Research Article

Warana Unwired: Replacing PCs with Mobile Phones in a Rural Sugarcane Cooperative

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Abstract

In this article, we present what we believe to be the first documented experiment to replace an existing PC-based system—one that had a goal of "bridging the digital divide" for an agricultural district—with a mobile phone-based system in which a small, but relevant amount of data is transferred to farmers via SMS (short message service) text messaging. Rural PC projects meant to serve socio-economic development are plentiful, but, in many cases, the PCs are overkill and cost too much to maintain. Warana Unwired sought to replace just such a PC-based system for managing information in a sugarcane cooperative in rural Maharashtra with an SMS-based mobile phone system. In an eight-month trial involving seven villages, Warana Unwired successfully replicated all of the PC-based functionality and was found to be less expensive, more convenient, and more popular with farmers than the previous PC-based system. This article discusses the early investigations of the Warana Wired Village Project that led to the conception and implementation of the Warana Unwired project. The new system is described in detail, and results, both quantitative and qualitative, are analyzed.

I. Introduction

Perhaps the most succinct statement of what many have recently come to believe about ICT for socio-economic development appeared in a well-cited article in the March 10, 2005 edition of *The Economist:*

> . . . the debate over the digital divide is founded on a myth—that plugging poor countries into the internet will help them to become rich rapidly . . . even if it were possible to wave a magic wand and cause a computer to appear in every household on earth, it would not achieve very much: a computer is not useful if you have no food or electricity and cannot read.

Despite such skepticism in some circles, rural PC projects in which a computer is meant to support socio-economic development in poor agrarian villages have proliferated over the last decade. The research literature on the impact and sustainability of these projects is often optimistic, but critical and skeptical with regard to their actual development value [24]. Indeed, the costs of such projects often outweigh the value they deliver.

In this article, we present an experiment to provide a more appropriate technology solution in a particular agricultural context: an ICT project with the quixotic goal of "bridging the digital divide" for an agricultural district. We believe our experiment is the first documented case to effectively replace an existing PC-based system with a mobile phone-based system that disseminates small, but relevant amounts of data via SMS text messaging to farmers.

Our work occurs at the intersection of a vast body of recent work on mobile phones for development and ICT for agriculture.

There are many kiosk-based projects that aim to target farmers, particularly in providing them access to agricultural information. For example, ITC's[1] e-Choupal effort is often identified as a successful rural ICT project, but its main innovation is in modifying the supply chain so that farmers can exchange harvested crops for instant cash, often yielding better prices to the farmer than going to the traditional market place [1]. Anecdotal evidence suggests that the PC kiosks are rarely used at the ITC's e-Choupal. The role of PC kiosks as tools are increasingly under scrutiny, and kiosks have huge sustainability issues [2]. The e-Sagu system was used to provide agricultural advice to farmers by taking preemptive digital photos of the farmer plots. The PC is used to burn CDs of the photos and as a communication device through which the end user can receive the advice as a file [4]. Results from surveys and from software logging tools that track user behavior show that, at some kiosks, the contributions to usage from development services, government services, and services addressing agriculture or health care amounted to less than 10% of overall kiosk usage [19] [18]. So, the point is that with all the excitement about PC kiosks delivering agricultural services, it is not clear whether PCs are being used optimally.

The case for the mobile phone being more important than a PC in developing countries has been made by researchers and practioners that are deploying technologies for development [9] [11] [20]. Increasingly, smartphone-based systems have been developed and proposed as a tool for development: as a game-based learning tool [6]; to collect information from self-help group (micro finance) members using a camera-enabled phone [7]; and for optimizing the rural supply chain using GPS-equipped phones [8]. While smartphones are here to stay and their numbers increase in market penetration, prices still remain too high to be the device of choice for low-income farmers. Our work relies primarily on "dumb" phones whose capabilities are limited to voice and SMS text messaging.

There are also a number of SMS systems available for free or downloadable for a small fee [13]. The idea of using SMS—when accessing advanced services provided over the network, it can allow even basic handsets to handle information search—has been proposed [11]. There have been some efforts to devise an SMS-based server for developmental causes [14]. The most relevant work is the recent development of aAqua [3] that allows questions to be sent via SMS message. There are a couple of differences between what we are presenting in this article and what has been done earlier. aAqua seeks to provide broad agricultural information to farmers through the Internet, with SMS being simply another channel to ask questions and retrieve answers. In Warana Unwired, the data being accessed is at once narrower and more tailored to practical needs, with a focus on farmers' personal accounting information. Also, the data being sent is syntactically structured, and that has implications on the type of scenarios in which it can be used.

We believe our work is unique in having taken an existing PCs-for-agriculture project and replacing it with one that predominantly relies on mobile phones and text messaging. Our results provide additional evidence of the power and efficiency of the mobile phone when working under the constraints of rural areas, at least for some kinds of applications.

II. Research Methodology

The work presented in this article occurred in two stages. In the first stage, an ethnographic approach was used to understand the workings of the eight-year-old Warana Wired Village Project (WWVP) in which a PC-based network of computers was set up with the intent to provide all the benefits of Internet access to farmers in a sugarcane cooperative. Our hope was to understand the degree to which the technology was having an impact on the cooperative, particularly with respect to farmers' agricultural practices, their productivity, and ultimately, their incomes. The study viewed agriculture not just as a process of production but as a social practice that involved interactions among farmers, cooperative administrators, extension officers, and ICT operators.

This first phase was conducted in the context of

1. ITC is a major Indian agribusiness company.

a broader study that hoped to answer two questions. First, how was the quality of Indian agriculture improved through ICTs? Second, what was the relative value that ICT had compared to various other alternatives for improving agriculture? Results from the first stage showed that the ultimate use of the PC system was highly specific and increasingly costly due to the high maintenance costs.

Thus, in the second stage, we proposed and implemented a new system that replaced the existing PC-based system with one that preserved the functionality of the earlier system, but at much lower cost. This system used a system of mobile phones and SMS text messaging. The system was piloted in seven villages in the cooperative over a period of eight months.

In the next section, we discuss our initial ethnographic investigations in detail. In Section IV, the implementation of the mobile phone-based system is discussed. Section V presents results of our eight-month pilot. Section VI concludes with a summary of our findings and a discussion of future work.

III. Stage 1: Initial Investigations

A. Background

Warana is a block (sub-district) in the Indian state of Maharashtra and is located 30km northwest of the city of Kolhapur in the second-richest district in India. Warana's economic success is linked to a local visionary, Tatyasaheb Kore, who mobilized local farmers four decades ago to form a sugarcane cooperative. Set up in 1959, the sugarcane factory revolutionized life in Warana. Kore's success led to the formation of more than 25 cooperatives in the area that supported several interrelated socio-economic activities, thus influencing the transformation of the Warana area. For example, the cooperatives promoted irrigation facilities, informed farmers of the latest agricultural practices, and constructed infrastructure such as roads and electricity generators. They also undertook employment-generation activities to keep labor in the villages and to prevent migration to cities.

The sugarcane cooperative, the focus of this study, is the most prominent among these cooperatives. It comprises about 50,000 farmers who live in 75 villages spread out over the 25,000 km^2 area covered by the cooperative. These villages span the Kolhapur district and the Sangli districts in Maharashtra.

The cooperative's main function was to centralize the system of collecting, processing, and selling sugar at a single processing plant; villages that were part of the cooperative were located anywhere from two to 50 km away. Sugarcane harvested by farmers was picked up by harvesting companies and taken to the processing center, where it was converted into refined sugar and sold wholesale to distributors.

The cooperative itself is jointly owned by farmer members. Each farmer has to sell part of his produce to the cooperative to remain a member in good standing, for which he is entitled to a number of services, including sugarcane collection and processing, irrigation facilities, and access to credit to purchase inputs from the cooperative. The members also receive 7 kgs of sugar at a subsidized rate of INR 2 (US$0.05) as opposed to the market price of INR 20 (US$0.50).

The Warana Wired Village Project traces its origin back to 1998, when the central government of India set up a national task force on information technology (IT) and software development. Among its many recommendations, the task force recommended the use of IT for agricultural and integrated rural development, with a "wired village project" called for specifically.[2] The Warana district was chosen for the pilot because it was believed to be among the most likely to succeed: it had good baseline economic status, as Kolhapur was the second-richest rural district in India, and the chairman of the cooperative had strong political connections. Thus, the WWVP was born. It was often touted as Asia's first ICT intervention on a large scale, with a total pilot budget on the order of INR 25 million (approximately $625,000). The project was funded jointly by the central government (50%), the government of Maharashtra state (40%), and the Warana cooperative (10%).

The original goals of the project, as mentioned in the project proposal, were quite ambitious [15]. They ranged from computerizing land-record transactions, allowing farmers to look up market prices in real time, providing farmers with expert agricultural advice, and providing Internet access to farmers.

2. http://it-taskforce.nic.in

B. Methodology

During the summer of 2005, the first author spent two months learning about the workings of the WWVP. During this time, the author lived in the Warana district, where he engaged in participant observation of farmers and kiosk operators performing their regular duties, and conducted structured and unstructured interviews of kiosk operators, farmers, and cooperative staff. During the two months, he visited 15 village kiosks and interviewed more than 200 farmers and 15 kiosk operators in unstructured interview sessions lasting between one to three hours per subject.

In all kiosks visited, hardware and software configurations were recorded, and kiosk usage was carefully observed and noted, with special attention paid to how actual usage compared with the initial goals of WWVP.

Members of the cooperative staff, including the IT manager, the cooperative chairman, and the managing director of the region's sugarcane operations were also interviewed at length in a number of structured sessions, as well as ad hoc interactions.

Separately, a more formal survey was conducted of 47 of the kiosks in the cooperative. The survey tallied daily use of the kiosks, as well as the whys of particular usage.

Finally, there was one opportunity to meet all of the kiosk operators in the 54 operational kiosks during an all-hands meeting held by the cooperative.

C. Physical Setup

The setup in each of the kiosks was almost identical. Kiosks were located in the generic concrete buildings one finds in rural India, of anywhere from 10–30m^2 in area. Most sites were paid for by the cooperative at no cost to the villagers. In some cases, the spaces doubled as administrative offices, and in others they also served as storage areas for farming equipment and supplies.

The hardware in the kiosks consisted of a PC (Pentium II), a printer, a modem, and in some villages, a UPS backup power supply. Most, but not all, of the computers were in working condition. Those that were not working were awaiting repairs. Since it had been about seven years since the initial purchase of the PCs, their maintenance costs were rising. In all of the kiosks we visited, the PCs that remained were covered with dust. PC covers were missing or loose from frequent replacements of components. Cables had apparently been chewed by rats in some cases and were frequently replaced or underwent casual repairs (i.e., twisting cables together).

Figure 1. One of the PCs in the kiosk system.

The PCs were running Microsoft Windows 95 and had two sets of additional software installed, including the original software written by the government. The left column of Table I summarizes the kinds of software and capabilities that WWVP initially planned to provide. The software originally developed was used during demonstrations for visitors, but was altogether unused by kiosk operators or farmers on any regular basis. The second set of software was written by an in-house IT manager[3] within the cooperative and allowed farmers to check their personal sugarcane-related interactions with the cooperative.

Connectivity was provided by landline telephone dial-up, at a rate of no more than 10kbps, and use of the Internet as such was restricted to the standard File Transfer Protocol (FTP) to communicate between the cooperative's server and the village kiosks. At times, the cooperative would hand carry floppy disks to transfer data between the kiosks and the server.

The kiosks were manned by computer operators who assisted the farmers seeking information from the kiosks. The operators, all employed by the coop-

3. The IT manager was the main person in the cooperative who very quickly realized the problems of the existing system and developed his own. Later, he would also become a supporter of the mobile system that we would build.

Table 1. Usage Stats of the Warana Wired Village Project.

Project goal	Past usage	Current status
Warana on NIC NET	Portal developed	Not used
Database of farmers on socio-economic status	Not started	Not available
Establish GIS of 70 villages	Not started	Not available
Local Language Interface	Demo only	Demo only
Land Record computerization	Not available	Not used
Intranet Site about Crops and Pests	Used for first several months in 1998	Not used
Agriculture Price Information	Initial demo	Not used
Personalized Sugarcane Information	Used heavily	Used heavily
Internet Connectivity	Almost none	Used for FTP only

erative, were male, with most being between 25 and 35 in age. Kiosk operators were required to attend a bi-monthly meeting held by the cooperative.

D. Kiosk Usage

Table 1 shows the past usage and current status of all the custom software planned for in WWVP. One key finding was that of the nine explicitly planned functions of the PC kiosks, only one function was in any use, seven years later when the project was studied—personalized sugarcane processing information that allowed farmers to obtain information from the cooperative records at their local kiosks. Specifically, the kiosks were used to transmit information either from the village to the processing center or vice versa. Information collected from the village includes the amount of fertilizer and water that was used by a farmer and validity of sugarcane harvesting permits. Information sent to the farmer included quantity of sugarcane output after a harvest and the payment schedule. Farmers were typically most interested in the payment information for their harvest.

Interviews with both farmers and cooperative leaders suggested that the original goals of WWVP were not met for a number of reasons. First, a no-needs assessment was conducted prior to the introduction of the system. Even modules that were demonstrated at one point to farmers did not receive significant interest. Second, although there was a lot of initial investment put into the project, not enough was invested in quality software development. As a result, the cooperative was left to its own devices, without a single one of the initial software packages being developed to a point where it could be used for more than demonstration purposes. Third, there was no significant effort to market the intended services in the villages. Farmers were generally unimpressed with the ability to access the Internet, because they did not have any idea of what the Internet was. One farmer remarked, "Need to know what is Internet. Need to know what all information are available. Only then we will know whether it is useful for us or not."

Finally, although all the kiosks were connected via dial-up connections, we found that the actual time it took to get sugarcane harvesting information from the center to the kiosk typically involved a wait of one or two days, as data was exchanged via FTP between the PC and the kiosk only once every day or two.

a) Benefit to farmers: The primary benefit of the kiosk to the farmer was the time saved by not having to visit the central processing center. Prior to WWVP, farmers had to go to the cooperative to retrieve information about their sugarcane harvests. According to estimates, they did this at least once a month, and based on opportunity-cost calculations of travel and time taken, they were able to save the INR 800 (US$20) per year—not an inconsequential sum for a farmer in these areas. Farmers also felt that there was better transparency in the system, as they were able to access this information freely at any time. Some mentioned a sense of increased security due to the automation on the back end, because it reduced the chance of manual tampering and user errors.

b) Benefit to the cooperative: Because the cooperative currently subsidizes the maintenance and operation of the kiosks, there ought to be some benefit to offset the cost. Interviews revealed that the cooperative capitalized on the computer kiosks as a competitive advantage over other cooperatives in the area. In fact, they started advertising the kiosks to differentiate themselves from their competitors, and felt that they also provided an incentive for members to stay on with the cooperative. In addition, the kiosks were able to reduce the workload at the central office, where earlier there had been long queues of farmers waiting for information. Nevertheless, cooperative officers, themselves, did not feel that they could justify the kiosks on purely economic terms; they felt their primary value was in providing a sign of modernity in the villages.

Figure 2. Low-cost mobile phones.

c) Quantitative usage findings: Based on the 47-kiosk survey, we were able to ascertain the following figures about usage: On average, kiosks entertained 38 visitors per kiosk per day when the processing center was in operation. When the center was closed, this number decreased to 22. A full 100% of the kiosk customers interacted with the cooperative management system, but none to use the PCs for activities such as browsing the Internet. When asked whether farmers would still use the kiosk if they were charged a small fee (e.g., INR 1, or US$0.02) per kiosk visit, only 5% said "yes," while the remaining 95% firmly indicated "no." (We caution that there is undoubtedly a bias toward a "no" response, as farmers may have believed that the survey results could influence a decision to begin charging for kiosk transactions.) Finally, 90% of the data transfer between kiosk and server was affected via dial-up and FTP, while 10% was via manually carried floppy disks.

d) Other qualitative observations: Our study was one of several parallel studies on the impact of ICT in agriculture, with the hope that policy recommendations would follow from the findings. Along these lines, we discovered such things as the importance of a project champion in driving ICT projects forward, the relative lack of desire for privacy in handling farmer information, as well as the great resistance among farmers to pay for individual transaction costs, no matter how small. The results of this analysis are available elsewhere [21].

During the two months that our ethnographic studies were taking place, the cooperative frequently discussed the future of the kiosk system. Maintenance costs were rising, and there were proposals to discontinue the system. But others believed that dismantling the system at this point would cause membership to decline, as farmers were used to the kiosks. There were also tinges of pride: "Our village needs this," was a mantra heard often, both from farmers and cooperative staff.

After our two-month fieldwork ended and we returned to the office, we asked ourselves whether we could preserve the functionality and convenience of the existing system, but replace it with a less expensive system the cooperative could afford to maintain. Approximately one year later, in October 2006, we returned to Warana with a potential solution.[4]

IV. Stage 2: Warana Unwired

The existing WWVP system had several problems: (1) It was expensive to maintain; (2) it was dependent on the village's intermittent power supply; (3) it was dependent on a poor connectivity solution; and (4) it was not, in any case, taking advantage of the full capacity of the PCs.

We believed these problems could be solved by a mobile phone-based system that allowed informa-

4. In that nearly year absence, we kept in touch with the project through phone calls and discussed the research project we were undertaking. In fact, we planned our next visit so that they were relatively free to work with us. We should point out that we didn't observe any obvious changes in their system from the last time we were there, except there seemed to be an increase in power cuts.

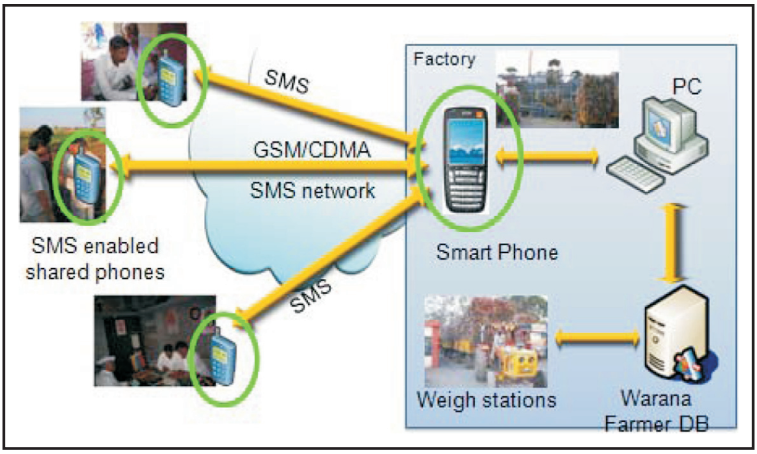

Figure 3. SMS server.

tion exchange through SMS text messaging. The distinct advantages of such a system are: Mobile phones are much less expensive to purchase and maintain than PCs; they have their own battery system; they provide a means of remote communication; and, for the kinds of information that were actually exchanged by farmers at these kiosks, SMS is more than sufficient, despite a 160-character limitation on message size. At the same time, there were a number of questions that needed to be answered before this solution could be confidently recommended to the cooperative:

- **Technology:** SMS does not natively interact with local PC systems. Could an inexpensive system be built that easily connects SMS with the cooperative's server?
- **Deployment:** Should the physical kiosk space remain, or was it sufficient to advertise the system to owners of mobile phones?
- **Cost:** Does the system ultimately cost less than the PC-based system, keeping in mind that while some elements are cheaper, SMS does incur a per-message charge?
- **Usability:** Could users of the WWVP system adapt to an SMS-based system, and how would they find it compared to the PC-based system?
- **Other:** Would there be any unanticipated social dynamics that would resist the use of a mobile phone-based system?

In the Stage 2 pilot, we hoped to answer these questions. In the remainder of this section, we discuss technology, deployment and cost, since these could be determined before a formal pilot. In Section V, we discuss the remaining two bullets as these results were known only through experimentation.

A. Technology

The technical solution was easy to implement. We made use of the SMS Toolkit, an existing SMS-gateway solution that is available via free download [22]. This tool provides a very simple PC-based programmable interface—it consisted of send, receive, and process APIs—to SMS messaging via a connection to an SMS sending/receiving port. Working in the office and on-site at the cooperative, we were able to develop a software solution on top of the toolkit that replicated the functionality of the WWVP PC-based system. The software written specifically for this application was only several 100 lines of C# code and was developed in a matter of days, with most of the time devoted to testing.

Our final technical solution consisted of the following: a single PC connected to the cooperative's server; one Windows Mobile Smartphone that provided our SMS sending/receiving port (this phone will be referred to as the "server phone" to avoid confusion with the mobile phones that communicate with it); the SMS Toolkit software; our customized software; and a number of "dumb" phones that were to replace the PCs in the village kiosks. The software components will be described in greater detail below. A standard GSM card built into the PC could achieve the same functionality.

a) Software in the server phone: The SMS Toolkit provides, on the Smartphone side, a software filter to intercept incoming messages, a filter to interact with the message queue, and an agent that maintains communication with the PC. The Windows Mobile operating system exposes a hook that allows for incoming SMS messages to be intercepted before they are stored in an inbox. Using this hook, the software agent running in the phone intercepts SMS messages that the phone receives and forwards them to the agent running in the PC. A queue of the messages is maintained to handle cases where the connection to the PC is broken or when messages are received in quick succession. The server phone components required no modification for our purposes.

b) Software on the PC: The SMS Toolkit also provides some software for the PC side in the form of an agent that contains a communicator, a parser, and an application sink. The communicator maintains communication between the PC and the server phone. The parser parses incoming SMS messages and raises various events. The application sink subscribes to particular events and interfaces with the data server, in this case, the cooperative's database. Our customized code is written into the application sink where it issues database queries and otherwise relays data to and from the database.

c) User interface and overall data flow: The software at the PC is custom built to handle the incoming messages, based on an agreed-upon syntax designed in collaboration with the cooperative IT staff and kiosk operators.

Farmers and kiosk operators send SMS messages via cheap mobile phones to the server phone (whose number must be known to users of the system). The entire server system described above receives the SMS and looks up the information the farmer has requested. The gateway then sends back a reply SMS containing the information requested.

The type of information that is queried is identical to that which was provided by the PC kiosks: the sugarcane output for a given farmer, their fertilizer usage, the status of harvesting permits, and the pay schedule for a given harvest.

For instance, a query SMS for checking sugarcane output has the simple syntax: TON<farmerid> <season>, or, for example, TON 123456 0807, indicating that farmer number 123456 is requesting sugarcane yield tonnage for August 2007.

Similarly, simple syntax is used to convey the other types of information. The response for these queries varied from 150–300 bytes, depending on the size of the farmer records which usually correlates to the size of the farm holding. It is technically possible to pack a number of the requests in one SMS to further reduce costs in situations where the SMS costs are high, although it may introduce additional usability challenges.

B. Deployment

a) Physical space: We discussed several alternatives of the system with the cooperative: (1) preserving the physical kiosk space, but replacing the PCs with mobile phones; (2) providing the kiosk operator with a mobile phone, but eliminating the physical space (the operator would roam and otherwise make himself available); and (3) removing all cooperative-owned kiosks and simply relying on farmers to use their own or their friends' mobile phones. Although the third option affords additional cost savings to the cooperative, we decided to start the deployment with the first option, as it was closest to the existing implementation. We also felt that the number of farmers owning mobile phones was too few for the majority of the farmers to be able to access the system. Finally, because the kiosks often doubled to provide other functions to the village, there was little advantage in not using the space.

b) Printouts: With the PC-based system, farmers take a printout of some of the information they retrieve on the PC. These printouts serve as a record of the transaction and are also occasionally needed by the banks for cross-checking the name of the farmer with his account. In our current mobile phone solution, there are no printouts, so we overcame this problem by providing the information in handwritten form, if requested of the kiosk operator. The handwritten forms are rubber stamped to certify them. Farmers were willing to accept this handwritten information in place of printouts.

c) Security and privacy: Because we did not implement a sophisticated, secure system, any farmer could conceivably query information about another farmer, if their ID was known. We did put in checks to restrict access, based on registered phone numbers that match with farmers' records. While a very small percentage of farmers (2–3% in our surveys) felt this to be a problem—information somehow getting into the hands of their local creditors—the vast majority of the farmers expressed no issues whatsoever. This is consistent with what we discovered in our preliminary studies about the relative lack or felt need for privacy about income information among peers.

C. Cost

There are no direct revenue sources for the cooperative from their information system. Thus, the only

Table 2. Annual Costs of Various Systems for Farmers (Rupees).

System	2007	2008	2009	2010	2011
Existing PC	178.4	179.3	180.3	181.5	182.7
New PC	330.3	309.3	299.1	293.3	289.8
Mobile (kiosk)	156.8	155.9	155.7	155.7	155.9
Mobile (no kiosk)	108.4	107.5	107.2	107.2	107.3
GPRS (kiosk)	128.3	124.6	122.9	121.9	121.5
GPRS (no kiosk)	80.1	76.3	74.5	73.5	72.9

question to be addressed is the relative cost of the system with respect to the existing PC-based system or other alternatives.

To compare the various alternatives, we calculated operational costs, following a method similar to that of a previous study of another ICT-and-agriculture initiative [1]. To simplify the analysis, we amortize the cost of hardware over eight years, assuming replacement will be necessary, and then add annual operational costs, so that we can compare "equilibrium" yearly costs for the cooperative per farmer. We considered a number of potential solutions and estimated the costs to understand how the various solutions would compare.

Specifically, we considered the following:

- Existing PC system: This is a hypothetical scenario which is, nevertheless, the basis on which the cooperative has been operating so far, namely, that it will never again need to buy hardware. The only ongoing costs are those of running and maintaining the computers.
- New PC system: This scenario assumes that new PC investments will be made every eight years, where the cost of the hardware is amortized over the same period.
- Mobile system (SMS) with kiosks: The PCs are replaced by mobile phones supplied by the cooperative, but everything else remains the same. In particular, the physical kiosk remains, and farmers can still visit the kiosk to access their information. Because SMS has a per-message charge, the cooperative absorbs the costs of messages sent in both directions.
- Mobile system (SMS) without kiosks: The PCs are eliminated with nothing to replace them. Farmers are expected to use their own or their neighbor's mobile phone to access the system. Thus, the cooperative pays only for outgoing SMS messages in response to farmer queries. In addition, kiosk operators are no longer needed. This further saves costs for the cooperative.
- GPRS system with kiosks: Where GPRS data service is available, it would be possible to use GPRS to communicate with the server. This avoids the need for the SMS-based data transfer. With high volumes of queries, it can also further reduce costs because GPRS services are based on monthly subscriptions and not on per-transaction costs as SMS messaging is.
- GPRS system without kiosks: Neither kiosk costs nor the cost of sending SMS messages back to farmers are required of the cooperative.

Table 2 shows the annual costs in rupees per farmer for the various systems described above, if WWVP were to conduct all of its operations under each of the systems. The source of the data came from the original project prospectus,[5] inspecting cooperative records for maintenance costs, and making some assumptions of the SMS costs, based on prevailing market rates. In particular, this assumes that 40,000 farmers in 54 villages are involved, accessing the system an average of 12 times per year. SMS costs are estimated at the current rate in Warana district at INR 0.5 (US$0.013) per message, and GPRS costs are assumed to be INR 0.1 (US$0.0025) per kilobyte.

Table 2 shows that the proposed mobile phone

5. *www.mah.nic.in/warana*

system costs less than the existing PC system. Over a year, the cooperative could save one million rupees (US$25,000) if they switched from the PC system to a mobile phone system.

Since GPRS is not yet available in Warana, and because few farmers have GPRS-enabled phones to begin with, our current SMS solution is the lowest possible cost among the feasible options considered.

One of the main reasons why the costs of the PC-based system are higher are the high maintenance costs, typically underestimated in studies of PCs in rural areas. This includes costs for a technician that can be broken down into replacement parts, travel, and time costs, as well as a premium for knowledge and services that are otherwise unavailable in the villages.

D. Sensitivity analysis

Our analysis was based on a straightforward model that summarized various costs as anticipated. However, these costs can change (and may differ in other geographic regions). So, to get a better feel for the model, we perform a sensitivity analysis below, based on differing input parameters. The four key inputs are: the average ratio of farmers to a cooperative-provided device (either PC or mobile phone); the average number of requests per farmer per year; the cost per SMS; and the maintenance costs of a PC per year. The cost of GPRS service is assumed fixed at INR 0.1 (US$0.0025) per kilobyte.

Starting with the current parameters for the Warana cooperative used above, and adjusting each parameter separately, we find the following:

First, because SMS costs are charged per message, the number of messages and the cost of a single SMS message has an immediate impact on the overall cost. For example:

- Even if only operational costs needed to be considered, the PC-based system becomes less expensive than the SMS-based system only if SMS costs exceed INR 1 (US$0.025) per message.
- If replacement costs for hardware are also included, the PC-based system becomes less expensive only if SMS costs exceed INR 3 (US$0.075) per message.
- Keeping the SMS cost fixed at INR 0.5 (US$0.013), but increasing the number of farmer accesses per year to 75 (albeit, unrealistic for the Warana use case), puts the SMS system at a disadvantage over an Evergreen PC system.
- If recurring hardware costs are considered, farmers would need to require 225 transactions per year (compared to 12 now) for the PC-based system to be preferable over the SMS-based system.

Overall, this suggests that the SMS-based system is stably less expensive than the existing PC-based system.

V. Pilot Experiment

A. Implementation

In October 2006, we began a pilot experiment in seven of the 54 village kiosks that were part of the cooperative.

We knew that farmers in villages closer to the cooperative generally tend to come to the central office for the information rather than go to the local kiosk. So, to account for these geographical variations in the kiosks, we picked kiosks at varying distances from the processing center: Two kiosks were in villages 4km away from the cooperative, and the remaining five villages were each about 20km away from the cooperative.

In these seven villages, the SMS-based system was set up in the existing kiosks. Because the system is not dependent on a particular location for the person querying, others were also able to access the system without going to the physical kiosk. The PC-based system remained intact, as back-up, in case our SMS system failed for any reason.

The kiosks were all identical in terms of what information was being relayed to farmers. During the pilot, there were no unexpected fluctuations in the demand from farmers for information with regard to the content and frequency of their queries; this was largely consistent throughout and only varied proportionately to the number of plots the farmer owned and the proximity of the village to the cooperative.

Kiosk operators engaged in the pilot were trained for one to two hours on the use of SMS (none were prior users of text-messaging), and they were taught the necessary syntax to enter the different possible queries. The query formats were also posted in the kiosk prominently for ease of use. Because farmers are mostly illiterate in these regions, the kiosk operators would type the messages for them as they had done in the PC-based system.

Table 3. Server-side Log File Summary of Eight-month Pilot.

Total SMS processed	8,169
Number of unique farmers	1,250
Nature of requests	75% sugarcane output;
	22% payment requests
	3% errors
Response time	< 5 seconds consistently
Query errors	269 SMS (3.2% error rate)
	Not supported: 90
	Not authorized: 51
	Error in syntax: 128

Table 4. Average Input Speed for Queries on SMS.

Information Type	Average Input Speed (sec)
Sugarcane output	83
Payment	96
Fertilizer input	390

B. Methodology

The evaluation methodology involved a combination of participant observation, surveys, and software logs, with the first two authors spending extended periods of time observing the deployment. Data were gathered by instrumenting the server software to log all the transactions in order to understand the usage of the system. We also asked kiosk operators to keep a list in a logbook of any problems they encountered in performing the tasks. Prior to the pilot, we conducted long interviews with the non-IT personnel of the cooperative and many short interviews with the kiosk operators, farmers, and IT personnel at Warana. Four different questionnaires were developed for the four groups: non-IT cooperative personnel, kiosk operators, farmers, and the cooperative's IT department.

Finally, several months into the pilot, we did some drop-in checks to observe general usability of the SMS-based system. We also timed the speed at which kiosk operators were able to key in requests for the various queries with 22 farmers across seven villages.

The technology was implemented in October 2006, and the pilot began in November 2006 in the seven villages. It has continued to this day; the data below summarize results from the first eight months.

C. Results

The SMS-based system has been in successful operation continuously for over eight months since the pilot's inception, and the overall results are positive.

a) Number of requests: The pilot showed an average of 6.5 SMS queries per farmer over the eight-month period, which would extrapolate to ~9.8 a year. That figure compares closely with average self-reports of 10 queries per year that farmers reported in the surveys for the PC-based system. This is expected, because farmers query for the information only when they need it. So, the change in systems did not increase or decrease consumption of available information.

The number of unique farmers who used the system was consistent with the total number who formerly used the PC-based system.

b) Nature of requests: Primary usage of the mobile phone system was for receiving information about sugarcane output and revenue. The other requests for information were for land-registration and for reporting fertilizer purchases, but this did not show up in the logs, which possibly implies that the kiosk operators used the PC-based system for those requests.

The total error rate of input queries according to the logs is 3.2%. In all cases, we find that the system replied to these errors with error messages, resulting in kiosk operators simply re-entering the intended query.

c) Usability: Overall, both kiosk operators and farmers were happy with the system. Operators quickly learned the syntax and use of the system, and in a few cases, taught farmers who had their own mobile phones. With a low query-error rate of 3.2%, the other question is the speed with which the kiosk operators were able to input queries. These results are shown in Table 4. Queries typically took 1.5 minutes to enter.

Given that fertilizer input took as long as six minutes on average, it is possible that the reason why kiosk operators preferred the PC-based system was due to easier input. This is a point that requires further investigation to verify.

The tiny key pads on mobile phones are not the easiest method of input for typing long strings of

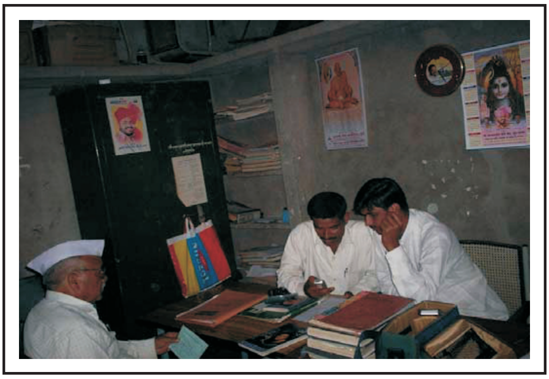

Figure 4. Farmer checking his information from a mobile phone in a kiosk.

Figure 5. Farmer checking his account information on his farm.

text, particularly for adults. In our interviews, kiosk operators initially expressed reservations about typing long strings into phones, so all of our syntax involved short strings that were easy to enter. Even so, the time it took to enter fertilizer purchase information remained high, and they preferred entry via the PC for these queries. This suggests that SMS has its limits as a UI for certain kinds of information transfer, and care must be taken not to generalize the positive results in Warana Unwired to other situations.

Finally, we have the farmers' informal comments on the system. Most were delighted to be able to see their results over the phone, possibly because they perceived mobile phones as a technology that they could understand, even if they didn't own one themselves. Some were skeptical that the system could be made to work over mobile phone at all, but skepticism was dispelled when they would test the system with queries to which they already knew the responses: "The information is exact and very good."

We found that news of the system spread quickly. Several months into the pilot, while we were gathering data to ensure that the system was working well, farmers in other villages clamored for the system to be implemented for them: "I saw messages are coming on the mobile phone. There is no problem. So where is the question of success?"

Some advantages of the mobile phone-based system that we observed are enumerated below:

- Battery power: It is widely acknowledged that poor electrical infrastructure is a problem in rural areas, and it is no different in the Warana area. High load in urban areas has possibly even worsened the situation for rural areas, which come under load-shedding programs, during which power is absent for more than six hours a day. The PC kiosks, despite having UPS backups, have not been able to handle power cuts this long. In addition, the UPS itself is prone to malfunction, and their maintenance costs are significant. Mobile phones, with their batteries and chargers, are much less likely to have problems due to power.
- Mobility: Kiosk operators double as agriculture extension aides and work with their districts' agricultural extension field staff, so they frequently make rounds of the village. Now, enabled with the mobile phone, they can (and do) provide farmers with their account information in the field. The database is now truly mobile, and in some cases, kiosk operators joked that they now have to work harder because farmers ask for information all day round.
- Fast access anytime: Farmers get paid by the weight of sugarcane, so they are always impatient post-harvest to learn how much they produced. In addition, a quick turnaround on the information is critical for settling disputes between the farmer and the weigh station, when everyone's memory is still fresh. This issue arises frequently during peak sugarcane har-

vesting seasons, when the outsourced transporters are busy making their trips and are more prone to delivery errors. Before the placement of PCs in Warana, the tonnage information was available to the farmer only after a period of two weeks, when they would finally hear from the local cooperative officer. With the PCs, this information lead-time was reduced to a couple of days, depending on the time when the information comes through via FTP. Now, with the SMS system, the responses are immediate (assuming that the data have been entered on the server side). In the logs, we have seen access of the database beyond 6 P.M., and on one occasion, as early as 3 A.M. This was not possible with the computer kiosk, usually available and running only during regular office hours.

- Democratization of access: Inexpensive mobile phones are increasing their penetration in rural India, and second-hand handsets can be acquired for as low as INR 500 (US$12.50) at local, petty shops. Although we intended that our study be restricted to access through the pilot-selected kiosk operators only, news quickly spread. Initially, only seven phones had been registered for the seven kiosks in the pilot. After eight months, however, an additional 61 phones have been registered, all owned by separate individuals. These, it turned out, are phone numbers of friends of kiosk operators, who, with help from the cooperative, had their numbers added to the database of allowed phone numbers. Of course, we have no reason to restrict this usage; now that the research phase has ended, our new goals are to allow as many farmers as possible to access the system easily.

Not all of the results favored use of the SMS-based system. Among some of the negative findings:

- As mentioned, there were issues with ease of use for anything that required entry of long strings into the mobile phone.
- The PC-based system operates with local caches on each PC, whereas the SMS-based system is entirely dependent on the availability of the server. Although server outages were relatively rare—once monthly, for a duration as long as until the IT staff notices the issue, which, on average, is no longer than a period of one hour, if during the day—they still did occur a few times, resulting in some farmers not being able to retrieve their data during the outage. As phones evolve with greater stores and capacity, it's not unreasonable to expect there could be caches on a mobile-based solution as well, particularly with GPRS. Alternatively, the server itself could be set up with redundancy so that complete outages are rare.

VI. Conclusion

The Warana Unwired project demonstrated a successful pilot in which an existing system of PC kiosks, set up by a sugarcane cooperative, was replaced by one using mobile phone-based kiosks to perform the same function. Although our results demonstrate the technical feasibility of the concept, as well as the upbeat comments of the farmers in response to the pilot, there are a number of questions that the work raises with respect to its value as ICT for development.

If we consider the actual impact of the mobile phone-based system on affected farmers' livelihood, it is a borderline contribution. On the one hand, the system could save several hundreds of rupees (no more than US$10) per farmer per year in cooperative fees. While this is not an insignificant amount for farmers in the area, it is also not a savings that would dramatically alter their lives.

Alternatively, the cooperative could keep the savings to invest in itself. One million rupees (US$25,000) is a significant sum, and it is money that could be put to use in a variety of other ways, possibly to maintain or improve the processing plant itself and to support other programs that may support farmers. Is this "development"? It could be, if the improvements to the cooperative further increased returns for cooperative members.

This latter point raises an issue about the nature of development, particularly with respect to ICT. On the one hand, the tangible short-term gains for individual farmers are not immediately visible with Warana Unwired. Farmers themselves express appreciation for the system, but that does not seem enough without measurable gains. On the other hand, there is a tangible benefit to the cooperative, which ultimately supports the farmers in their profession. In a way, Warana Unwired has reduced the cost of doing business for a successful sugarcane cooperative. This will undoubtedly increase its chances of growing and impacting more farmers over time and possibly in scenarios beyond just sugarcane cooperatives.

These musings about the development impact of Warana Unwired urge us forward to consider how we could further expand the system for greater impact. There are two approaches we are considering for future work.

The first is to replicate the back-end system for Warana Unwired for other cooperatives that may have similar needs. If the gains that result are primarily for cooperatives, then by replicating such gains among many cooperatives, we can have wider, if diffused, impact.

The second approach is to add additional services on top of the existing system. At this point, farmers in the pilot villages are very comfortable with the SMS-based system. Is there a way to incrementally add additional exchanges of information that would be of immediate value, possibly returning to the original goals of the Wired Village project? Could the technology itself go beyond SMS to voice-activated help lines, etc.? These are questions we hope to address in future work. ■

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