ISSN 2234-3075(Print)
ISSN 2288-7806(Online)
Http://dx.doi.org/10.14771/AIM.8.1.1

Information and Communication Management Systems (ICMS) in India -Connecting the Resource Poor Farmers to Knowledge and Institutions

Suresh K Mudda[1], Ravikumar N K[2], Chitti B Giddi[3]

Abstract Information and communication technologies (ICTs) have always mattered in agriculture too. In day-to-day practices of agriculture and allied sectors, the farmers often share their information. Changing weather patterns, soil conditions, pests and diseases always throw challenges to small and marginal farmers. So, the farmer needs up-dated information to cope with and even benefit from these changes. In the developing countries like India, where agriculture still plays a crucial role (over 58% of the rural households depend on agriculture as their livelihood) and the rising population from 1027 million to 1419 million during 2001-16 (a total rise of 38 percent or 1.3 percent per year) pose a lot of pressure on land and other resources to meet the food security needs on one hand and to meet the challenges of globalization on the other. Understanding and addressing these challenges are very crucial, in which ICT can play a major role. With the booming mobile, wireless, and Internet industries, ICT has found a foothold even in poor marginal and smallholder farms and in their activities. The survey conducted among the 120 farmers in Srikakulam district in India revealed that, ICT has revolutionized the agriculture in the modern days. Production and marketing information is accessed by 91% of the sample farmers through mobile in 2015, where it was only 5% in 2005. The extent of use of mobile phones by the farmers varied with the decision to be taken by them like Harvesting, packing, and storing (94%), Selling Decision (91%), Seed purchase (89%), Application of fertilizers and pesticides (88%) and Land preparation and planting (84%), other package of practices (77%). The farmers further opined that, 'Voice' was the dominating source of communication (96%) compared to Short Message Service (SMS) (only 27%) and Internet access (10%), as majority are illiterate. The use of camera (71%), Bluetooth (33%), Radio (61%) TV (41%) are the other means of sharing the information. In this context of importance of ICTs in Indian agriculture, greater attention justifies about the applications of ICT's to alleviate poverty and promote economic growth of the farming population.

Keywords ICTs, Mobiles, Networking, Resource poor farmers

Article history
Received 31 May 2016
Received in revised form 23 June 2016
Accepted 11 July 2016

1 Introduction

Information and communication technologies (ICTs) have always mattered in agriculture too. In day-to-day practices of agriculture and allied sectors, the farmers often share their information. Farmers in India find it difficult to obtain answers to the questions raised, even though they are repetitive for them in agriculture. Over 58 per cent of the rural households depend on agriculture as their principal means of livelihood. Agriculture, along with fisheries and forestry, is one of the largest contributors to the Gross Domestic Product (GDP). As per estimates by the Central Statistics Office (CSO), the share of

[1]Professor & Coordinator, District Agricultural Advisory and Transfer of Technology Centre, ANGRAU, Amadalavalasa, Srikakulam, A.P., India.
skmudda@rediffmail.com (✉)

[2]Assoc. Professor & Head, Dept. of Agril. Economics, Agricultural College, ANGRAU, Mahanandi, A.P., India. drknrk@gmail.com

[3]Scientist, Crop Protection, District Agricultural Advisory and Transfer of Technology Centre, ANGRAU, Amadalavalasa, Srikakulam, A.P., India. bgchitti@gmail.com

agriculture and allied sectors (including agriculture, livestock, forestry and fishery) was 15.35 per cent of the Gross Value Added (GVA) during 2015−16 at 2011−12 prices. The Department of Agriculture and Cooperation under the Ministry of Agriculture is responsible for the development of the agriculture sector in India. However, even today, agriculture in India is still considered as a complex enterprise dominated by resource poor small and marginal farmers with little or no access to modern technologies. So, ICMS is therefore, a very challenging task in Indian agriculture. Unless everyone connected with agriculture is brought to a common platform for sharing and refining information, finding solutions to local problems through crowd sourcing information is not easy. With the recent advances in Information and Communication Technologies (ICTs), connecting people on a common knowledge platform is not that difficult in technical terms.

2 The Setting

In the past few decades, while other economies have used technologies such as hybrid seeds and precision agriculture (using detailed soil, water and geographical data to guide planting) to raise crop yields, India has fallen further behind. According to estimates by the UN Food and Agriculture Organization, India's yield per hectare is half the average level for China, Vietnam, Indonesia, Malaysia, and Thailand. By raising the crop yields on par with the yields of other Asian countries could help bring 125 million poor and vulnerable Indians to a minimum acceptable standard of living. It is a known fact that, technology can help at every stage in the agricultural value chain, from soil and water management, to seed hybridization, to post-harvest logistics and improved market access. McKinsey, Global Institute estimated that, applications of a range of digital and agronomic technologies could have an economic impact of $45-80 billion per year in Indian agriculture in 2025 and would help up to 90 million farmers raise their incomes. In addition, some 200-250 million Indians could benefit from better nutrition from more plentiful harvests. Further, as many as one million Indians in rural communities could find decent productive work in the agricultural sector as computer-equipped farm-extension workers. It is in this context, the use ICMS deserve special attention.

Already, many of these technologies have proven their potential economic impact on the ground. Genetically modified (GM) crops a product of advanced genomics are raising yields by creating drought-resistant and pest-resistant varieties of crops, including soy beans, wheat, maize, cotton and canola. GIS technology and sensors are being used in precision agriculture, gathering and analyzing data about soil, weather, and ecological conditions for a specific piece of land, and then guiding planting, fertilizing, and watering of various crops to maximize yields and avoid wasted inputs. Originally developed for large tracts, precision farming techniques are now being applied to small plots in India. In this paper, the researchers focus on the ICMS that rely mostly on Digitally-enabled farm extension services that are particularly important in the context of modern agri-business. It is to be noted that, India has just 750 extension workers per million farmers, in comparison with 2,500-3,500 in China and Vietnam. With the mobile Internet, tablets and intelligent applications, a relatively unskilled worker can deliver superior extension services to far more farmers. So, it is high time to train moderately skilled farmers, who are well-regarded in their communities and chosen by their peers, to bring farm extension services to their neighbours using smart phone apps. These apps provide information on weather and commodity prices, crop management and pest and disease control. The workers disseminate the knowledge to farmers and train them to use the smart phone apps themselves.

ICMS is the buzz technology now-a-days. It is the technology that is helping to exchange the information in fast and easier way. Due to this technology the distance between the scientists and the resource poor farmers, who have to access the information is reduced and now world is becoming a global village. So, this technology provides an opportunity to the developing nations like India to build up their strategies and compete with the developed nations. It is a known fact that, in any sector, information is the key for its development. Agriculture is not exception to it. If the relevant and right information in right time is provided, it can help agriculture a lot. It helps to take timely action, prepare strategies for next season or year, speculate the market changes, and avoid unfavorable circumstances. So the development of agriculture may depend on how fast and relevant information is provided to the end users. The earlier methods of information and communication are traditional, as they are mostly untimed and also uni-directional. In the context of modern agri-business, its time to look at the new technologies and methodologies that ensure effective communication through information kiosks, which provide not only the basic services like email, helps in education, health services, Agriculture and Irrigation, online trading, community services etc., expert systems which helps in

determining marketing alternatives and optimal strategies for producers, integrated crop management systems for different crops, Farm-level Intelligent Decision Support system developed to assist in determining optimal machinery management practices for farm-level system. Many organizations and Institutes are utilizing the information technology to provide solutions to the problems faced by the agriculture sector in a cost effective manner with proper business models.

3 Materials and Methods

Srikakulam district has got good reputation in the cultivation of agricultural and horticultural crops in Andhra Pradesh, India. Farmers find it difficult to obtain answers to the questions raised, even though they are repetitive for them in agriculture. Changing weather patterns, soil conditions, pests and diseases always throw challenges to small and marginal farmers. So, the farmer needs up-dated information to cope with and even benefit from these changes. However, because of the highly localized nature of agriculture, the information must be tailored specifically to distinct conditions. A wide variety of modern technologies like genetically modified (GM) crops, Geographical and Information Systems (GIS) technology and sensors, precision farming techniques, ICT etc., help at every stage in the agricultural value chain. Among these ICT is extremely important, as it can bring expert knowledge and advice to farmers in their own languages to implement the technologies on their farms. Digitally-enabled farm extension services may be particularly important in India. So, with use of mobile Internet, tablets and intelligent applications, a relatively unskilled worker can deliver superior extension services to far more farmers. In this context, it is felt appropriate by the researchers to know the extent of use of ICT in Srikakulam district towards improving the agricultural and economic well-being of farming community. Srikakulam district in Andhra Pradesh, India was purposively selected for the study, as the researcher hails from this district. Top two mandals in terms of area under agricultural crops in Srikakulam district viz., Ranasthalam and Santhabommali were selected. From the list of villages arranged in descending order of acreage under agricultural crops, top two villages from each mandal (Sancham and Kosta from Ranasthalam mandal and Arkavalasa and Aspeta from Santhabommali mandal) were selected. For the selection of farmers, a list of farmers from the selected villages was obtained from the respective Gram Panchayat Offices. Then the farmers were categorized based on size of land holding i.e., Marginal (less than 1 ha), Small (1-2 ha), Semi medium (2.1 to 4.0 ha), Medium (4.1 to 10 ha) and Large (>10 ha). From these five different categories, a total of 120 farmers were selected at random based on probability proportion to size ie., 35 marginal farmers, 30 small farmers, 25 semi-medium farmers, 18 medium farmers and 12 large farmers. So, the sampling frame consists of one district, two mandals, four villages and 120 farmers, which forms the basis to elicit the requisite data. A well structured pre-tested questionnaire was employed to collect the requisite information from the sample farmers. The study was conducted in the year 2014-15.

4 Results and Discussion

4.1 Applications of ICT in agriculture

The application of ICT in agriculture in India in general and in Srikakulam district is not a new concept. The role of ICT is to contribute to ‘smart; agriculture, and incentivize farmers through making them aware about the modern technology and its application to boost agricultural production. With the booming mobile, wireless, and Internet industries, ICT has found a foothold even in poor marginal and smallholder farms and in their activities. The selected sample farmers in Srikakulam district had access to a variety traditional information sources (TV, radio, newspapers, other farmers, government agricultural extension services, traders, input dealers, seed companies and relatives), which they regularly access for agricultural information. These traditional ICT’s have been an important tool since past several decades to disseminate scientific and technical agricultural knowledge to farmers and also leading to improved adoption of technologies (Table 1). They played an important role during the green revolution in 1970’s and 1980’s (Sulaiman *et al.,* 2011). In late 1950’s and early 1960’s radio broadcasts were initiated (Purushothaman *et al.,* 2003; Kameswari *et al.,* 2011). Krishi Darshan was the first television based programme for farmers which started in 1960’s on the national channel of India. Various new television and radio based agriculture programs were launched in 1990’s and farmers’ were also using television and radio, and these media had strong positive influence in adopting modern technologies on the farms. (Glendenning *et al.,* 2012).

Table 1 Selected modern ICT models in India and their evolution over years

Tele-centre based	**Internet based**	**Video based**
• Kisan Call Centers, GOI, 2004 • BSNL Help line	• Village Knowledge Centres, 1998 • ITC e– chaupal, 1999 • e– sagu, 2004	• Digital Green, 2009
Mobile- SMS based	**Mobile based application**	**Mobile- voice message based**
• Reuters Market Light (RML), 2007 • Warna Unwired – Microsoft, 2007 • KVK's – NAIP, 2009 • Kisan Sanchar, 2010	• Fisher Friend– MSSRF, 2008 • Nokia – Life tools, 2009 • Tata– M Krishi, 2009	• IFFCO Kisan Sanchar Limited (IKSL), 2007

Source: Compiled by authors

The radical changes in the extension system in the country in general and in Srikakulam district in particular, have greatly improved the efficiency, effectiveness and timeliness of extension services. These reforms included the development of public private partnership to provide extension services and strengthening the linkages between researchers in laboratories and farmers in the field. Modern ICT-based extension services provide an opportunity to strengthen these linkages. The introduction of mobile phones and web portals generated a great scope to deliver information and technology to farmers at wider scale.

There are many applications and ICT-enabled tools for data collection purposes in India.

Table 2 Important ICT applications in Indian Agriculture

Applications	Description
Digital Green	An organization that works to increase agricultural productivity by training small and marginal farmers via short instructional videos. The Digital Green system combines technology and social organization to improve the cost-effectiveness and broaden the community participation of existing agricultural extension systems. *http://www.digitalgreen.org*
e-Arik	ICTs for Agriculture Extension. A research project to experiment the application of ICTs in agricultural extension services provision and also to measure its impact on the tribal farmers has been implemented in "Yagrung" village of East Siang District of Arunachal Pradesh State. *http://www.earik.in*
e-Choupal	The e-Choupal model has been specifically designed to tackle the challenges posed by the unique features of Indian agriculture, characterised by fragmented farms, weak infrastructure and the involvement of numerous intermediaries, among others. 'e-Choupal' makes use of the physical transmission capabilities of current intermediaries − aggregation, logistics, counter-party risk and bridge financing − while disintermediating them from the chain of information flow and market signals. *http://www.echoupal.com*
Honey Bee Network	The Honey Bee Network for dissemination and documentation of local and farmer innovation processes. *http://www.worldchanging.com/archives/006333.html*
ICAAP	Documentation of best practices at farmer level (e-portal). The portal aims to provide comprehensive and interactive agricultural information to stakeholders for better decision making on various agricultural enterprises across the world. *www.advanceagriculturalpractice.in*
IKSLI	The IKSL initiative has been documented by mFarmer in a case study as an example of a successful partnership. IKSL is a joint collaboration between the Indian Farmers Fertilizer Cooperative Ltd (IFFCO) -the largest farmer cooperative in India- and Airtel, a mobile network operator. *http://www.iksl.in*
Intelligent Advisory System for Farmers (IASF)	An advisory system, a hybrid system by integrating Expert System (ES) and Case-base Reasoning (CBR) for answering queries related to farming activities carried out in Northeast states of India. *http://iasf.cdacmumbai.in/ias/jsp/about.jsp*
LifeLines India	LifeLines India-Agriculture brings agri-advisory right to the field of a farmer. LifeLines India-Education provides pedagogic support in rural and remote areas. *http://lifelines-india.net*
mKisan	m-Kisan: Using mobile technologies to strengthen farmer-extension-expertlinkages in India. Launched in June, 2012, the m-Kisan project will run in six Indian states for the next two years, using additional information provided by CABI and Digital Green. mKisan is part of the *mAgri initiative* and it looks at issues of dissemination of information without intermediaries to focus on scale and content quality management. The medium is voice with restricted use of SMS linked to Voice messages. *http://ilriclippings.wordpress.com/2012/06/26/m-kisan-launch*

Number of mobile connections in Srikakulam district

In April 2016, the number of mobile phone subscriptions surpassed the 13.56 lakh mark (Table 3 & Figure 1), further establishing mobile phones as the most popular form of connectivity between the scientists and farming community. In their various designs and capabilities,

mobile phones can be found in the pockets of the wealthy and poor alike. Even in rural areas of the district, mobiles are growing in number and sophistication. The informal discussions with the sample farmers revealed that, nearly 17 per cent of them regularly use the internet to elicit useful information about package of practices of crops, market prices in major wholesale markets of the country, weather forecast etc.

Table 3 Number of mobile phone connections in Srikakulam district

Year	No. of Mobile connections (Lakhs)	No. of Mobile connections per 100 inhabitants
2005-06	96000	6.857143
2006-07	163000	10.75908
2007-08	221000	13.90674
2008-09	274000	16.22247
2009-10	429000	23.97233
2010-11	562000	30.22118
2011-12	786000	39.98344
2012-13	915000	42.38144
2013-14	1016000	42.8947
2014-15	1187000	45.87589
2015-16	1356000	50.22276

Source: Department of Telecommunications, Srikakulam district

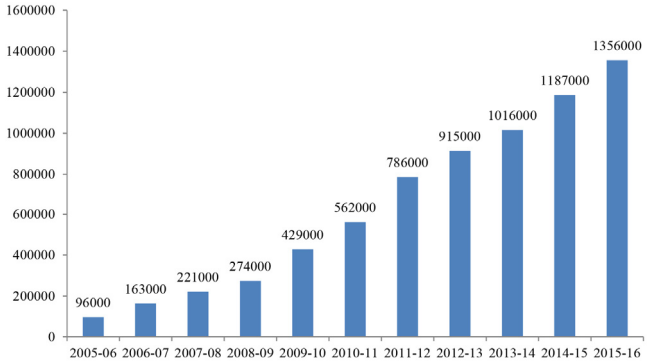

Figure 1 Number of Mobile Connections to Farmers in Srikakulam district

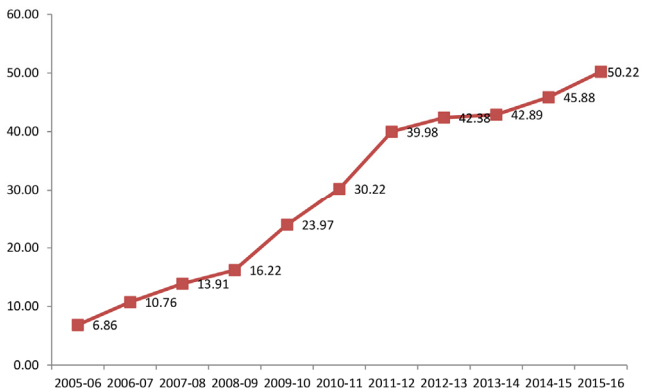

Figure 2 Number of Mobile Connections to Farmers for every 100 inhabitants in Srikakulam Dist.

The interesting aspect here is that, nearly 93 percent of the sample farmers are claimed to have access to a mobile phone, although only one-quarter of farmers said they actually owned one. This highlights the impact of mobile phones on agriculture and rural development by outlining current knowledge and describing innovative practices. The rise of the mobile phone usage (Table 3) has been one of the most stunning changes in the Srikakulam district over the past decade. The increasing ubiquity of mobiles in this district presents both opportunities and challenges, especially for critical areas like risk management, on-line trading etc. Like other technologies before it, the mobile phone is likely to be the subject of inflated expectations and hopes. To caution against the hype, this module also explores barriers to using mobile phones to benefit agriculture and provides recommendations for practitioners seeking to use the mobile platform to improve farmers' livelihoods.

The study further revealed that, though sample farmers are also using personal computers, laptops, the Internet, television, radio, and traditional newspapers for their improvement, the focus is mainly on mobile phones (Table 4). This is because of the sheer scale of adoption. In the ten years before 2005-06, mobile phone penetration rose from 12 percent of the population to nearly 67 percent in the district. The newest smart phones are far more sophisticated than the more affordable models populating poor regions, but those simple phones are still leaps and bounds ahead of devices that were cutting edge a decade ago and they are entirely relevant to agriculture.

Table 4 Percentage of usage of Media to access agri-information

Item	% of usage
Personal Computers	5
Laptops	7
Radio	91
News papers	74
Mobile phones	93

Lowering the Costs of Information

The most obvious and cross-cutting way that mobile phones can improve agriculture is by improving access to information and making it less costly to obtain. In selected villages of Srikakulam district, the arrival of mobile coverage is a radical change in the nature of the information ecosystem. Although simply having more information is not sufficient to make advantageous decisions (other resources may be needed to implement them), it is a necessary step toward access to knowledge.

Transaction costs are present throughout agricultural value chains, from initial decisions about, what to produce to all of the operations during the production period, harvesting, post-harvest and processing operations, and selling (to intermediaries, consumers, processors, exporters). These costs can account for a large share of the cost of a farm enterprise. The informal discussions held with the sample farmers revealed that, nearly 15 percent of the total cost of farming was transactional, and of that, 70 percent was informational (as opposed to, say, the cost of transporting crops to market). The study further revealed that, about 51 percent of the informational transaction costs were incurred during the production period of crops (Figure 3), especially when farmers were attempting to ascertain fertilizer costs. Another 21 percent were incurred during the initial decision to plant or not, while only 11 percent of the costs related to information were incurred during the selling stage *i.e.,* when and where to sell the produce.

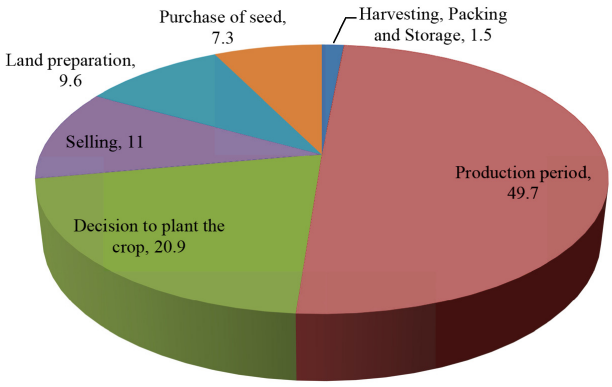

Figure 3 Proportion (%) of Informational transaction costs across decisions taken by the sample farmers

It is easy to understand, how mobile phones could reduce farmers' informational transaction costs at critical points in the production cycle. Mobile phones help the farmers to substitute phone calls for travel. Where safety standards are minimal, roads are in disrepair, and distances are great, substituting phone calls for travel reduces farmers' time and cost burdens. Time savings are important for agricultural households, because many crops have extremely time-sensitive and labor-intensive production cycles. Farmers who use mobiles can also save on transport costs (Overa, 2006) an effect that is stronger the more rural the area (Muto and Yamano, 2009). Of course, especially in marketing the produce, transportation cannot be avoided entirely, as the produce need to get to customers. Although mobiles can inform farmers, where they should travel to market their crops, the farmers who use this information at the earliest is most benefitted. In Srikakulam district, the farmers increasingly use mobile phones to coordinate supply among themselves and to improve profits by facilitating reductions in their transportation and opportunity costs (Overa, 2006). These costs are particularly high in commodity chains that are geographically extensive and organizationally complex, such as the paddy trade.

Besides farmers, even for extension workers, the numerous capabilities of mobile phones provide ample opportunities to deliver traditional and innovative services. Traditional agricultural extension agents are increasingly being outfitted with mobile phones through programs to increase their effectiveness by networking them to knowledge banks. Extension can reach more clients through mobile-based learning platforms textual or richer platforms, such as video that provide tips to farmers to improve agricultural skills and knowledge.

Thus, the informal discussions with the sample farmers highlight that, the use of mobile phones help to increase income, improve the efficiency of markets, reduce waste, and improve welfare. They can reduce agriculture's significant transaction costs, displace costly and time-intensive travel, and facilitate innovative interventions, especially in service delivery.

Market access and Price information

The study on the sample farmers revealed that, the potential benefits of information flow have been obtained mainly by large farmers in Srikakulam district. This is so, because the small farmers, despite access to information, have not succeeded in overcoming constraints resulting from poor access to capital, poor infrastructure and lack of access to markets. The Table 5 reveals that, almost 91.26 per cent of the large farmers who were using mobile phones could get a better price for their commodities while only 64 per cent of marginal farmers and 72 per cent of small farmers could benefit from the price information. It is interesting to note that, although the share of farmers perceiving price gains differed for different farm sizes, the number of farmers perceiving better market connectivity is very similar and high for almost all farm sizes (Table 5). This finding re-emphasizes the fact that although with availability of information on prices and markets made available to the farmers, even the small farmers are able to access markets and are better connected to markets, but when it comes to count it in terms of actual prize realization it is only the relatively large size farmers who gain the most. This is mainly because of various constraints faced by the

farmers like poor bargaining ability, credit 'bondedness' to middle men (Mittal *et al.,* 2010) etc.

Table 5 Benefits of mobile phones based on land size in Srikakulam district

Land size	Per cent of farmers using mobile phone	Getting connected to market	Getting better price
Marginal (less than 1 ha)	27.13	74.29	64.17
Small (1-2 ha)	38.65	91.26	71.64
Semi medium (2.1 to 4.0 ha)	54.81	92.17	73.21
Medium (4.1 to 10 ha)	61.29	93.09	80.03
Large (>10 ha)	67.29	95.67	91.26
Total	42.63	89.57	72.19

Note: This percent of farmers is from the total farmers who are using mobile phone to access agricultural information. Farmers have multiple responses.

The study of farmers showed that, with access to information through mobile phone they are now better connected to the markets and mobile phones have helped them to get better prices too. Nearly 90 per cent of the farmers feel they are better connected to the markets after the introduction of mobile phones, while 72 per cent of the farmers have now better access to the price information. From the focus group discussions with farmers revealed that, the sample farmers reportedly benefited in terms of better price realization and increased revenues through better adjustment of supply to market demand. These farmers used information on market demand predictions to adjust the quantity of supply they harvested and took to market during a given period. Market information influenced farmers to alter where and when they sold their crop in order to maximize revenues and, in some cases, provided ammunition to farmers to negotiate better pricing terms from local traders.

Use of mobile phone for accessing production information

The use of mobile phones to access production information was rapidly increased during the past one decade in Srikakulam district. It was found that, production information is accessed by 91 per cent of the sample farmers through mobile in 2015, where it was only 5% in 2005. The extent of use of mobile phones by the farmers varied with the decision to be taken by them like Harvesting, packing, and storing (94%), Selling Decision (91%), Seed purchase (89%), Application of fertilizers and pesticides (88%) and Land preparation and planting (84%), other package of practices (77%). The farmers further opined that, 'Voice' was the dominating source of communication (96%) compared to Short Message Service (SMS) (only 27%) and Internet access (10%), as majority are illiterate. The use of camera (71%), Bluetooth (33%), Radio (61%) TV (41%) are the other means of sharing the information.

ICT and Economic Growth

ICT is considered as an engine of economic growth. It affects it in two ways, directly via the ICT producing sectors and indirectly through the sectors called users. All economic sectors are or become users of ICT to the extent that indirect productivity gains related to digitization and the way it is used are often seen as the main vector of growth in the developed economies. (Faucheux *et al.,* 2010). There are possible impacts of ICT on economic growth of the country. Firstly, investment in ICT increases the capital stock available to the workers and thus contributes to the improvement of the labor productivity. Secondly, the rapid technological progress in the production of ICT goods and services can contribute to the progress of the capital and labor efficiency, or the multifactor productivity (MFP) in the producing sector of the ICT. Thirdly, a wider use of ICT in the economy can help companies be generally more efficient and therefore increase the multifactor productivity (MFP). The ICT is also likely to enhance the network effects, external effects, such as the reduction of the transaction costs and the acceleration of innovation, which can also improve the MFP. The diffusion of ICT is the main factor of competitiveness gains of the developing economies like India.

Major constraints to ICT uptake for Agriculture in Srikakulam district

It is to be noted that, ICT are for communities not just individuals. This dictates a more holistic view of the ICT adoption processes. Further, the ICT tools themselves can do nothing. There must be effective participation of the communities as a prerequisite to identify optimal solutions, empower leaders to effectuate them and ensure relevant local content. In view of this, it is felt appropriate by the researchers to identify the major constraints to ICT uptake for Agriculture in Srikakulam district and the findings are shown through Table 6.

Table 6 Major constraints to ICT uptake for Agriculture in Srikakulam district

Item	Marginal farmers	Small farmers	Semi-Medium farmers	Medium farmers	Large farmers
Lack of awareness about technology	40.13	43.23	32.39	31.64	22.86
Cost of technology	78.13	77.53	67.83	51.73	37.64
Do not understand about the benefits of ICT	54.32	49.76	41.76	32.74	33.17
Personal impediments (Illiteracy about computer skills)	65.13	61.28	58.83	47.53	36.76

This is an indicative quantification of what farmers think regarding the main constraints to ICT adoption (Table 6). The replies across the different categories of farmers infer that, the Government should take much more pro-active steps to implement the use of ICT at grass root level. The personal interactions with the sample farmers and also with the Officials of line departments like Department of Agriculture, Department of Horticulture, Department of Sericulture etc., brought to light the following issues and constraints:

- Research has not devoted sufficient time and resources to identify solutions for effective adoption of technological innovation including ICT.
- To a large extent, there was note of a general feeling of complacency among all stakeholders in regard to ICT adoption in rural areas. Even today, the farmers still complain that, "we are still learning"
- There seems to be a lack of cost/benefit evaluation in ICT adoption research. This is especially important considering that, there is need to identify measurable benefits, the benefits (and costs) are not always the benefits you expect, there are derived community and stakeholder benefits, financial spill-over and as always the risk of failure.
- In general, there is a lack of recognition that adoption complexity increases with the increased sophistication of ICT development and content.
- The lack of physical and human resource infrastructure was a major impediment. Even wireless facilities need infrastructure as well.
- Too much innovation can be an obstacle by blocking the use of older technologies which can often be more effective and/or by imposing an unacceptable cost.
- A few of the barriers were identified explicitly: lack of leadership and/or agents of change, the need to support effective and successful traditions concurrent with adoption of innovations, lack of end user and community involvement, lack of political will, conflicting interests, fragmented coordination among donors and failure to adopt participatory measures, uncoordinated strategy and policies, lack of funding, resources and start-up support and more.
- ICT adoption based on working within communities takes longer in many cases because of the lack of understanding and awareness of the needs and challenges of small-scale farmers, the lack of understanding what ICT can do including unexpected deviations from initial farmer and community expectations.
- The impact of ICT in agriculture is not evenly distributed across different categories of farmers.
- One way flow of ICT is not enough nor does it attract willing participants.
- Knowledge workers are not fully trained agro specialists therefore the system lacks credibility among farming community.
- Lack of updated content leads to lack of utilization.
- Farmers expect more information especially from other areas then from their own areas.

Suggestions to promote the adoption of ICT in agriculture

The following suggestions must be looked into for effective adoption of ICT in Indian agriculture in general and in Srikakulam district in particular:

- Strong leadership from the community is essential for the success of any ICT project in agriculture. Understanding and taking on board the key requirements for users in terms of end user skills, motivation and their realities in terms of access must be factored into the ICT adoption process;
- The strong leadership encourages farmers' awareness about the technology and reduces technology cost with subsidy, which eventually leads to higher number of users who will share more helpful and related information.
- ICT will not necessarily change the lifestyles of the rural communities. Rather they will introduce new methods of doing the same traditional activities and/or enable new activities;
- Allocation of sufficient resources to develop practical and more efficient training programs is essential. ICT adoption by diffusion and spontaneity is pervasive and

powerful but insufficient and in many cases counter-productive, A point to consider is that sharing of lessons is not enough, there needs to be willingness to learn from each other;
- Use of simpler technologies may get better results, can take projects forward and trigger learning that leads to adopting more advanced ICT (Gelb *et al.,* 2008).
- ICT Infrastructure for rural areas must be part and parcel of all national infrastructure planning and programs;
- Utilization of ICT for strengthening the linkages between agricultural policy, research and extension institutions, communities and individuals is a political issue as well as an organizational option. Different types of stakeholders in this context include private and public agricultural service suppliers, small-farmer and other non-governmental organizations, the media and a wide range of other entities involved with agricultural production and all aspects of the rural sector;
- Partnership with the private sector has been shown to be an essential mechanism for the public sector to develop enhanced ICT in a sustainable way. The roles and responsibilities for public and private sectors have to be clearly defined in each particular case, noting that the most frequent split of roles is that the former provides the content and the latter provides the delivery mechanism.
- Involve all ICT stakeholders in setting of the ICT R&D priorities and the measures needed to attain the successful transfer of these technologies;
- Strengthen the "Agricultural ICT" curriculums in the formal and informal educational and training programs;
- Focus ICT training for teachers/researchers/extension and farmers on practical implementation;
- Link Village Knowledge Centers and agri-clinics to farmer needs. Where possible involve unemployed university graduates in this activity.
- Instead of one way ICT, live and video demonstrations are preferred.

5 Summary and Conclusions

In view of the challenges that are confronted before Indian agriculture in general and in Srikakulam district in particular, there is a greater need for the private and public sectors to get more involved with the emphasis of using ICT to get integrated in agriculture development. The significant contributions of ICT in the forms of:
- Improving easy access to information through cost-effectiveness.
- Improves access to knowledge rather than simply having more information.
- Greater reduction in transaction costs throughout agricultural value chains.
- Help to increase income, improve the efficiency of markets, reduce waste, and improve welfare.
- Facilitate market demand based supply of produce by the farms and thus contribute to both domestic and export competitiveness.

To further popularize ICT in agriculture in India in general and in Srikakulam district in particular, it is essential to develop appropriate user-friendly systems, especially in local languages with the material, farmers and other people interested in working at the grassroots can produce. These services are to be made available to all the farmers, as this technology is scale-neutral. The various stakeholders like State Agricultural Universities, Department of Agriculture, Department of Irrigation etc., must prepare various modules that help the farmers throughout their supply chain, as providing a better quality of life in rural decision making capabilities can be improved by the quality of information inputs. Even at this early stage, mobile phones are being used in agriculture in India in general and in Srikakulam district in particular, and are starting to deliver agricultural productivity improvements, an impact that is enhanced by the new mobile-enabled information services.

The overall goal of using the mobile phone-enabled information delivery mechanism is to have inclusive growth by reducing the knowledge gap between large and small farmers and by creating awareness. The process of adoption of mobile telephony based information delivery systems has been slow and many of the models are still at an early stage of development. As mobile penetration continues to increase among farming communities and information services continue to adapt and proliferate, scope exists for a much greater rural productivity impact in future.

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