E-agriculture: A Golden Opportunity for Indian Farmers

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Abstract: Agriculture is an information intensive industry that is spatial in nature. To be successful, farmers must be generalists who are not only well versed in the latest farming technologies but also astute businessmen who are technologically savvy. Further, the globalization has very adverse effects on Indian farmers, as they have to compete with the farmers of developed countries. To cope with challenges posed by the globalization of agriculture, the farmers have to produce quality product at par with world market at reasonable prices. Thus, the farmers need to be well informed and well trained in the management of natural resources and production of agricultural commodities. E-agriculture plays an important role in addressing these challenges and uplifting the livelihood of Indian farmers. This paper explores the potential contribution so far been attempted under the aegis of e-agriculture or Information and Communication Technology (ICT) to the livelihoods of farming community in India. Further, a general framework of the current state-of-the art wireless sensors network is given as a challenging technology for Indian farming community to monitor their crops from a remote place.

I. INTRODUCTION

In a country like India, where large numbers of people earn a living as farmers or landless labourers, broad-based agricultural development on small farms has been a powerful force for promoting growth and reducing poverty [1, 2, 3]. Once the agricultural sector is developed it paves the way for the development of the rural areas and agricultural development becomes the foundation for the development of the rural areas. Agricultural development depends to a great extent on how successfully knowledge is generated and applied [3]. For millennia, people have used knowledge from family and friends to grow crops or raise livestock. Investments in knowledge especially in the form of science and technology have been featured prominently and consistently in most strategies to promote sustainable and equitable agricultural development at the national level. Although many of this investment have been quite successful, the context for agriculture is changing rapidly- sometimes radically and the process of knowledge generation and use has been transformed as well. It is increasingly recognized that traditional agricultural science technology investment such as research and extension, although necessary are not sufficient to enable agricultural innovation. Globally, new digital systems now exist for sharing information on agricultural innovations and markets [4]. Today, Information and Communication Technology can and should be a key agent for changing people’s lives by improving access to information and
sharing of knowledge. As this paper will demonstrate, a new perspective on the nature of the agricultural innovation process can yield practical approaches to agricultural development that may be suited to this changing context. Figure 1 shows a historical development of agricultural technologies with an initial configuration of human labor and followed by tractors to wireless sensors and robotics under the umbrella of ICT [5].

As far as agricultural development is concerned India is a unique country in the world. The country has diverse geographical settings such as hilly areas, wetlands, deserts, and coastal areas. Diversity of soil and climatic conditions are existing in the country. A variety of crops can thus be grown and various agricultural technologies can be adopted and adapted to the specific needs. Both the advanced and primitive kind of agricultural technologies are practiced in the country. On the one hand there are most modern agricultural implements such as tractors and harvesting combines, on the other hand there are millions of farmers using bullock carts and ploughs. There are farmers who have developed hundreds of web pages of agricultural information and communicate through email and there are also the farmers who still dispatch their messages through pigeon carriers. There are several languages spoken and several ethnic groups of farmers living in various states and having different cultural belief and ethical systems.

India is a vast country with 127 different agroclimatic zones [6]. Agriculture contributes 22% of its gross domestic product (GDP) and approximately 60% Indians derive their livelihood from the agricultural sector. Thus, agriculture plays a vital role in India’s economy from the perspective of poverty alleviation and employment generation. However, Indian farming community is facing a multitude of problems to maximize productivity. Due to several reasons, the majority of the farming community is not getting the upper bound yield, despite successful research on new agricultural practices by inventing new crop varieties, crop cultivation and pest control techniques. The per capita income of the farmers is one-fifth of that of an average Indian. An Indian farmer faces several impediments. These are related to issues such as fragmented land holdings, monsoon dependent irrigation, disrupted power supply, increasing cost of farm inputs, non availability of international quality seeds, exploitation by intermediaries and lending institutions, price realization, lack of adequate information on the kinds of crops s/he should grow, how s/he should grow, what planning s/he need to do with respect
to his/her area and soil conditions and what are the market dynamics.

With continuing population growth and a fixed land base, small farms are getting smaller. Small farm holdings are one of the barriers to modernization and automation of agricultural farms. Much of the small farms are perhaps too small to be productive and supportive of sufficient livelihood for the families that they support. According to the study conducted by the International Development Enterprises India (IDEI) [7], in India 70% of farmers are cultivators of small plots from which they can hardly get food security let alone sustainable incomes. Most of them are small and marginal farmers cultivating land less than one hectare in size, average size of which decreases by half in every 15 years due to rapid population growth. Today nearly 60 percent of farmers belong to marginal category with an average of 0.4 ha land. There is the problem of price realization. There is heavy fluctuation in the prices of agricultural commodities. The prices of potato or onion may be less than rupees five when the farmer sell it in the local market but may increase ten times when sold in the retail market at a different time and such price hikes not only affect the farmers but also severely affect the common people.

The increasing cost of agricultural inputs and comparatively low cost of agricultural products in the international market is creating a crisis situation for Indian agriculture. The constantly growing cost of agricultural inputs is affecting the small farmers and their families and they have started thinking that agriculture is not a viable occupation. The small farmers are increasingly under debt and stress. Small land holdings, growing cost of production, increasing debt, low prices of some agricultural commodities in the international market is aggravating the problems of small farmers and leading to some suicides. Hundreds of farmers in the Vidarbha region have committed suicides and such incidences have also been reported from other parts of India. As pointed out by the National Knowledge Commission (NKC) set up by the Government of India in it’s 2006 report “low and volatile growth rates and the recent escalation of an agrarian crisis in several parts of the Indian country side are a threat not only to national food security, but also to the economic well being of the nation as a whole”.

Agriculture involves risks and uncertainties, with farmers facing many threats from poor soil, drought, erosion, and pests. Further, rural population in our country have difficulties in accessing crucial information in the forms they can understand in order to make timely decisions for better farming. Thus, Indian farmers need timely expert advice to make them more productive and competitive. It is true that India possesses a valuable agricultural knowledge and expertise. However, a wide information gap exists between the research level and practice. The appropriate and timely scientific advice about farming is not reaching to farmers.

Information and Communication Technology (ICT) is generating possibilities to solve the problems of different categories of Indian farmers. ICT in agricultural sector is of special significance and plays a vital role due to the transformations relating to the delivery of services as well as agricultural products. Accordingly, various high tech information and communication technologies ranging from the agricultural product development, marketing, distribution to training of agricultural sector personnel etc is in use in the agricultural sector around the world. The demand for agricultural information is now stronger than ever before.

The rest of the paper is organized as follows. In Section 2 an introduction to e-agriculture in global context is discussed. Section 3 discusses the role of e-agriculture in India
followed by concluding remarks in Section 4.

II. E-AGRICULTURE–AN INTRODUCTION

E-agriculture [8] is a new term to study the role of Information and Communication Technology in agricultural development. Simply speaking, it is a way of harnessing the power of ICT in agricultural domain. It is an emerging field for enhancing sustainable agriculture and food security and rural development through improved processes for knowledge access and exchange using ICT’s. More specifically, e-agriculture involves the conceptualization, design, development, evaluation and application of innovative ways to use ICTs in the rural domain, with a primary focus on agriculture. Figure 2 illustrated various steps involved in e-agriculture.

![Figure 2: Steps Involved in E-agriculture](image_url)

E-agriculture is one of the action lines identified in the declaration and plan of action of the World Summit on the Information Society (WSIS) [9]. The Food and Agriculture Organization of the United Nations (FAO) [10] has been assigned the responsibility of organizing activities related to the action line under C.7 ICT Applications on E-agriculture.

2.1 Overview and role of ICTs in Agriculture

Information and Communication Technology (ICTs) denote a wide range of services, applications and technologies, using various types of hardware and software, often running over telecom networks. ICTs facilitate improvement in information management and dialogue between individuals, groups, communities etc. It consists of mainly three technologies. They are, Computer Technology,
Communication Technology and Information Management Technology. These technologies are applied for processing, exchanging and managing data, information and knowledge. The tools provided by ICTs include computer hardware, operating systems, application software, as well as networks and intranets, telephone and electricity lines, radio and satellite systems by which they operate.

The main focus of this subsection is to elaborate how the achievements of ICT can be applied in Agriculture sector and its development. The application of ICT in agriculture is increasingly important. The biggest advantage of ICT is that it is far more interactive and personalized that can render services, particularly the information as per the needs and requirements of end users. Such a facility makes a favorable impact on adoption and utilization of the improved and innovative techniques in agriculture. The information technologies that can be used in agriculture are Satellite Communication, Geographic Information System (GIS), computer network, video, radio and reprography. Teleconferencing, e-mail, fax and mobile phones are some other potential technologies that could be used in effective transfer and dissemination of agricultural information to the farmers.

Awareness of up-to-date information on prices for commodities, inputs and consumer trends can improve farmer’s livelihoods substantially and have a dramatic impact on their negotiating position. Such information is instrumental in making decisions about future crops and commodities and about the best time and place to sell and purchase goods. ICT plays an important role in agricultural marketing. With improved record-keeping, more detailed cost analysis and more sophisticated marketing strategies, it can help farmers to make better decisions and earn higher profits. ICT can help to provide the information on the price distribution of key commodities over the years. Such information helps farmers and traders to make decisions on when and in what ways to market their agricultural outputs. When combined with enterprise budget data, the information can also be used in deciding which crops to produce in the next season. Information on the status of price of various agricultural output markets is also provided to facilitate farmer to move his produce to the market where he can expect better price. Farmers, cooperatives, suppliers and buyers use the Internet to exchange ideas and information, as well as to conduct business with each other. Machinery, seed, chemicals and other types of agricultural products can be purchased and sold online.

In order to solve the problems of agricultural marketing, initiatives have taken in various countries. Simple websites to match offer and demand of agricultural produce are a start of agricultural trade systems. These sites tend to evolve from local selling/buying websites and price information systems to systems offering marketing and trading functions. For this, price information is collected at the main regional markets and stored in a central database. The information is published on a website, accessible to farmers through information centers. To reach a wider audience, information is broadcast through radio and TV and thereby creating a link between producers and traders in a region. In recent years, short message and text services have taken up and effectively deliver prices and trading information via mobile phone to farmers. In India the private sector-led Agriwatch and e-Choupal programme support several million farmers with price information, trade and transaction facilities. In the fertilizer marketing context, ICT can play a major role in efficient sales, operations, checking the marketing costs, safeguarding market share and providing efficient customer services. A well conceived IT set up can endow decision makers at all levels with better reflexes to effectively respond to market conditions.
ICTs also play an important role in making processes more efficient and transparent. It helps in making laws and land titles more accessible. Global Positioning Systems (GPS) linked to Geographical Information Systems (GIS), digital cameras and internet help rural communities to document and communicate their situation [11]. ICT enables rural communities to interact with other stakeholders, thus reducing social isolation. It widens the perspective of farming communities in terms of national or global developments and opens up new business opportunities.

ICTs can provide a comprehensive solution to the farmer’s financial needs. It can be used to manage financial services, savings, credit, investment opportunity, hedging negotiation, etc for the farmers. For transforming the economy, there is a need to develop a comprehensive rural information system to identify credible borrowers. Each farmer should be given a unique identity card or e-passbook which has to be machine readable and must provide electronic and biometric access. Using ICTs in the rural banking, the processes should be automated and the applications should be customized and made more flexible. There are already several connectivity options and many access devices present, but we also need to consider unconventional delivery technologies like ATM, digital cash, mobile banking etc to make rural finance reach till the last mile. The energy-electricity network can be used to connect villages with the mainstream. Another possibility is that of Wi-Max, for the financial inclusion of rural areas. Mobiles using GSM could be another possibility in this regard.

ICTs in universal access to financial services should not merely be limited to the access but take into account the process and the end usage. For successful rural e-banking every village should have one knowledge centre to fill in the grand gap, which existed between village panchayats and farmers, on one hand and the financial institutions based at national and district levels on the other.

ICTs used in agriculture production cover three aspects: data collection or information input, analysis or processing of the precise information, and recommendations or application of the information. Data collection occurs both before and during crop production and is enhanced by collecting precise location coordinates using the GPS (Global Positioning System). GPS determines precise location based on radio signals from 4 or more of the 24 satellites in the GPS launched and maintained by the US Department of Defense (DoD).

Data collection technologies operating in advance of crop production include grid soil sampling, yield monitoring, remote sensing and crop scouting. In the grid soil sampling technique soil samples based on a systematic grid laid out across a farmed field are collected. Soil samples are then analyzed in a laboratory to determine soil characteristics such as texture, organic matter, pH and concentration of nitrogen, phosphorous and other nutrients. Yield monitoring is an automated measurement of the amount of production taken at intervals as the combine or harvester passes over a field. Data from the yield monitor must be integrated with data on vehicle speed, head position, and crop moisture level derived from separate sensors. These data are combined in onboard computers to produce an estimate of harvested yield for each area of the field that can be incorporated into a GIS database for the field. In the remote sensing technique data on light reflectance are collected by instruments carried in airplanes or orbiting satellites that can be used to estimate the spatial pattern and vigor of vegetation at small areas within the field. Crop scouting often involves use of pheromone or other insect traps to estimate pest levels as part of integrated pest management approaches.

Other data collection takes place during production through “local “ sensing
instruments [12] mounted directly on farm machinery or equipment to detect soil conditions, nutrient concentrations, weed density and location, soil moisture, livestock identity and other conditions for real time input to variable rate applications.

Precise data are useless unless they can be analyzed to enable management adjustments. Geographic Information Systems (GIS) are the principal technology used to integrate spatial data coming from various sources in a computer. It is a computerized map and database program that contains spatial (map) and attribute (characteristic) data linked by a common geographic identifier. GIS software provides for overlays and geographic analyses of multiple mapped layers, representing the spatial patterns of soil, crop yields, input applications, drainage patterns and other variables of interest in a PA system.

Data collected at different times on the basis of different sampling regimes and different scales must be combined for use with subsequent decision technologies, such as process models, artificial intelligence systems, and expert systems. Computer process models use frequent time-steps to stimulate the processes of crop growth and movement of nutrients and pesticides through the environment. Artificial intelligence systems use heuristic or empirical decision rules in most process models to recommend appropriate management choices. Expert systems incorporate the “rules of thumb” used by human experts that match the conditions reflected in the input data in order to reach recommendations.

Communications links cut across all three stages of the e-farming process, contributing to data collection, analysis, and application. Fiber optic and satellite communication links, local area networks and the like link producers, cooperatives, extension experts, processors, input dealers, consultants and others involved in the production process. These communications links enable a nearly continuous electronic conversation or virtual community that puts many heads to work on interpreting precision information for better production decision making.

2.2. ICT for Improved Resource Use

A farmer walks through his rice field in Orissa (a state of India having 80% of people are mainly dependent on rice agriculture, shown in Figure 3) [13], heading for a spot pinpointed by a remote sensing image the farmer downloaded in that morning’s e-mail. Pest infestation in this small spot, indicated by a change in the vegetative index would not be detected this quickly. Untreated, it could spread rapidly and destroy the entire crop. The farmer opens his computer, brings up information on the pest, completes an economic threshold analysis, and determines what control measures he will use. He records the exact location of the infestation using the integral GPS receiver and alerts his pest control advisor and custom pesticide applicator through cellular phone link.
III. E-AGRICULTURE IN INDIA

Although accounting for just about 20 % of the country’s GDP, the role of agriculture in the Indian economy cannot be undermined even today because; nearly 70% of the country’s population still depends on agriculture to earn their livelihood. Thus, in order to revive the agriculture sector and usher in the era of e-agriculture India needs to effectively harness the power of ICT [15]. Experts opine that introduction of IT in agriculture can bring the second Green Revolution in India with easy and cost effective information to the farmers at the right time. Enormous efforts are thus made in India for adoption and absorption of information technologies for agriculture information communication [16, 17]. The National Agricultural Policy lays emphasis on the use of Information Technology for achieving a more rapid development in India. Accordingly, the Department of Agriculture and Cooperation (DAC) has formulated information technology vision 2020 [15]. This vision states that:

1. Information relating to agriculture sector would be available to the ultimate users—the farmers for optimizing their productivity and income.

2. Extension and advisory services making use of information technology would be available to the farmers on round the clock basis.

3. The tools for information technology will provide networking of agriculture sector not only in the country but also globally and the Union and State Government Departments will have reservoirs of data base and

4. The long term vision on ‘Information Technology in Agriculture
Sector’ is to bring farmers, researchers, scientists and administrators together by establishing ‘Agriculture on-line’ through exchange of ideas/information.

Numerous initiatives have been taken throughout the length and breadth of the country, aiming at extending the benefits of the information revolution to rural and remote areas. These includes the establishments of Kisan call centers [6], Gyandoot project [18], Village knowledge centers [6], AGMARKNET [6], eSagu system [19], etc.

Kisan call centers (KCCs) [6] were launched on 21st January, 2004 by the Department of Agricultural and Cooperation with the aim to deliver the extension services to the farming community in the local languages. The farmer dials a toll free number 1551, and the agricultural scientists provide the initial enquiry. The cost to the farmers is almost zero and they get the response in their local languages. If the farmers want more information, the call is forwarded to level II and level III executives. (See Figure 4)

The Bhoomi project [18] is a significant achievement on its own right and is an example of how an ICT project can be used for data processing, information production and access supportive of the right to information. It is primarily a state based project, which involves the digitalization of all land records in Karnataka and the provision of access to these records through information kiosks and fingerprint authentication systems. This computerized land record facilitates the farmers in obtaining, so called technically, the Rights, Tenancy and Cultivation certificates (RTCs). Moreover, the Bhoomi project also provides online connectivity to various courts to make use of the land records database to settle civil disputes on land ownership and cultivation.

The Gyan Ganga project [18] is what one would call a premium telecentre project that is committed to providing a range of ICTs services from telephony to e-governance. It is a joint state private sector initiative aimed at the use of ICTs in development, in Gujurat. It is an ambitious project aimed at the provision of information, connectivity, education, e-health and e-governance broadly within the parameters of the right to information. It currently operates 212 ICT kiosks in Gujurat. In this project the villagers pay for the services. The project is based on a business model in which the key players- the private firm N-Logue, the Local Service Providers and operators of the local kiosks are involved in selling their services. Another feature of this project is the role of N-logue which is commited to providing low-cost voice and internet services to rural India.
The Gyandoot Project [18] was started in the Dhar district of Madhya Pradesh, which covers 600 villages and 26 Soochananalayas. Soochananalayas are nothing but information centers at the village level. The service covers to provide information about the agricultural produce, auction center rates, copies of land records, on-line registration of applications, village auction sites and more. The village Auction Site Project allows farmers and villagers to advertise and sell land, agricultural machinery, equipment and other durable commodities. In order to provide information minimum user fees are charged by the information centers.

AGMARKNET, (Agricultural Marketing Information Network) [6] is a joint venture of the Directorate of Marketing and Inspection (DMI) and the National Informatics Center (NIC). Currently, it covers 2800 market nodes and 300 commodities and provides information in ten languages. It has increased the efficiency in marketing activities by establishing a nation-wide information network, which provides information on prices, arrivals, availability, trends, analysis, laws etc. These timely information data are helpful to producers, traders and consumers. It has been connected to 670 agricultural produce markets and 40 State Agricultural Marketing Boards And Directorates. Each AGMARK portal of wholesale market provides daily information to AGMARK portals of its respective states, and then each state’s AGMARK portal sends the information to the AGMARKNET portal. The National Information System maintains all of these portals. The food processing units, traders and different village kiosks, to help the farmers in taking the right decisions mainly use these portals.

The e-Choupal project [6] is very popular in the country. The project now covers nine states and around 36,000 villages, empowering around 3.5 million people. These e-Choupal centers deliver real-time information and customized knowledge to improve the farmer’s decision making ability, thereby better aligning farm output to market demands, securing better quality, productivity and improved price discovery. It also helps farmers to access higher quality farm inputs at lower cost.

The eSagu project [19], an initiative of the Indian Institute of Information Technology,
Hyderabad, provides crop related advice from the experts in cities to the rural areas of Andhra Pradesh, using digital technology. In this system, a coordinator collects all the information regarding the crop in the local area and sends it to the team of experts in Hyderabad by using a storage device. The experts then evaluate the crop system and suggest solutions, which can be downloaded in the village information centers.

In India the use of the Internet in the farm decision making is very less. Hardly 12 percent of farmers are applying this technology and majority of them are using traditional technologies like radio, television and newspaper. Thus a central scheme involving mass media support to agriculture extension has also been launched. The existing infrastructure of Doordarshan and All India Radio (AIR) is being utilized for production and telecast of 30 minutes agricultural programmes five or six days a week. Farmer’s feedback is being collected regularly through the Audience Research Units and AIR state/district level monitoring committees are mandated to guide and monitor implementation of scheme at the respective levels.

3.1 Sensor Technology for Indian Farmers

A wireless sensor network [12, 16, 20] is a system comprised of radio frequency (RF) transceivers, sensors, microcontrollers and power sources. Wireless sensor networks with self-organizing, self-configuring, self-diagnosing and self-healing capabilities have been developed to solve problems or to enable applications that traditional technologies could not address. Once available, these technologies would allow us to find many new applications that could not have been considered possible before. Wireless sensor technology is still at its early development stage. Applications of wireless sensors in agriculture and food industry of India are still rare. This Section intends to give an overview of available wireless sensor technologies that can enhance the productivity obtained from agriculture Sector of India [12]. An example is given below.

PhyTech is a pioneer and a leader in Phytomonitoring: the practice of remote sensing and monitoring of plants. The advanced solutions use innovative software for collecting and analyzing data, state-of-the-art sensors, and wireless communication. The system improve crop production and reduce cultivation costs by providing timely and accurate information regarding the physiological status of the plants and...
identifying stress conditions before they impact the plant or the fruit. Figure 5 describes the system.

Figure 6: A Sensor in Field

In a nutshell, PhyTalk is designed as a modular and distributed system. New sensors can be added as and when needed. The architecture supports cost effective deployment of sensors over large geographical area. The system consists of four modules.

Sensors: Measure a variety of parameters, providing relevant and precise information about plant and environmental conditions. Example of such type of sensors is illustrated in Figure 6.

Communications: Supports cordless deployment of sensors in the field and wireless communication to remote computer anywhere in the world.

Software: Developed by experts in the field of phytomonitoring [20, 21], the software supports the analysis and interpretation of data in real time by displaying it in easy to read formats such as graphs and tables and supporting disorder prevention.

Application Technique: Recommended measurement protocols and decision support procedure for major horticulture crops.

Deployment of wireless sensors and sensor networks in agriculture is still at the beginning stage. Applications can be classified into five categories: (1) environmental monitoring, (2) precision agriculture, (3) machine and process control, (4) building and facility automation and (5) traceability systems.

The recent progress obtained from our team is as follows: 1) deploying the sensors for plant monitoring; and 2) concentrated on developing sophisticated software for analysis and decision making.

IV. CONCLUDING REMARKS

There is abundant prospective for effective use of ICT in agriculture and initiatives are promising. However, much still remains to be done. The implementation of these following recommendations can help to realize the full potential of ICT in agriculture and improve rural livelihoods.

Research and Innovation:

- Technical information systems in agriculture need to incorporate local knowledge, be integrated into regional and international systems and maintain links to policy makers. More investment in infrastructure and skilled human resources is needed for such systems.
- Researchers and extensionists require continued training in how to interact and share knowledge more effectively using the new digital technologies.
- Academic and research data in agriculture, available in the form of journals and research paper needs to be digitalized to facilitate cross flow of information.
- At local and sub-national level, there should be institutional mechanism,
mainly multi-stakeholder, to link rural communities with universities, research agencies through intermediary organizations.

**Enhancing Rural Access:**

- While investing in communication infrastructure the Government must focus on financially viable and socially acceptable approaches that are accessible to the rural poor. In order to enhance rural access, the Government should, ensure low prices for broadband Internet in rural areas.
- Foster combined public private efforts and cost sharing arrangements to ensure sustainability of rural information centers.
- Foster awareness raising and capacity building of rural communities to use and maintain ICT.
- Support technical innovations for rural connectivity such as wireless broadband connections or solar powered systems.
- Foster the adoption of information into formats and languages relevant for rural areas. Investment is needed to repackage technical information for farmers and make it available in local languages.
- Existing channels for technical information (e.g., extension services, radio stations) should be integrated with new communication technologies, which are accessible to farmers.

**Education:**

Another major challenge for putting agriculture knowledge to work in agricultural fields is farmers’ information literacy level, urge to learn and learning facilities available to them. The farmers do not adopt the solution due to low literacy. Thus, the farmers education from lower level will be required and the sooner it commences the better. Information literacy will help the farmers to even independently access information of their interest and profitably use it for better functioning and performance.

- Agriculture should be introduced as a subject in school curriculum and computer education should be an important part of Agriculture Education System.
- Development of digital libraries in rural areas can play an immense role in providing adequate learning environment, imparting literacy to rural communities and even in transfer of agricultural technologies to farmers.
- In India, agriculture is close to tradition. Farmers sometimes become averse, as they think that they might lose their traditional methods of cropping practices. They do not want to utilize the system, even if the cost incurred by them is very low. Thus, it is necessary to change the attitude and mindset of the farmers. There is the need to win the confidence of the poor farmers and make them aware of the benefits of ICT in agriculture.

**Market chains:**

The growth of communication networks needs to be supported amongst actors in the chain (farmers, transporters, buyers, traders, etc) in order to ensure more equitable, timely and collaborative access to markets for small holders.

**Government policy:**

The social and political environment within which ICT projects operate is crucial and supportive Government policies and measures are required.

- The government should appoint a commission to study the deployment of IT for the benefit of farmers and recommend ways to expand the role of IT in agriculture.
Agriculture should be on the Concurrent List to have better results out of the efforts being made.

Government should put policies into place that systematically capture local knowledge, ensure appropriate research agenda setting and support the functioning of intermediary organizations.

Government should aid the process of identification and vertical integration of diverse ICT tools that are employed in present day agricultural practices.

The need of the hour is to make IT usable for the farmers, i.e., making IT farmer friendly, rather than making farmers IT friendly. There is the need to tailor rural ICT policies, aiming to deliver information to solve the problems that rural people perceive important for their well being. The process has to be a step-by-step approach, not neglecting the process of rural readiness within the broad context. Since the use of ICT in agriculture is still a new and rapidly changing area, there is a need to raise awareness among government and other national stakeholders.

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