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

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*Abstract*— **In this paper, we present what we believe to be the first documented experiment to *replace* an existing PC-based system that had goals 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 text messaging.**

**Implemented in rural Maharashtra, *Warana Unwired* sought to replace an existing PC-based system for managing information in a sugarcane cooperative 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 paper 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.**

***Index Terms* — *agriculture, developing nations, rural areas, mobile phones, SMS server, ICTD, PC kiosk, sugarcane cooperative, supply chain.***

## I. Introduction

Perhaps the most succinct statement of what many have recently come to believe about information and communication technology (ICT) for socio-economic development appeared in an 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… Plenty of evidence suggests that the mobile phone is the technology with the greatest impact on development." [23]

In this paper, we present what we believe to be the first documented experiment to *replace* an existing PC-based system, that had goals 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 text messaging.

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

There is a lot of work using kiosk based projects, which allows the farmer to access agricultural information using the PC often through an intermediary. For example, ITC's e-Choupal project is often hailed as a successful PC-kiosk project, but its main innovation is modifying the supply chain whereby farmers can bring the crops and get 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. 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 pre-emptive digital photos of the farmer plots. The PC is used to burn CDs of the photos and used as a communication device to receive the advice as a file [4]. Results from surveys as well as software logging tools that track user behavior, show that at some kiosks the contribution to kiosk usage, of development services, government services, and services addressing agriculture or healthcare together, was 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.

A recent article in the New Scientist refers to the smart phones as the PCs for the developing countries [20]. The case for a phone as being more important than a PC has been increasingly being made [9][11]. Increasingly, smart phones based systems have been developed, be it a game based learning tool [6], smart phones enabled with camera has been used to collect information from self help group(micro finance) members [7]. Smart phones equipped with GPS would be invaluable for the rural supply chain [8]. While smart phones are here to stay and increase in market

Manuscript received August 31, 2007.

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penetration, prices still remain 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 that are available for free or downloadable for a small fee [13]. The idea of using SMS, when used to access advanced services provided over the network, can allow even basic handsets to handle information search has been proposed [11]. There have been some efforts in devising an SMS based server for developmental causes [14]. The most relevant work is the recent development at aAqua [3] which allows for questions to be sent via SMS message. There are couple of differences between what we are presenting in this paper and what has been done earlier: first, the data that is been accessed in our case is something very specific to the farmer and the specific setting and will never be on the Internet; second, the data that is sent is very structured and that has implications on the type of scenarios that 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 in working under the constraints of rural areas.

## II. Research Methodology

The work presented in this paper occurred in two stages. In the first stage, an ethnographic approach was used to understand the workings of the 8-year old Warana Wired Village Project (WWVP), in which a PC-based network of computers was used 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, incomes. The study viewed agriculture not just as a process of production but as a social practice that involved interactions between farmers, cooperative administrators, extension officers, and ICT operators.

This first phase was conducted in the context of a broader study that hoped to answer two questions: First, how was the quality of Indian agriculture improved through ICTs? And second, what was the relative value that ICT had among various other alternatives for improving agriculture?

Results from the first stage showed that use of the PC system was very specific and increasingly costly due to the high maintenance costs.

Thus, in the second stage, we proposed and implemented a new system which replaced the existing PC-based system that preserved the functionality of the earlier system, but did so at much lower cost. After a cost-benefit analysis and experimentation with various technology approaches, we settled on a mobile-phone SMS-text-messaging-based system. This 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 result of the eight-month pilot. We conclude with a discussion of related work and some discussion.

## III. Stage 1: Initial Investigations

### A. Background

Warana is a block (subdistrict) in the Indian state of Maharashtra, located 30km northwest of the city of Kolhapur, located 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 cooperative and build a sugar refinery. Set up in 1959, the sugarcane factory revolutionized life in Warana. Kore's success led to the formation of over 25 cooperatives in the area, and the cooperatives helped undertake several interrelated socio-economic activities, influencing the transformation of the Warana area. For example, the cooperatives promoted irrigation facilities, informed farmers with latest agricultural practices, constructed infrastructure such as roads and bio-gas electricity generators. They also undertook employment-generation activities to keep labor in the villages and to prevent migration to cities.

The sugarcane cooperative which is the focus of this study is the most prominent among these cooperatives. It comprises about 50,000 farmers who live in 75 villages spread in the 25,000km$^2$ area covered by the cooperative. These villages span the Kolhapur district and the Sangli districts in Maharashtra. The western part of Warana area receives between 100-250 inches. The eastern side receives rainfall ranging from 25 to 40 inches. The soil zones are laterite soil, brown soil, medium and deep black soils.

The cooperative's main function was to centralize the system of collecting, processing, and selling sugar at a single processing plant which was anywhere from 2-50 km away from villages in the cooperative. Sugarcane harvested by farmers was often 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 their 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, access to credit to purchase inputs from the cooperative. The members also get 7 kgs of sugar at a subsidized rate of Rs. 2 as opposed to the market price around Rs.20.

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 out specifically [17]. Warana district was chosen for the pilot because it was believed to be the most fertile district for success: It had good base-level development, as Kolhapur was the second richest district in India, and the chairman of the cooperative had strong political connections. Thus, Warana Wired Village Project was born, often touted as Asia's first ICT intervention at a large scale, with a total budget of the pilot on the order of 25 million rupees (approximately $500,000 at the time). 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 otherwise providing Internet access to farmers.

### B. *Methodology*

During the summer of 2005, one of us (the first author) spent two intensive months learning about the workings of the WWVP. During this time, the author lived in Warana district, where daily, he engaged in participant observation of farmers and kiosk operators performing their regular duties, and conducting extensive interviews of kiosk operators, farmers, and cooperative staff. During the two months, he visited 15 village kiosks and interviewed over 200 farmers and 15 kiosk operators there in unstructured interview sessions lasting between one to three hours with each 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 one IT manager, the cooperative chairman, and the managing director of the region's sugarcane operations were also interviewed at length in a number of *ad hoc* sessions during the course of the two months.

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 in an all-hands meeting held by the cooperative.

### C. *Physical set up*

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, for the most part granted for use 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), a printer, a modem, and a UPS backup power supply (although the presence of the latter was not consistent). Most of the computers were in working condition. Most, but not all! Those which were not working were expected to be repaired. Since it had been about seven years since the initial purchase of the PCs, maintenance cost of the PCs 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 also frequently replaced (or casually repaired).

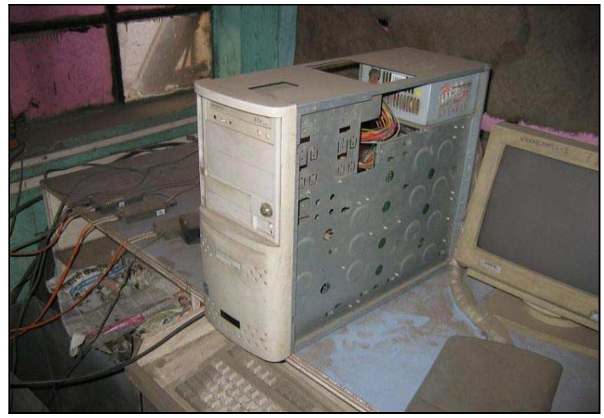

Fig. 1. One of the PCs in the kiosk system

The PCs were running Microsoft Windows 95 and had two sets of additional software installed. One set was the original software written by the government. The leftmost column of Table I contains a breakdown of the kinds of software and capabilities that WWVP initially planned to provide. The software that was actually developed was used during demonstrations for visitors, but it was entirely unused by kiosk operators or farmers on any regular basis. The second software was written by an in-house software team within the cooperative which 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 use of the standard File Transfer Protocol (FTP) to communicate between the cooperative's server to the village kiosks. At times, the cooperative would hand carry floppy disks to transfer data between the kiosks and the server.

The kiosks were operated by kiosk operators whose duties were to operate the PCs and to interact with farmers seeking information from the kiosks. The operators were all male, with most being between 25 and 35 in age. They were largely sons of farmers, and all were employed by the cooperative. Kiosk operators were required to attend a bi-monthly meeting held by the cooperative.

### D. *Kiosk usage*

Table I shows the usage and current status of all of the custom software that was either planned for or actually available in WWVP. One of our key findings was that of the nine explicitly planned functions of the PC kiosks, only one function was in any use whatsoever, seven years later when the project was studied – personalized sugarcane processing information, in which farmers were able to get 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 includes quantity of sugarcane output after a harvest and the payment schedule. Farmers were typically most interested in the payment information for their harvest.

TABLE I
USAGE STATS OF THE WARANA WIRED VILLAGE PROJECT

| Project goal | Historical value | 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 |

Interviews with both farmers and cooperative leaders suggested that the original goals of WWVP were not met, for a number of reasons. First, no needs assessment was conducted prior to the introduction of the system or even of the setting of project goals. Even modules which were demonstrated at one point to farmers did not receive significant interest. Second, although there was a lot of initial investment in the project, not enough of it 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 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 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 find this (and other) information many times a year. According to farmer 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 about 800 rupees (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, as 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 previous members to stay on with the cooperative. In addition, the cooperative was able to reduce the workload at the cooperative, where earlier there were long queues of farmers trying to get their information. Nevertheless, cooperative officers themselves did not feel that they could justify the kiosks in economic terms – they felt their primary value was in providing a sign of modernity in the villages.

*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 seven days a week. When the center was closed, this number decreased to 22. 100% of the kiosk customers came to interact with the cooperative management system, and not to use the PCs for other usage, such as possibly browsing on the Internet. When asked whether farmers would still use the kiosk if they were charged a small fee (e.g., 1 rupee, or US$0.02) per kiosk visit, only 5% said yes, with the remaining 95% firmly indicating "no." (We caution that there is undoubtedly a bias in these responses towards "no", as farmers may have imagined that the results of the survey could influence a decision to begin charging for kiosk transactions.) Finally, 90% of the data transfer between kiosk and server happened via dial-up and FTP; 10% happened by 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 what we found. 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. Others felt 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 that the cooperative could afford to maintain. Approximately one year later, we returned to Warana with a potential solution…

Fig. 2. Low-cost mobile phones

## IV. STAGE II: WARANA UNWIRED

The existing WWVP system had several problems: (1) It was expensive to replace or 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 felt that these problems could be solved by a mobile-phone-based system which allowed information exchange through SMS (short message service) text messaging. 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 the kiosks, SMS with its 160 characters per message is more than sufficient. 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 the Internet. 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
- **Cost:** Does the system ultimately cost less than the PC-based system, keeping in mind that while some things are cheaper, SMS incurs a per-message charge?
- **Usability:** Could users of the system use a SMS-based system, and would they find it at least as easy and convenient to use as the PC-based system?
- **Other:** Would there be any unanticipated social dynamics that would resist the use of a mobile-phone-based system? Etc.

Our experiments in Stage 2 were meant to answer these questions. In the remainder of this section, we discuss answers to the first three bullets above, since these could be determined before a formal pilot. In Section V, we discuss the remaining two bullets, as the 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 for free download [22]. This tool provides a very simple PC-based programmable interface (consisting of send, receive, and process APIs) to SMS messaging via a connection to an SMS sending/receiving port. Working in the office and onsite at the cooperative, we were able to develop a software solution on top of the toolkit that replicated the functionality of the PC-based system. The software written specifically for this application was only several hundred lines of C# code and was developed in a matter of days, with most of the time taken up by testing.

Our final technical solution used one PC (which was connected to the cooperative's server), one Windows Mobile Smartphone which provided our SMS sending/receiving port (this phone will henceforth 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 it to the agent running in the PC. A queue of 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.

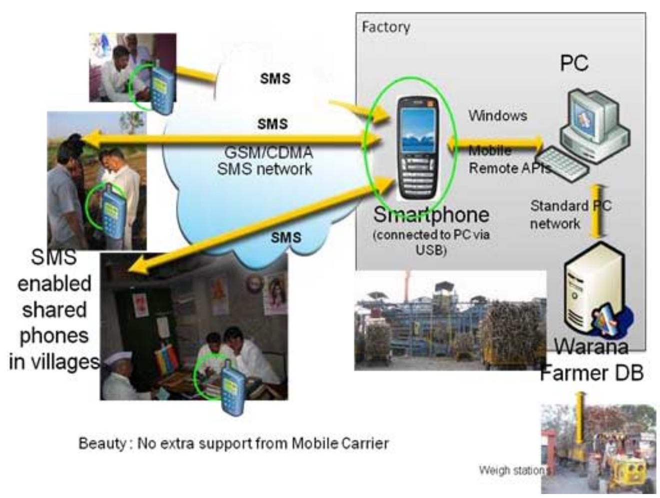


Fig. 3. SMS server

*b) Software on the PC:* The SMS Toolkit also provides some software for the PC side in the form of an agent which 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. And, the application sink subscribes to particular events and interfaces with the data server, in this case the cooperatives 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 that was 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 ahead of time). The entire server system described above receives the SMS and looks up the information that the farmer has requested. The gateway then sends back a reply SMS containing the information that was requested.

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

A query SMS, for example for checking sugarcane output has the simple syntax: TON<farmerid> <season>, or as an 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.

### B. Deployment

*a) Physical space*: The system could have been on the village side in a number of ways: (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 himself roam and otherwise make himself available); and (3) removing all cooperative-owned kiosks altogether 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 with their own mobile phones was too few in number 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) Print outs*: 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 for the transaction and also occasionally needed by the banks for cross checking the name of the farmer and 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 any 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. Although a very small percentage of farmers (2-3% in our surveys) felt this to be a problem due to the possibility of the information getting into the hands of their local creditors, the vast majority of the farmers expressed no issues whatsoever. This is consonant with what we discovered in our preliminary studies with respect to 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 question is the relative cost of the system with respect to the existing PC-based system or other alternatives.

To compare the various alternatives, we compared operational costs following a method similar to a previous study of another ICT-and-agriculture initiative[1]. To make the analysis simple, 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 on 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 SMS's 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 phones 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 II shows the annual costs per farmer, in rupees, for the various systems described above, if WWVP were to conduct all of its operations under each of the systems. In particular, this assumes that 40000 farmers are involved, in 54 villages, accessing the system an average of 12 times. SMS costs are estimated at the current rate in Warana district at 0.5 rupees (US$0.012) per message, and GPRS costs are assumed to be 0.1 rupees (US$0.002) per 1kilobyte.

The table shows that the proposed mobile phone 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.

TABLE II
ANNUAL FARMER COSTS OF VARIOUS SYSTEMS (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 |

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 systems are higher are due to the high maintenance costs of these PCs which are typically underestimated in studies of PCs in rural areas. This cost includes the technician's costs, which breakdown into cost of 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 summed various costs as anticipated. However, these costs can change (and may differ in other geographic regions), and so in order 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 0.1 rupees (US$0.002) per 1kilobyte.

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 and 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 would be less expensive than the SMS-based system only when SMS costs exceed 1 rupee (US$0.025) per message.
- If replacement costs for hardware are also included, then the PC-based system is less expensive only if SMS costs exceed 3 rupees (US$0.075) per message.
- Keeping the SMS cost fixed at 0.5 rupees (US$0.013), but increasing the number of farmer accesses per year to 75 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 against 12 now) for the PC-based system to be preferable over the SMS-based system.

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

## V. Pilot Experiment

### A. *Methodology*

In October 2006, we began a pilot experiment in seven out 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 cooperative for the information as opposed to going to the local kiosk. So, to account for these geographical variations in the kiosks, we picked two kiosks that 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 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 who were engaged in the pilot were trained for couple of hours on the use of SMS, 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. Farmers are mostly illiterate in these regions the kiosk operators would type the messages for the farmers, similar to how they were doing it for the PC based system.

We instrumented the server software to log all the transactions to understand the usage of the system. We also asked kiosk operators to keep a list of any problems that they faced in performing the tasks.

Prior to the pilot, long interviews were conducted with the non-IT personnel of the cooperative (long interviews), and many short interviews with the kiosks operators, farmers and the IT personnel at Warana. Four different questionnaires were developed for the four groups of non-IT cooperative personnel, kiosks operators, farmers, and the cooperative's IT department.

Finally, several months into the pilot, we did some drop-in checks on the pilot, to observe general usability of the 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. The pilot has continued to this day; the data below summarizes results from the first eight months.

## B. Results

The system has been in successful operation continuously for over eight months since the inception of the pilot, and the results overall are positive.

TABLE III
SERVER-SIDE LOG FILE SUMMARY OF EIGHT-MONTH PILOT

| | |
|---|---|
| Total SMS processed | 8169 |
| Number of unique farmers | 1250 |
| Nature of requests | 75% sugarcane output;<br>22% payment requests<br>3% errors |
| Response time | < 5 seconds consistently |
| Query errors | 269 SMS (3.2% error rate)<br>Not supported: 90<br>Not authorized: 51<br>Error in syntax: 128 |

*a) Number of requests:* The pilot showed an average of 6.5 SMS queries per farmer over the 8 month period, which would extrapolate to ~9.8 a year, which 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 system 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 used to use the PC-based system.

*b) Nature of requests:* It turns out that the main usage through the mobile phone system was for receiving the sugarcane output and for checking their payments. The other requests for information were for land-registration and for the reporting fertilizer purchases, but this did not occur at all 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%. We find in all cases, that the system replied to these errors with error messages, resulting in kiosk operator 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 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 IV. Most of the actual queries took close to a minute and a half to enter.

TABLE IV
AVERAGE INPUT SPEED FOR QUERIES ON SMS

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

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 text, particularly for adults. In our interviews, kiosk operators initially expressed reservation 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' own 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 themselves could understand, even if they didn't own a phone themselves. Some expressed suspicion 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."

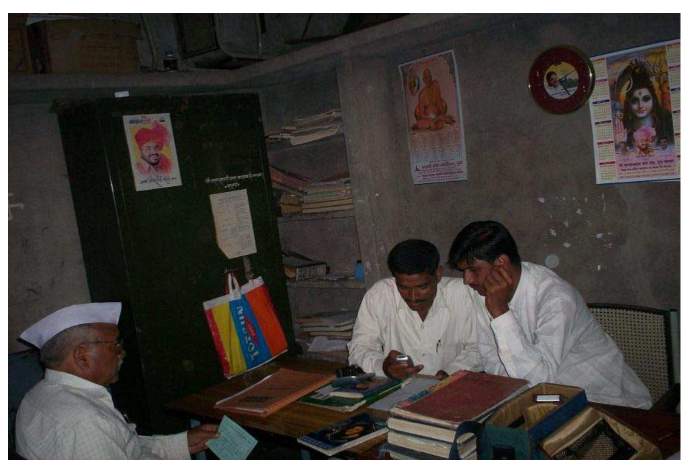

Fig. 4. Farmer checking his information from a mobile phone in a kiosk.

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 the regular load shedding, during which power is absent for over 6 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 very 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 aids and work with their districts' agricultural extension field staff. Because of this, they frequently make rounds of the village. Now, enabled with the mobile phone, he can (and does) provide farmers with their account information in their field. The database is now truly mobile and in some cases kiosk operators were joking that now they have to work harder as farmers are always asking about their information when they see the kiosk operator on the street.

Fig. 5. Farmer checking his account information in his farm.

- Fast access any time: Farmers get paid by the weight of the 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 harvesting seasons, where 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 got 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 has been entered on the server side). We have seen in the logs, access of the database beyond 6pm and in one occasion, as early as 3am in the morning. This was not possible with the computer kiosk, which usually was available and running only during regular office hours.

- Democratization of access: Inexpensive mobile phones are increasing its penetration in rural India, and second-hand handsets can be acquired for as low as Rs. 500 (US$12.50) at local petty shops. Although we intended for our study to be restricted to access through the selected kiosk-operators only, news quickly spread. Initially only seven phones had been registered, for the seven kiosks in which we piloted, but after eight months, 61 additional 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, and now that the research phase is over, our new goals are to allow as many farmers to access the system easily.

Not all of the results came out in favor 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 a month, for a duration as long as until the IT staff notices the issue; on average no more than a period of an hour, if during the day), they still did happen a few times, and resulted in some farmers being unable to retrieve their data during the outage. As phones evolve with greater stores and capacity, it's not unreasonable to expect that 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. Discussion and Future Work

The Warana Unwired project demonstrated a successful pilot whereby 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 the value of ICT and 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 an amount 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 possibly 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 ways that we are considering for future work.

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

The second 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.

## ACKNOWLEDGMENT

The authors specially thank the Warana Sugarcane cooperative team for inviting us to work so closely with them in the field and the many farmers that welcomed us into their homes.

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