KisanVikas – Android Based ICT Solution in Indian Agriculture to Assist Farmers

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Abstract. Agriculture accounts for ~15% of the Gross Domestic Product (GDP) of India but employs close to 50% of the working population. Average yield in India is quite low compared to other countries. Advances in Information and Communication Technology (ICT) and the government initiatives in e-governance are only promoting e-agriculture in India. This can not only improve the condition of Indian agriculture but also the life and working conditions of the farmers. This paper proposes KisanVikas (Farmer Development), a mobile application, using ICT and promoting e-governance by provide continuous information pertaining to agriculture- weather forecast, crop prices, news, government helplines, and an inventory database manager. The mobile application also connects to an Arduino based wireless sensor network (WSN) comprising soil moisture, pH and temperature sensors to control water pumps for watering small fields, irrigation over the Global System for Mobile communication (GSM) and Bluetooth networks.

Keywords: e-agriculture, ICT, (WSN) wireless sensor networks, mobile application, android

1 Introduction

Agriculture, "The backbone of Indian economy" as quoted by MK Gandhi is defined as an integrated system of techniques to control the growth and harvesting of animal and vegetables. It is an uncomplicated endeavor comprising of technical and practical processes that helps in the maintenance of the ecological balance and protects human resources; most importantly it is a viable food production system (Agro Products 2015). In 2012-13 agriculture contributed to 13.9% of the total GDP (Economic Survey & CSO 2014, p. 23), and employed 47% of the total workforce population (World Bank 2014). The combined efforts of Central Government, State Governments and the farming community have succeeded in achieving a record production of 264 MT of food grains during 2013-14 (Economic Survey & CSO 2014, p. 19). This record production has been achieved through effective transfer of latest crop production technologies to farmers under various crop development schemes being implemented by the Department of Agriculture & Cooperation backed by remunerative prices for various crops through enhanced minimum support prices.

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As Indian economy has diversified and grown, agriculture's contribution to GDP has steadily declined from 1951 to 2014, yet it is still the largest employment source and a significant piece of the overall socio-economic development of India. Crop yield per unit area of all crops have grown since 1950, due to the special emphasis placed on agriculture in the five-year plans and steady improvements in irrigation, technology, application of modern agricultural practices and provision of agricultural credit and subsidies since the Green Revolution in India. However, international comparisons reveal the average yield in India is generally 30% to 50% of the highest average yield in the world (Economy of India 2014).

There are 38 crore mobile telephones in rural areas, 9 crore farm households and Internet penetration is currently at 5% but improving (TRAI, GoI 2014). Rural India leads a record 35% surge in use of e-governance. Of the 3.5 billion electronic transactions reported in 2014, 50% of them were from rural areas, which were responsible for only 20% of e-transactions in 2013 (Patil, 2015). This increasing penetration of mobile networks in India therefore presents an opportunity to make useful information more widely available. This could help agricultural markets operate more efficiently, and overcome some of the hurdles faced by it.

Mobile or smart phones are becoming an essential device for all types of users irrespective of the age group. High resolution cameras, high definition video with huge amount of memory; internet browsing through your handset and 3G and Wireless LAN connectivity; hardware like GPS, accelerometers, gyroscopes, Bluetooth are common to find on smart phones these days. Android, the open-source mobile operating system developed by Google, is quickly becoming the smart phone operating system choice for all. As of June'14 there were 57,380,000+ Google Android and 4,854,000+ Apple iOS users in India [Webenza Survey 2014].

The Ministry of Agriculture, Govt. of India, started various schemes in the interests of the farmers for mobile phones. The mKisan Portal (Ministry of Agriculture, GoI 2014) inaugurated in July'13 by Honorable President of India has received as of 1,85,40,07,285 messages, 5,74,40,63,746 and 237,777 advises as of 8th April'15. The weekly/ daily stock availability with dealers of seeds and fertilizers was made available at Rs. 5/month/dealer. USSD (Unstructured Supplementary Service Data), IVRS (Interactive Voice Response System) and Pull SMS provide broadcast messages – to get web based services on mobile without internet, in their language and voice messages for the illiterate. Based on NSS (National Sample Survey Organization) 59th Round Survey (cited by Singhal, Verma & Shukla 2011) the information regarding seeds was the most inquired information followed by the *mandi* (market) prices by the farmers. Based on the survey, the most important requirements of the farmers were divided into 3 broad categories -know-how about seed varieties to use; contextual information for weather, local soil conditions; and market information about commodity prices.

According to Saravanan R. (2014), there are many mobile advisory services in India, both by private as well as public sectors. Most of these are however regional services offered by the state governments directly or by the center for a particular region. Because of this, there is not only discontinuity in services across the nation but also a language barrier for out-of-state people.

Some initiatives in the public sector are Kissan Helpline (Farmer helpline), Mandi on Mobile Service by BSNL, Kissan Kerala, vKVK (Virtual KrishiVigyan Kendra),

and Mobile based Agro-Advisory System in North-East India (m4agriNEI). Private sector services include Fasal (crop), Awaaz de (voice it), Videokheti (video farming), Mandi Bhav (market price).

Extensive research has taken place in this field of using information and communication technology for agricultural purposes. Prabhakar, Jamadagni, & Sudhangathan, (2013) write about a 'datamule' which captures data from sensors like soil moisture in the field and is communicated over WiFi network to a mobile phone. Wilton, Hans and Carlos (2014) propose a telemetry system to record soil moisture, temperature data and store into a database for future diagnosis. Ariff, and Ismail (2013) have proposed an android application to maintain a database of various information related to the livestock in the farm. Singhal, Verma, and Shukla (2011) have developed an android application which provides information in the form of crop prices, weather information, farmer loan schemes, etc. to the user.

2 Objectives

As discussed earlier, there is a need to exploit the advances in ICT to foster egovernance which is important as the farmers need to work in tandem with the government and take full advantage of the services provided by it. The proposed mobile application acts as a farmer's assistant in the field. It provides essential agriculture related information like government helplines, weather forecasts, news, mandi (market) prices of crops to the farmer. There is also an in-built database in which the farmer can keep a track of his inventories, harvests, seeds and fertilizer purchases, vehicles and equipment, etc. He can also document the crop cycle by taking snapshots of the map of the field (displayed within the app) at regular intervals. To reduce the amount of field work for the farmer the application also offers wireless switching on-off of pumps for watering, irrigating. Wireless sensor network of soil moisture sensor, soil pH sensor and soil temperature sensor is connected to an Arduino Mega 2560 microcontroller board. The android application controls the pumps over GSM network via SMS (which enables pump control over long distances) and Bluetooth (when in close proximity for real time diagnosis of the sensor readings). We shall next see each feature of the application in detail.

3 Software Features

1: Language support: The application is offered in 8 regional Indian languages namely Hindi, English, Marathi, Bengali, Urdu, Kannada, Tamil and Telugu. The user has to choose his preferred language as soon as the application is started. 2: Sign in and Registration: The app requires the user to sign up with his mobile number, a 4 digit numerical password. The user is verified by sending a SMS to this number (i.e. itself) and detecting it. Upon successful verification, the registration details are written through a PHP script and HTTP Client Server APIs into a MySQL database at a remote central server. The database table returns JSON data every time the user attempts a sign in which is parsed to allow further access or not. The registration system architecture as well as the recorded user database table are shown in Figure 1.



Fig. 1. Registration and Sign-in architecture

3: Weather Forecast: A HTTP Connection is made to the OpenWeatherMap Web service over WiFi/ GPRS which queries the data from servers. The data which the client gets regarding forecast is in the Extensible Markup Language (XML) and JavaScript Object Notation (JSON) formats. XML provides a language which can be used between different platforms and programming languages and still it can express complex messages and functions. JSON is used primarily to transmit humanreadable text consisting of attribute-value pairs between a server and web application. Figure 2 shows the architecture of retrieving information as well as the weather data, which is in the form of XML and is parsed before being displayed in the application screen. User can search based on current GPS location or directly by city name; the 16 days' forecast includes information about – weather type, image, min-max temperature, pressure, wind speed, humidity, clouds; graphical trend over the next week of various parameters are also available in the app for visual aid [Figure 3]. These data will enable the farmer to better plan his actions during the agricultural cycle like taking precautionary measures over a predicted hailstorm, and hence safeguard his interests.

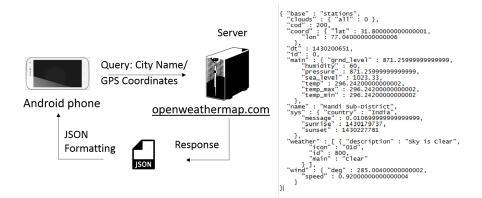


Fig. 2. Process of retrieving weather data from server; the response in JSON format



Fig. 3. Screenshots: various weather parameters; graph of min-max temperature

4: Commodity Market Prices: Agricultural commodities are traded in mandis (markets) at the district level. The government sets support prices to stabilize the prices but the Mandi prices are dynamic. The farmer, to access these prices enters the date, crop name and the Indian state. The application uses APIs provided by Open Government Data (OGD) – Platform India to make HTTP requests to the Agmarket Portal servers from where data in XML format is received, which, after formatting, is made available on the app in a human-readable form. The result table contains information about market (district name), arrival quantity (in MT), origin, variety, grade, minimum price, maximum price, and modal price (in Rs. / quintal) [Figure 4]. With a rough idea about the prices, the chances of a farmer being exploited and cheated are minimized.



Fig. 4. Process of retrieving crop prices from server; the app screenshot with results

5: Agricultural News: Keeping oneself updated about the happenings in and around the world is essential in taking precautions or planning for a better produce. An HTTP Connection is made to the database/ web server over WiFi/ GPRS which gets the data from AgriFeeds and indiaTogether websites. The data, in the form of RSS Feeds is parsed and then displayed in viewable form. News are obtained using RSS feeds on 82 topics globally, national (pertaining to India) or regional (state-wise news). Clicking on the headlines enables reading of the complete article [Figure 5].



Fig. 5. Screenshots: News headlines as a list; redirection to complete news article

6: Farm Manager (Inventory management): The application has an in-built farm manager module with which the user can better manage his field and crops. The farmer can keep a track of his assets, inventories and also his cropping cycle.
1: Vehicles and attachments – name, id, purchase date, cost, last, next servicing dates
2: harvested crops – name, quantity, harvest date, amount unsold and check date.
3: seeds and fertilizers - name, quantity, purchase date, cost, quantity remaining.
The app also generates alarms based on these dates to remind the farmer about upcoming servicing, maintenance dates. A SQLite database for android is used to manage (insert, edit, delete, view) the data. The SQLite database is exported to the more common Microsoft Excel format (.xlsx) using Android APIs [Figure 6].

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•			a	1	Seeds and Fertilizer Database						
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U	Enter ID:			3	NPK 13:33:0:6	50000g	m 800	30-Apr-14	40000gm	20-Apr-15	
	Min Enterity.			4	Brinjal	2000g	m 23000	01-May-14	250gm	20-Apr-15	
	Purchase Cost:		TT I	5	Cabbage	500gr	n 5750	06-Sep-14	0gm	20-Apr-15	
	Purchased On:			1	A		В	C D	E	F	
	+ + +			1	Harvest inver	ntory					
				2	Name	Qu	antity Han	vest Date Wor	h Amount unsold	on	
				3	Wheat	1	MT 01-	May-14 15000	0 0	20-Apr-15	
				4	Cabbage	1	MT 06	-Sep-14 1200	0 0.5MT	20-Apr-15	

Fig. 6. App UI to insert data; snapshots of the databases into excel format

7: Map of Field: Google Maps V2.0 API was used to display the area around the farmer's current position (supposedly near his field). The map features the terrain, normal, marker only views. The farmer can insert any markers to mark his field boundary. There is also a map screenshot option to take timely snapshots during the crop cycle [Figure 7] to monitor his crop for healthy growth.



Fig. 7. Map of the farmer's field; list of snapshots of the field taken during the agricultural season

8: Farmer Helplines: As stated earlier, the Indian government comes up with time to time schemes and farmer assisting centers fostering e-governance. The Indian government has come up with Kisan Vikas Kendras (KVK), and Kisan Call Centres (KCC) as advisories to respond to issues raised by farmers instantly as well as continuously in their local languages. There is a toll free helpline of the KCC set up by the government at the farmers' disposal. The application provides the state wise addresses and contact information of the various KVKs and KCCs in the country.



Fig. 8. Result of KCC contact information for Maharashtra, Goa, Daman, Diu region; Result of KVKs based in the state of Gujarat

4 Wireless Pump Operations

The mobile application is designed to establish a dual communication with an Arduino microcontroller controlled wireless sensor network and water pump. 2 types of wireless networks, namely GSM and Bluetooth [Figure 10], were used to establish this communication channel. 4 sensors measuring soil moisture, soil temperature, soil pH, and air humidity respectively are connected to the microcontroller and they send their data to the android application for diagnosis as well as appropriate decision making on operating the pumps. The system architecture is shown in Figure 9.

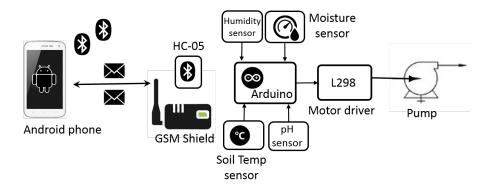


Fig. 9. Architecture of the mobile (android) - microcontroller (arduino) interface with the sensor-actuator networks.

- Over GSM: The merit of using this communication channel is that it can be operated over long distances too. An Arduino GSM shield with a SIM card was connected to the microcontroller and the wireless sensor network. The farmer queries for the status of the sensors before taking a decision. The SMS received from the microcontroller contains the current pump status and the sensor readings at that very instant. Taking stock of these readings farmer can remotely switch on-off the water pumps by setting the target soil moisture parameter. The pump will be switched ON till the farmer specified soil moisture value is reached.
- Over Bluetooth: When the farmer is at his field, he can directly connect the android application with the wireless pump system over Bluetooth. A HC-05 Bluetooth module was connected to the same microcontroller to establish a duplex communication channel between itself and the android smart phone. Data is encrypted, for example, into strings like <!"data"\n!> where "data" is the actual data for example start; '<' is the start bit, '!' is the start confirm bit, '\n' is the end of data bit. Similarly, '!' is the end bit and '>' is the end confirm bit. This encryption is necessary to avoid any noise (fuzzy data) collected by the sensors from the environment. For example: The string value for retrieving the sensor information is <!"57","69","24","8.2"\n!> which has the various sensor readings in the order of moisture, humidity, temperature and pH. Because this is a real time connection, there is continuous exchange of data at a high rate. The application records the sensor readings every 2 minutes and graphs all the sensor readings over time for diagnosis. The readings are also saved in a local sqlite database table only to be exported to the excel format later [Figure 11].



Fig. 10. Pump operations over GSM; Bluetooth



Fig. 11. Real time sensor data in a graph when connected over Bluetooth; sensor data tabulated every 2 minutes and exported into Microsoft Excel format

5 Conclusion

The mobile application was tested by some local residents of a village and they expressed an interest to really use the technology. The fact that it was also offered in multiple regional languages made it easier for them to learn its operation. An agricultural field setup was made on a table with soil all over. The small submersible pumps along with the moisture and pH sensors were put in a fixed place with a small container with mini pipes acting as the water tank. The mobile phone successfully switched the pumps on and off based on the moisture and other readings, thereby irrigating the field. The mobile application will truly serve as a great assistant to a farmer by providing continuous real time information as and when required. Productivity will increase and a farmer's time on field or going to nearby cities will considerably decrease. This ICT revolution promoting e-governance will lead to more enthusiasm among farmers fostering the need for more information for better decision making. In the long run, this will lead to overall development in India in the agricultural sector. The wireless sensor network system is to be made more robust and self-sufficient by installation of solar panels in the field and housing the electronic components in proper casings. More features providing information on availability of seeds and fertilizers, farmer loan and credit schemes will be incorporated into the application.

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