arena is a sense of empowerment, arguably something which is particularly the case for vulnerable groups in society, whose economic position may have consequences for their social standing. Khan and Ghadially (2010) take the example of Mumbai – second only to Bangalore as a centre for ICTs in India – and show that, despite the widespread availability of ICTs, uptake shows gendered differences, with women far less likely to use computers and the internet outside of their college time. However, those women that have benefited from training in ICTs report higher indicators of empowerment than their male counterparts, thus suggesting that if women are enabled to cross the digital divide, ICTs do have a potential to reduce inequality. Psychological perceptions of well-being thus also form a critical component of development.

Staying with the more qualitative definitions of development, a sense of empowerment can also be brought about by the availability of increasing choices available to individuals. In the third policy arena paper, Kleine (2010) zeroes in at the individual level, looking at the impact ICT plays on the life of a single female micro-entrepreneur living in Chile. Underlying the fact that development involves so much more than economic growth, she finds that the choices now open to this woman might be overlooked by quantitative indicators. However, to the woman herself, the ability to "visit" online a German city in which she once had a pen friend was just one example of how ICTs offered her a choice that was of significant value to her life.

The following chapter applies the various conceptions of development to women-led farming cooperatives in Lesotho. The Thulare Dairy Farmers Cooperative (established in 1997) comprises a number of member groups based in different agro-ecological zones in Lesotho – the lowlands, foothills, and highlands. The cooperative was provided with 10 mobiles in 2006, and subsequent follow-up visits for evaluation took place in July 2007, January 2009 and July 2010. The frequency of visits and length of time that has elapsed since the initial provision of mobiles exceeds that which might be expected as part of a typical monitoring and evaluation framework attached to development funding. The qualitative nature of the evaluations also provides an extra dimension that is typically overlooked in quantitative studies. Thus this case study is ideal to critically assess the role of mobiles in promoting development over the long term.

4. "Ten seeds": background to the provision of mobiles to the cooperative

As part of its remit to build evidence on innovative approaches to develop better, more dynamic, ways of tackling both acute hunger and chronic, predictable vulnerability, the Regional Hunger and Vulnerability Programme (RHVP) undertook a pilot project to see how vulnerable people benefit from mobiles. Ten mobiles were provided to the Thulare Dairy Farmers Cooperative in Lesotho in August 2006, five of which stayed in the lowlands groups, 1 of which went to the foothills groups, and 4 of which went to the highlands group (see figure 1).

The Regional Hunger and Vulnerability Programme (www.wahenga.net) is a UKAid by the Department for International Development and AusAID-funded programme in southern Africa. It advocates for long term social protection to at-risk groups in order to reduce their vulnerability and hence reduce the likelihood that episodic events such as drought plunge such groups of people into crises. Cash transfers are a popular example of social protection in southern Africa, taking the form of non-contributory social pensions, child support grants, and disability grants. Effective and efficient delivery of cash transfers is, however, an important policy question (Devereux and Vincent, 2010). Electronic delivery systems, using smart cards, debit cards, and mobiles, have been proposed and trialled but, initially, opponents cited an obstacle to their use: the inability of vulnerable groups (such as those targeted by cash transfers) to handle ICTs. RHVP provided these mobiles to the cooperatives on the basis that cooperative members had similar demographic profiles to the target beneficiaries of cash transfers, and thus was interested to see how they would be used.

Evaluations subsequently took place in July 2007 and January 2009 (for further information, see Vincent et al, 2009; Vincent and Freeland, 2008). The results showed that, contrary to the arguments against using mobiles to deliver cash transfer, even illiterate vulnerable people are actively able to embrace ICTs. Moreover, these women-led cooperative groups had greatly benefited from improved communications, both in terms of their farming activities and the reduced time and cost of staying in touch with each other. Furthermore, they had even been able to use their mobiles as effective income-generating tools through selling airtime by SMS, thus raising revenue to enable further development of their cooperative.

4.1 Background to the Thulare Dairy Farmers Cooperative

The Thulare Dairy Farmers Cooperative has its headquarters at the Bishop Allard Vocational School in Roma, and benefits from skill sharing and training from the school. Indeed, the cooperative was initially formed by a number of agriculture teachers at the school who had benefited from overseas training on the management of cooperatives. The cooperative was formed in 1997 and formally registered with the Ministry of Trade and Industry, Cooperatives and Marketing in Maseru. In order to be registered, the cooperative had to have a formal structure, including an Executive Committee comprising 1 representative from each of the member groups. Figure 1 shows the six member groups that belong to Thulare. Three of these (Itjareng Manonyane, Maliele Progressive, and Tsoelang Pele/Makanyane/Raohang) are based in the lowlands; two are based in the foothills (Machache and Kopananang Matiama), and one is based in the highlands (Haesise Basotho). Reflecting the different agro-ecological zones, as well as group preferences and priorities, each group concentrates on, and specializes in different crops and livestock.

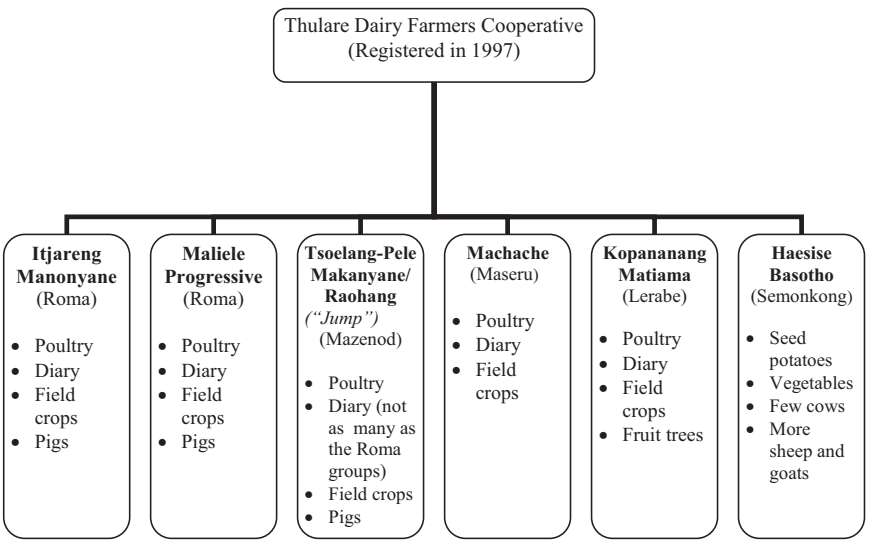

Figure 1: Structure of the Thulare Dairy Farmers Cooperative, highlighting the location and primary agricultural activities of the member groups.

4.2 Provision of mobiles to the Thulare Dairy Farmers Cooperative

The mobiles provided to the Thulare Dairy Farmers Cooperative were Siemens handsets and training was provided by the Maseru-based service provider (Vodacom Lesotho). Recognising the lack of exposure to mobile telephony amongst the target users, joint monitoring committees comprising a teacher in the community and a young student, together with the members of each farming group, were established. As it was beyond the scope of RHVP to provide a regular cash transfer, each handset was preloaded with ZAR500 (approx $50) of airtime, with the intention that the recipients would use ZAR100 of this for group communication, and then sell the remaining ZAR400 (as airtime or SMS) to other community

members, such that the enterprise becomes self sustaining. Follow-up evaluations were conducted in July 2007, January 2009 and July 2010.

5. Impacts of mobiles within the Thulare Dairy Farmers Cooperative

5.1 Mobiles and economic growth

Perhaps the most immediate impact of mobiles on the farmers was the way in which the improved ability to communicate contributed to economic growth. Economic growth is brought about in two interlinked ways: by reduced transactional costs, and by increased sales. Lesotho's terrain is mountainous and outside of the capital, Maseru, transport infrastructure can be poor, meaning that disproportionately long times are often spent travelling short distances. This meant that, even within the cooperative, internal communications were arduous. Often letters detailing monthly meetings had to be personally delivered and in the lowlands groups, for instance, the distance between groups can be up to 200km which meant an 16 hour round trip by taxi costing ZAR130 (approx $13) and necessitating an overnight stay. This situation is compounded in the winter, when inclement weather in the mountains can impede physical transport. At the time of the third evaluation, for example, in July 2010, the group based in Semonkong (in the highlands) was unable to travel to Roma for the meeting at the last minute due to the forecast of imminent snow. Now that groups are connected by mobile, internal communications are far easier, and costly physical meetings are only arranged when there is a need, which of course can be ascertained by calling ahead.

As well as being more economical through reducing transport costs, the availability of mobiles has also improved the productivity and marketing successes of the cooperative groups. Marketing their produce is one of the focal areas of the cooperative. A lot of trade takes place between the members of the different groups within the cooperative, with goods typically available more cheaply than through the market. In the highland location of Semonkong, for example, women would typically have to make a long and difficult journey to the Bishop Allard Vocational School where ad hoc meetings were held concerning the marketing of produce. After mobiles had been distributed, it was possible for the women to call ahead to the market and obtain pricing information, and then to communicate with each other, removing the need for physical travel. The different groups have also been able to make better use of product exchange, building on their geographical advantages: such that in the last year those in the lowlands could swap maize for wheat from the highlands.

Similarly, external trade (outside the cooperative) has improved through the availability of mobiles. In one case, reported in January 2009, those in Nyakosoba had a surplus of beans, and were able to successfully market them by using their mobiles to contact potential markets. In 2010, as a result of financial pressures, the government has reduced the number of agricultural shows it hosts, thus limiting a traditional product marketing opportunity. Thulare Dairy Farmers Cooperative thus plans to hold regular open markets at the Bishop Allard Vocational School, as well as in other key centres, where group members will be able to sell their produce. Before instant communication was available through mobiles, such open markets would have been impossible due to the time taken to communicate, both internally (with members on what products to bring) and externally (with potential buyers).

Thus mobiles have clearly enabled economic growth within the Thulare Dairy Farmers Cooperative. Findings correspond with those noted by Donner and Escobari (2010) and Jensen (2007), that mobiles increase the depth and quality of trading relations, both within and outside the cooperative. However, economic growth benefits are not limited to progression in existing activities – there is also evidence for transformation, in terms of new and expanded activities.

Discussions with the cooperative member groups on all three occasions highlighted the role that mobiles had played in creating new income-generating activities which had, in turn

expanded the roles of the cooperative. Trading airtime vouchers is undertaken by all the groups. They purchase discounted airtime vouchers from town-based outlets, and sell these on within their communities at the list price, thus making a very small profits on each sale. The exact modality of this varies from group to group: at Bishop Allard Vocational School a small stall has been set up, which sells vouchers to pupils at the school and community members who particularly appreciate the flexibility of being able to purchase airtime outside of formal shop opening hours. In the highlands, where the distance from shops is greater, group members based in the city may purchase airtime and use Vodacom Lesotho's network facility to transfer that airtime to the highlands. From there it can be purchased and transferred (again via network facility) to other mobile owners.

Despite the very small margins on each sale, the cooperative has been able to capitalise on the greater diffusion of mobile technology and tap into the resultant market for airtime for prepaid subscriptions. Within the whole of Thulare Dairy Farmers Cooperative, for example, they began with ten mobiles but this has now grown to 27 handsets. Thus 17 have been purchased using income generated through the sale of airtime over the last 4 years. In January 2009, the Maliele group explained how they had initially saved up ZAR1000 from airtime sales, and then used that to purchase 4 additional mobiles. Now the greater availability (and thus distribution) means it is easier for those group members not charged with holding a mobile to access one, thus further benefiting the groups, as well as the individual members.

Some member groups have furthered their agricultural activities with the profits from airtime sales, leading to economic growth. Two of the lowlands cooperative groups purchased two piglets which they fattened up and slaughtered, thus further generating income through the sale of the meat. This money was invested in a stokvel (savings wheel) for the farming groups, the profits of which enabled a further member group to be formed. The lowlands groups' next plan is to buy a breeding pair of Duroc pigs, from which they intend to distribute piglets so that eventually each group has a breeding pair of Duroc pigs. Having breeding pairs, in turn, increases the availability of income through the sale of piglets.

Other groups have expanded their activities beyond the agricultural sector. One of the groups in the foothills has embraced trade in second hand clothes, which it sources in bulk from Maseru and then sells locally. Generating income from airtime sales gave them the initial capital required to commence this business, which has become so successful that other member groups in the lowlands are considering following suit. The highlands group put the first ZAR1000 generated from airtime sales to another use. Due to its location in the mountains, Semonkong is a popular tourist destination. The group loaned the first profit to a community member who was setting up a guesthouse, to enable her to purchase linen. She will pay this money back to the group with 5% interest. It is intended that further profits will also be invested in tourist-related small businesses.

5.2 Mobiles and empowerment

In addition to communication and income generation advantages, the availability of mobiles has had some other important, and perhaps unanticipated, benefits for the farming groups. These benefits relate to empowerment. As already explained, Thulare Dairy Farmers Cooperative was targeted to receive the mobiles from RHVP primarily because the members have demographic profiles similar to those typically targeted by cash transfers. On the whole, members are women, elderly, and with generally poor levels of education. As noted by Heeks (2010), measuring empowerment is arguably more difficult than economic growth as it requires more qualitative indicators, but on all three follow-up evaluation visits, comments from various group members verified that empowerment certainly was a consequence of having access to mobiles.

The mobiles had been presented to the Thulare Dairy Farmers Cooperative on Women's Day (9th August) in 2006, and one female chicken farmer from the Maliele Progressive group recounted in the July 2007 how she had felt so proud as a woman to have been chosen to

benefit from technology, which is arguably typically a male-led phenomenon. Similarly in January 2009 the head teacher at the Bishop Allard Vocational School explained how farmers now have much more confidence, both personally and in their farming ability – "mobiles have enlightened us". In July 2010 a spokesperson from one of the foothills groups said that before his group had had access to mobiles and the income generation opportunities that they brought, he was not as well-presented (i.e. dressed) as he is now.

The empowerment advantages of having mobiles extend beyond individual feelings of self-esteem and confidence. In Semonkong, which is much more remote from urban areas and has high levels of illiteracy, the chieftainess reported in January 2009 that members of her community have learned basic English and mathematical literacy through using the phones – they know how to do sums (to work out how much airtime they have used) and understand the instructions on the phone.

Empowerment has also resulted from a better sense of cohesion and belonging that is felt by group members within the cooperative. There is a Basotho saying that translates as "If you walk alone, you are doomed", which reiterates the importance of collective action in Basotho society. In July 2010 one lowlands group said that "we want to buy more mobiles in order to stay united" and the manager of Thulare Dairy Farmers Cooperative also explained that "we are vulnerable – to be strong we need to be able to communicate". The headquarters of the cooperative at the Bishop Allard Vocational School is now home to a number of trophies and awards that they have won at past agricultural shows and exhibitions, all of which have helped to instil pride and confidence, which is vested not only in individuals, but in the groups as a whole.

Similarly empowerment has resulted from the way mobiles have facilitated access to networks and relevant expertise. The Thulare Dairy Farmers Cooperative is now able to collaborate more effectively with relevant government structures, including the Ministry of Agriculture, and the Ministry of Trade and Industry, Cooperatives and Marketing. In fact on the day of the July 2010 follow up evaluation visit, the cooperative had arranged for both the local extension office and their official liaison person from the Department of Cooperatives to be present, to capitalise on the fact that the majority of the cooperative members were having a physical meeting. Representatives from UNESCO were also in attendance to document the cooperative's activities as a case study of best practice for a development publication. Similarly the cooperative is also a member of the Participatory Ecological Land Use Management (PELUM) network, "a civil society network that aims to build the capacity of farming and rural community groups to enable them to accumulate skills, stimulate farmer learning and inspire experimentation and innovation in their quest to achieve food security" (www.pelumrd.org).

As well as improving access to relevant networks and social capital, mobiles have also brought about empowerment through facilitating access to formal education. By the time of the January 2009 follow up evaluation, income from the mobiles had enabled 4 group members to attend formal training arranged by the Department of Cooperatives in Maseru. Similarly cross-border training has occurred, with visits to South Africa. In early 2009 the lowlands dairy farmers visited a Jersey cow farmer in Ladybrand, South Africa, with a view to learning about, and potentially purchasing, breeding stock. In July 2010, the cooperative reported that a number of South African farmers have assisted with the participation of group members in informal training opportunities. One, in particular, had offered free training in artificial insemination, enabling further participation by the cooperative since they only needed to contribute travel costs. Clearly without mobiles finding out about such training opportunities would have been much more difficult, and would have impeded the increase in skills amongst group members.

The provision of a valuable commodity to vulnerable groups has raised concerns that it would inadvertently increase the vulnerability of the recipients. Although there had been no incidents of mobile theft amongst the recipients, the women were all familiar with incidences of mobile theft within their social circles, with one lady explaining how her daughter's phone

had been stolen at a party attended only by family and friends. Electricity availability for battery charging was problematic, particularly for the highlands groups, where mainline electricity is only available in Semonkong town. Farmers in this community have to travel 20km to get here – but tend to send their phones for recharging (at nominal cost) with anyone who is going to town. However, solar chargers are now very inexpensive (available for US$30), and would be an ideal solution to this problem for each community as well as providing a further income-generating opportunity for small businesses.

5.3 Mobiles and choice

To a certain extent, it is already evident from the preceding sections on economic growth and empowerment that, in the four years since first having access to mobiles, members of the Thulare Dairy Farmers Cooperative has had increasing access to choice. Furthermore, arguably the choices they have made have contributed to the extent of economic growth and empowerment they have experienced over the past four years. This is perhaps best summarised by a quotation from the manager of the Thulare cooperative, that "we turned the mobiles into a business."

The most recent follow up evaluation visit, in July 2010, shows that the range of choices available to group members has grown exponentially with time. A fairly universal wish for the future among groups is for the installation of wireless landline telephones. Like mobiles, these wireless landlines do not require fixed telephone infrastructure, although they do need to be connected to a power supply (which can be provided by a solar charger or car battery in non-electrified areas). Airtime is prepaid and purchased in vouchers, similar to mobiles, but the advantage is that call rates are much cheaper, thus facilitating the level of communication to which they have become accustomed at lower costs. The main office of the Thulare cooperative has already purchased one of these, at a cost of ZAR330, and is making a profit of between ZAR150-200 per month through selling call time to community members.

Even greater availability of communications, through mobile and wireless landline services, will also act to facilitate the cooperative's latest development, the creation of a Savings and Credit Association. The majority of cooperative group members do not fit the profile of typical bank clients, and most are unbanked. This inhibits their access to credit and ability to take the risks necessary to further their growth and development. However, the capital which are being raised through the mobiles have facilitated the cooperative acting as a *de facto* bank, where both individual members and groups collectively are able to save money and access loans.

The savings and credit scheme is financed by each of the six member groups paying ZAR200 per annum to the cooperative (which is added to the account which holds their ZAR500 once off membership fee). The policy is that 20% of the total funds must remain in the bank while 80% of the funds should be loaned out to members of member groups at a rate of 2.5% per month. At the same time, each member of a member group is entitled to use the cooperative as a savings scheme for their own personal funds. Savings lodged with the cooperative earn interest of 1.5% per month. Furthermore, the Thulare cooperative is undertaking training around banking for its members. At the July 2010 follow up evaluation meeting ZAR680 was invested by individual members, highlighting the trust in, and support for, the initiative. The cooperative foresees employing a permanent "teller" to handle transactions in the future.

6. Conclusion

Criticisms have been raised that impact assessments of the role of mobiles in development have been lacking in analytical rigour and restricted to considering only certain elements of development. This chapter has added empirical weight to the argument that mobiles do indeed promote development, as defined in broad terms to include economic growth, empowerment and choice, using a qualitative and longitudinal case study of women-led

farming cooperatives in Lesotho. In this case access to mobiles has been both progressive, in terms of improving the ease and efficiency of existing operations, as well as transformational, in extending the range of activities as chosen by the cooperative themselves, as opposed to being externally-led. Arguably one of the reasons for this is that the initial provision of ten mobiles to the cooperative was part of a small intervention by RHVP, who imposed no conditions whatsoever, including no demands for reporting back on progress. As a result, all the progress observed and development that has taken place has been driven entirely by the enthusiasm and capacity of the cooperative leadership, together with the commitment of its various members. It is thus fair to say that, in this case, from ten seeds the Thulare Dairy Farmers Cooperative has grown and even blossomed.

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