# Information and Communication Technology (ICT) in Agriculture: An assessment in India

M. Balakrishnan[1], M. Pratheepa[2], Ch. Srinivasa Rao[1], P. Krishnan[1], S.K. Soam[1]

[1]ICAR-National Academy of Agricultural Research Management, Hyderabad, Telangana
[2]ICAR-National Bureau of Agricultural Insect Resources, Bengaluru, Karnataka

**Abstract**

In the past decade, many Information and Communication Technology (ICT) schemes in Indian agriculture have emerged, either substituting or supporting extension services by providing farmers with access to agricultural information. ICTs have the potential to reach many farmers with timely and accessible content. But the content that the ICTs deliver has more relevance if it is localized and context specific, as this improves the value and action ability of the information, which can have important impacts on farm management. The localization of content is influenced by how the ICT projects access, assess, apply, and deliver content. Information is power and power is information. Without information there can be no growth. Now information is penetrating into rural India as well, because without its presence there, we cannot think about development of the entire country. India is in the midst of a knowledge revolution, complemented by the opening up of entirely new-vistas in information and communication technology. It is widely believed that Information and Communications Technologies (ICTs) are effective tools in the development of rural India. Rural people are less knowledgeable rather than their city counterparts. Thus, technological advancement is necessary for every nook and corner of India. Despite the best efforts of these and many other e-agriculture initiatives in India, there is no easy way for their collective knowledge to be tapped, tracked and put to use across the different platforms. In fact, there is a critical missing link to bridge the gaps between local or parochial access and serving public needs. Hence, the various on-going ICT applications in India has been discussed in detail.

**Key Words**: ICT, Mobile Apps, E-chuopal, Mkisan and Kisan Credit Card, Databases, Decision Support System, ikissan

## I. Introduction

India is one of the largest producers of fruits and vegetables in the world, yet the majority of its farmers are smallholders, and like smallholders in most low-income countries, they make a tenuous living. A lack of access to seeds, fertilizers and machinery, information on good growing practices and perhaps most importantly, market information, keeps them in poverty. In the context of agriculture, the potential of information communication technology (ICT) can be assessed broadly under two heads: (a) As a tool for direct contribution to agricultural productivity and (b) As an indirect tool for empowering farmers to take informed and quality decisions which will have positive impact on the way agriculture and allied activities are conducted [1]. Popularly developed countries like India, extensively uses Information Technology (IT) in precision farming to make direct contribution to agricultural productivity. The satellite techniques like Remote Sensing in Geographical Information Systems, Agronomy and Soil Sciences are used to increase the agricultural output. These approaches are capital intensive and useful where large tracts of land are involved. Consequently, it is more suitable for farming taken up on corporate lines. Many Far East Asian countries like Japan, Korea, and China have practically implemented ICT based development campaign for agriculture and rural development. To develop agriculture information systems further in India, the various applications of ICTs, have been discussed, which have a relevance in agricultural research and education and extension.

## II. ICTs initiatives in Indian Agricultural Research and Education

The application of Information and Communication Technology (ICT) in agriculture is increasingly important. E-Agriculture is an emerging field focusing on the enhancement of agricultural and rural development through improved information and communication processes. More specifically, e-Agriculture involves the conceptualization, design, development, evaluation and application of innovative ways to use information and communication technologies (ICT) in the rural domain, with a primary focus on agriculture. All stakeholders of agriculture production system need information and knowledge about these phases to manage them efficiently. ICTs are most natural allies to facilitate the outreach of Agricultural Extension system in the country [2]. The distinguished ICT applications in Indian agricultural research and technology are mentioned in the following:-

### A. Decision Support Systems

A decision support system (DSS) is a computer program application which provides a framework for integrating database management systems, analytical models, and graphics, in order to improve decision-making process. The complexity of problems faced by the farmers like yield loses, soil erosion, selection of crop, increasing chemical pesticides cost, pest resistance, diminishing market prices from international competition and economic barriers hindering the farmers growth. An advanced ICT based decision support system with Internet technologies playing major role to clear the doubts and gives guidance to the farming community in several areas. Database systems supports decision making with the importance on storage, retrieval and management of the data [3]. Recently, Govt. of India has taken an initiative to develop Krishi-Decision Support System (Krishi-DSS) by using geospatial technologies and related databases to assist the stake holders and policy makers to take appropriate decision in agriculture sector. There are several DSS available in the field of agriculture and few of them are mentioned here.

DSS - Crop-9-DSS, will aid as a decision support system for identification of pest and diseases with control measures, fertilizer recommendation system, water management system and identification of farm implements for leading crops of Kerala (India) namely

Coconut, Rice, Cashew, Pepper, Banana, four vegetables like Amaranthus, Bhindi, Brinjal and Cucurbits. 'CROP-9-DSS' will act as assisted tool to agricultural officers, scientists in the field of agriculture and extension workers for decision-making and help them in suggesting suitable recommendations [4].

DSS with GIS tool can better organize and analyze spatial data, address the problems related to spatial and temporal variability of various natural resources on agricultural systems helps in decision making especially for the policy holders. Spatial Decision Support System developed by studying the changes in area and productivity of rainfed crops Sorghum, Pearlmillet, Pigeonpea, and Chickpea by linking the time series data of each districts with district map of India. Further Agro-eco regions were [5] overlaid. These maps reveal the spatial trends in area and productivity of rainfed crops in different Agro-eco regions in India [6].

A Decision Support System (DSS) was developed for the selection of optimal farm machinery systems to incorporate regional variations in crops and cropping practices, farm characteristics, sizes of farm equipment, and costs of the resources and outputs in India [7].

**B. Expert Systems and Knowledge management**

An Expert System, also called a Knowledge Based System (KBS) is a problem solving and decision-making systems based on knowledge of its task and logical rules or procedure by using the knowledge and rules obtained or trained from the experiences of a specialist in the area stored in the database.

Expert system for Paddy is available at TNAU Agritech Portal and gives enormous information about Rice crop like Rice Ecosystem, Nursery management, Cultivation practices, Nutrient management, Crop protection, Farm Implements, Post Harvest Technology, Botany and Climate, Season and varieties. Rice growers can be benefited from this expert system for rice crop farming and its management [8].

SIMCAS model has been developed for simulating the growth of cassava and to predict the final yield by estimating the stress due to shortage of water, nitrogen and potassium integrated with IoT based weather sensors [9].
Further IoT based real-time expert system is required for weather data handling and to be linked with crop modelling.

**C. Embedded ICTs in Farm equipment and processes**

The current iteration of agriculture called as agricultural era 4.0, involving the engagement of IoTs by developing low-cost sensor and network platforms to increase the yield production with minimal usage of water resources and other agricultural inputs. Real-time programming is being developed with artificial intelligence concepts and embedded in IoT devices, helping the farmers to make appropriate decisions in farming [10]. Enabling greater efficiencies in farm equipment and agricultural processes and in what is termed "precision agriculture" as also in agricultural products transport and marketing by use of RFIDs (radio-frequency identification), Wireless Internet and Cellular Telephony in labelling and traceability helps to reduce the burden of farm workers by automation. RFIDs are very useful in agricultural supply chain management. RFID has many advantages for the busy farmers since RFID is non-contact with mass memory, secure access and can be integrated with any existing system easily. Data collection in green house will be easier with specialized RFID tags and readers, which are designed for warm and humid conditions.

**D. ICTs embedded in agricultural processes, tools and machinery**

The Information Communications Technologies (ICT) embedded in agricultural processes, tools and machinery will reduce energy utilization and costs, improve quality, change time in production and reduce intensity of human labour, especially in farming and post-harvest processing. Equipment, such as water pumps and sprayers, will lower energy use and reduce wastage if embedded with ad hoc ICTs. Sensors embedded in soils will monitor and control use of water and soil nutrients. GPS enabled sprayers will improve pesticide applications and reduce their hazards. The reduction in human labour through the use of ICTs will liberate huge numbers of low paid workers, mainly women and children. They will enable use of their labour in more productive and higher paying occupations and enable children opportunities for education and progress.

**E. Connecting Communities for Learning**

Using ICTs to connect communities such as farmers, researchers, extension workers related with agriculture gives fruitful results. ICTs are already playing a significant role in connecting scientists and researchers in agriculture to communicate to each other and in scientific and technical publications. Use of ICTs to connect farmers and producers to new agricultural knowledge and technology and in problem resolution have been tested and found very useful so much so that ICTs are now considered to be transforming agricultural extension. ICT based teaching methods in agricultural extension benefit the farmers and rural communities to get the training in a better way. The hybrid combination of traditional teaching methods and ICT based teaching methods gives better results. The role of ICT for community education during Covid-19 was tremendous.

**F. Delivering of Weather Services**

India Meteorological Department (IMD) started weather services for farmers in the year 1945. It was broadcast by All India Radio in the form of Farmer's Weather Bulletin (FWB). Subsequently, in the year 1976, IMD started Agro-Meteorological Agricultural Advisory Service (AAS) from its State Meteorological Centers, in collaboration with Agriculture Departments of the respective State Governments. Though these services are being regularly provided by IMD for the past many years, the demand of the farming community could not be fully met due to certain drawbacks in the system. In view of that IMD launched Integrated Agromet Service in the country for 2007 in collaboration with different organisations/institutes.

## III. ICT Initiatives for Agricultural Development in India

ICT has various roles in the field of agriculture to improve food production worldwide. ICT can provide agricultural extension services easily, quickly with higher accuracy. ICT also supports easy information access and communication in agricultural development. Government of India launched various initiatives to promote use of ICT in agriculture. The various initiatives include include National e-Governance Plan in Agriculture (NeGP-A), various Touch Screen Kiosks, Krishi Vigyan Kendras, Kisan Call Centres, Agri-Clinics, Common Service Centers, mKisan, Kisan TV and various other applications.

The agricultural sector is confronted with the major challenge of increasing production to feed a growing and increasingly prosperous population in a situation of decreasing availability of natural resources.

Factors of particular concern are water shortages, declining soil fertility, effects of climate change and rapid decrease of fertile agricultural lands due to urbanisation. However, the growing demand, including for higher quality products, also offers opportunities for improving the livelihoods of rural communities. Realising these opportunities requires compliance with more stringent quality standards and regulations for the production and handling of agricultural produce. New approaches and technical innovations are required to cope with these challenges and to enhance the livelihoods of the rural population. Although it is a relatively new phenomenon, evidence of the contribution of ICT to agricultural development and poverty alleviation is becoming increasingly available.

### A. Farmers' Advisory Services

The most widely used and available tools of farmers' advisory services are (i) Telephone based Tele Advisory Services (ii) Mobile based Agri Advisory services (iii) Television and Radio based mass media programmes (iv) Web based online Agri Advisory services (v) Video-conferencing (vi) On-line Agri video Channel (vii) various Touch Screen Kiosks, besides traditional media like, printed literature, newspapers, and farmers exhibition/fair etc.

Most of the agricultural institutes and organizations have their own telephone based advisory services for farmers which provide telephone based Agri advisory services through a dedicated telephone number to provide real-time information and advisory.

The on-line phone based expert advice service, Kisan Call Centres (KCC), launched by the Ministry of Agriculture, Government of India is available for all within the country since January 2004. The mobile based Agri Advisory services offers text, voice and video content based Agri information services through mobile phones.

Community radio is one of the important tools of ICT that offer farmers and the people a voice and help development of the community. Community radio is owned and operated by a community or members of a community.

### B. ICTs for Empowerment of Women and in Rural Development

ICT promises a fundamental change in all aspects of our lives, including knowledge dissemination, social interaction, economic and business practices, political engagement, media, education, health, leisure and entertainment. ICTs can play a significant role in combating rural and urban poverty and fostering sustainable development through creating information rich societies and supporting livelihoods. If ICTs are appropriately deployed and realize the differential needs of urban and rural people, they can become powerful tools of economic, social and political empowerment [11].

ICT has the ability to reach women who, up until now, have not been able to access any other forms of media, enabling them to take part in on-line trainings, upgrading of skills which helps rural women in economic advancement and help them to make proper decisions about issues that directly impact them.

Several nongovernmental organization (NGO), voluntary group of individuals are working for the betterment of women and give them training for self-independence. In this situation, ICT is playing a major role and through this women are acquiring security, awareness, knowledge and confidence.

Women face enormous challenges to use ICT for their own economic empowerment. Using and benefiting from ICT requires education, training, affordable access to the technology, information relevant to the user and a great amount of support to create an enabling environment. Access to affordable services and availability of infrastructure is without doubt a major requirement if ICTs are to be used for women's economic empowerment [12].

A UNESCO report on "Gender Issues in the Information Society" stated that the capability of women to use information through ICT is dependent on many social factors, including literacy and education, geographic location, mobility and social class. Social development movements, various kinds of development activities, programmes, welfare schemes and constitutional facilities have helped women to reach the main stream of society. In the process of women empowerment, the ICTs are also playing a major role especially through technologies like cell phones and the internet. The cell phone is an extremely efficient ICT for the empowerment of women. It has been accessed by the majority of the people, rural and urban, rich and poor, educated and uneducated, because of its features.

There are number of projects implemented in developing countries by UN, World Bank, government, corporate and private sectors, through the millennium development goals and local and international programmes.

Mobile phone technology plays major role in the field of women empowerment. Women are also using the mobile phone for different ways: to be safe in times of difficulty, as a media connector with current updates in day to day and as an e-learning device to become literate. The scaling of women centered mobile programs and applications can only be achieved with improved financial, commercial, and marketing incentives and of course, cooperation [13].

The socio-economic inclusions of rural women tale place through the two kinds of information and communication technologies, *i.e.* cell phones and internet in rural areas. Most women now search for jobs by using cell phones and personal contacts [14].

### C. Corporate sector sponsored programmes in ICT

(i) **E-Choupal (ITC-IBD)**

E-Choupal is an India-based business initiative by ITC Limited that provides Internet access to rural farmers. The purpose is to inform and empower them and, as a result, to improve the quality of agricultural goods and the quality of life for farmers. ITC Limited (formerly India Tobacco Company Limited) is a consumer product and agribusiness conglomerate in India known for their production of cigarettes, specialty paper, food products and packaging services. Through the e-Choupal initiative, ITC has created more than 6,500 e-Choupal computer stations in rural areas that serve an average of six hundred farmers each. Using this technology, farmers may order supplies, learn about best agricultural practices, receive weather reports and read about pricing for crops throughout the region [15].

(ii) **EID-Parry**

EID Parry was the first company to start a sugar mill in India. The company launched the Parry's Corner ICT initiative to derive the synergies from its vast experience and the farmers's knowledge pool. Parry's Corner was pivotal in increasing the yields and reducing the expenditures for the farmers. Farmers here are able to access a wide range of information from the information kiosks such as the climatic conditions, knowledge about the urea, fertilizers, seeds and also the cropping patterns. This project was successful as it helped in the creation of skills at the local level.

## IV. ICT Initiatives for Agriculture extension

**A. AGMARKNET**: A Flagship project of Digital Art Centre (DAC) for Agricultural Marketing Information System; which networked about 2800 agricultural wholesale mandis
in the country.

**B. Kisan Call Centres(KCC)**: Kisan call centres have been established across the country with a view to leverage the extensive telecom infrastructure in the country to deliver extension services to the farming community. It is to make agriculture knowledge available at free of cost to the farmers as and when desired. Queries related to agri. And allied sectors are being addressed through the kisan call centres, instantly, in the local language by the experts of State departments, SAUs, ICAR institutions etc.

**C. HORTNET**: A National Horticultural Mission Project for developing an ICT based Value-Chain from the Farmers

**D.** Community Information Centre (CIC): The CICs are used to transfer vital information to and from government offices. Through ICT several blocks of the districts in various Indian states have been linked which helped for easy accessing and communicating the important information.

**E. Rashtriya Krishi Vikash Yojana (RKVY):** It was launched under the aegis of the National Development Council, it seeks to achieve 4% annual growth in agriculture through development of Agriculture and its allied sectors

### F. State government sponsored and developed ICT initiatives in India

**(i) Janmithra (Rajasthan)**
JANMITRA is an integrated e-platform through which rural population of Rajasthan can get desired information and avail services related to various government departments at kiosks near their doorsteps. It is a rural centric project with thrust on service delivery system. Kiosks are service centers in the form of small enterprise from where the citizens can avail the services of different departments [15].

**(ii) Gyandoot (Madhya Pradesh)**
The Gyandoot intranet community network was conceptualized on 1 January 2000, and installed and made operational within less than two months in the tribal dominated, poverty-stricken Dhār district in the Central Indian state of Madhya Pradesh. Gyandoot in Hindi means "purveyor of knowledge". The four pillars on which the Gyandoot community network was established were People, Content, Services and Server. It was decided at the outset after consultation with the villagers to provide all the proposed facilities in the local language (Hindi). Software, eventually developed and installed for the network, was user-friendly and menu-driven at the client end. Initially, the network offered five services. Within a few months of its installation, the network was offering 22 services including rates of agriculture produce, land records, grievance redresses, Hindi e-mail, rural matrimonial services, rural e-market, application for caste/residence/income certificates, information regarding government programmes and schemes, etc. Later, educational, health and commercial services were added [16].

**(iii) Bhoomi Land Record Computerization, Karnataka**

It provides transparency in land records management with better citizen services and takes discretion away from civil servants at operating levels. The Revenue Department in Karnataka, with the technical assistance from National Informatics Centre (NIC), Bangalore, has built and operationalized the BHOOMI system throughout the state. The BHOOMI has computerized 20 million records of land ownership of 6.7 million farmers in the state. BHOOMI has reduced the discretion of public officials by introducing provisions for recording a mutation request online. Farmers can now access the database and are empowered to follow up. A farmer can check the status of a mutation application on Touch Screen Kiosks. If the revenue inspector does not complete the mutation within 45 days, a farmer can now approach a senior officer person with their grievance [17].

The other some of the e-Agriculture services are Raitha Samparka Kendra online (Karnataka), Rasi, Miyams Karchipular (Tamil Nadu), Seva - Automated Milk Collection Centres of AMUL (Gujarat) and E-Srinkala (Kerala) [15].

**G. Non-government organizations and other private sector organizations**

**(i) Information Village Research Project in Pondicherry**

Information Village Research Project had its genesis in an interdisciplinary dialogue held at the M.S.Swaminathan Research Foundation (MSSRF) during the year 1992, titled "Information Technology: Reaching the Unreached". One of the important. It was felt that ICT has the ability to take the generic information and convert it into local specific. A small beginning was made in 1997 by MSSRF when it embarked upon a programme that would use access to information as a key to holistic rural development. Information Village Research Project was launched with financial support from International Development Research Centre, Canada, on an experimental basis, in the Union Territory of Pondicherry in South India, in January 1998. Pondicherry was formerly a French colony, which came under the Indian Government in 1954. Later, in 1962, it was organized as a Union Territory [18].

**(ii) Agriwatch.com**

The agribusiness sector is characterized by multi layered channels on the Agricultural Input and Output side, poor quality of information and analysis about Demand, Supply, Prices, Market Trends for various agri-commodities. The promoters of this organization, coming from an Agricultural background felt the need to address these anomalies in this sector and therefore have come together to create a professional team and an organization to deliver value to the participants at all the levels in this sector [19].

**(iii) VOICES by Madhyam Communications**

It advocates communications for change through Communication production and dissemination; Communication training and action research; Development education; and Networking and consultancy. Among the NGOs, VOICES has taken a leading advocacy role for independent community broadcasting in India. These efforts received a major boost in February 1995, when the Supreme Court made a landmark judgment on broadcasting declaring that the airwaves should be regarded as "a public good". VOICES received UNESCO support to introduce a regular community radio programme through the local AIR radio station. Other activities of VOICES include conducting workshops on radio and print, for grassroots development workers from various parts of Karnataka. VOICES in collaboration with others, has produced and aired a series of films on the impact of technology on the lives of people with various kinds of disabilities [20].

## (V) ICTs in Animal Disease Management

The use of ICT in animal husbandry and hospital management achieved enormous growth in addressing various issues. Recent concepts like Internet, Geographical Information System (GIS), Global Positioning System (GPS), Database Management, Computer Aided Design (CAD), computer Networking, Artificial Intelligence adds strength and efficiency to the ICT in animal disease management. Most of the ICT tools currently used are in Herd Health management.

The livestock industry is facing public examination of the sustainability and environmental impacts of animal production and welfare of farm animals [21]. IoT- enabled livestock management solutions help to take care of herd health. By using a wearable collar or tag, batter-powered sensors assist to monitor the location, temperature, blood pressure and heart rate of animals and wirelessly send the data to farmer's devices.

## (VI) Web Portals/ Knowledge Management Portal in agriculture

A. **Agropedia**

The Agropedia is a peer-group tool for interaction among the farmers. This is a comprehensive, integrated model for digitalized content of agricultural domain. This e-initiative intends to bring together a community through ICT enabled knowledge creating and organizing platform with an attempt to leverage the current agricultural extension system [22].

B. **TNAU AGRITECH Portal**

The TNAU Agritech Portal is a dynamic portal and e-linkage with research stations and farm sciences centres for agro-advisory services [23].

C. **e-Sagu**

e-Sagu is a tool for IT-based personalized Agro-Advisory system. ('Sagu' means cultivation in Telugu language). It aims to improve farm productivity by delivering high quality personalized (farm-specific) agro-expert advice in a timely and continuous manner to each farm at the farmer's doorsteps before the farmer arise the question. The expert advice is a provided at regular intervals to each farm from pre-sowing stage to post-harvesting stage.

D. **Aqua e-Sagu**

Aqua e-Sagu is an ICT based tool for personalized aqua-advisory system. It aims to improve farm productivity by delivering high quality personalized (farm-specific) aqua expert advice in a timely manner to each farm at the farmer's doorstep [24]. The aquaculture extension services are extended through ICT tools like database, internet and digital photographs [25].

E. **Aqua-Choupal**

The Aqua-Choupal model in Godavari districts of Andhra Pradesh, a web supported initiative of the Indian Tobacco Company (ITC) was designed to provide market and farming related information to enhance farmers' productivity and their farm-gate price realization. This approach revolved on a network of information units called Aqua-Choupal equipped with a computer connected to the internet, located in villages. Through Aqua-Choupal, farmers could access information on weather, scientific farming practices and market price. Aqua-Choupals also facilitate the supply of farm inputs to the farmers as well as purchase of shrimps at their doorstep [26].

F. **indiaagristat.com**

It is a comprehensive source for Indian agriculture statistics which is regularly updated. It provides authentic statistical information on sectors like agricultural education, agricultural export, agriculture census, agriculture prices, agricultural insurance, animal husbandry, agricultural marketing, horticulture production, agricultural wages and all other relevant agricultural statistics of India [27].

G. **Electronic solutions against agricultural pests (e-SAP**)

**e-SAP** is an ICT based system developed by UAS, Raichur, Karnataka to help the farmers by providing solutions right in their field as mobile application tool. e-SAP targets one of the critical requirements of a crop cycle, pest management. e-SAP consists the features that brings the farmer, extension worker, scientist and policy maker on the same platform, thereby helping them for pest management.

H. **Geo-informatics technologies**

At present, Geographic Information System (GIS), Remote Sensing (RS) and Global Positioning System (GPS) are used in convergence for animal disease management. Both GPS and GIS collect and analyze the data with geographical reference respectively. These geo-reference points are based on the longitude and latitude coordinates of the location under study. GIS based applications in agriculture helps to analyze the cropping area, cropping pattern, pest and disease attack, yield prediction, etc. to take up the appropriate measures in time.

I. **E-learning courses on aquaculture**

Initiated with the financial support of National Agricultural Innovation Project (NAIP), of Indian Council of Agricultural Research (ICAR), the College of Fisheries, Mangalore and Fisheries College and Research Institute, Thoothookudi have developed the e-learning courses for undergraduate fisheries programme to enable the students throughout the country to acquire more effective learning systems. The e-learning courses would enable the students to interact with the teachers more effectively to enhance their knowledge and skills apart from providing them an anytime and anywhere learning opportunity [28].

J. **'Phone- in' Programme (PiP)**

The PiP is an e-initiative and service facility where farmers/ fishermen can telephone and record their queries on a given telephone number. It would be called back and provided the required information. At the time of live interaction, they can ask questions to the experts at the station and get replies to their queries immediately. The Central Institute of Brackishwater Aquaculture in collaboration with M.S. Swaminathan Research Foundation (MSSRF) conducted PiPs on "Better Management Practices (BMPs) of Shrimp farming and Sea Bass Culture and its Farm Management Practices" several times to educate the farming community.

K. **e-TSA**

The extension module on Tiger Shrimp Aquaculture (e-TSA), a PC based application was developed for knowledge management and dissemination of Better Management Practices (BMP) of tiger shrimp (Penaeus monodon). Information on BMPs has been covered under ten headings, viz., site selection, pond design and construction, pond preparation, seed selection and stocking, feed management, water quality management, health management, water management, harvest and post-harvest management, and shrimp farm bio-security [29].

## (VII) Mobile phone applications in Indian Agriculture

Mobile phones are becoming an essential device for all types of users irrespective of the age group. In India mobile technology has unleashed a paradigm shift in the communication medium to reach out to the masses.

Digital India, launched in 2015 by Indian Prime Minister Narendra Modi, aims towards the promotion of digital literacy and creation of digital infrastructure for empowering rural communities. Considering that 58% of rural households depend on agriculture as one of their most eminent source of livelihood, the role of Digital Agriculture needs to be considered within Digital India.

The use of Information and Communication Technology (ICT) to support the transmission of localized information and services working towards making farming socially, economically and environmentally sustainable, while contributing to the delivery of important information in the field agriculture comprises Digital Agriculture. This led to the rise and development of mobile apps in several aspects of agriculture to reach farmers in rural India. This digital change is acting as a game-changer for Indian agricultural conditions**.**

### A. Technology dissemination through mobile phones

Mobile phones are the most important medium through which short messages on farming and related aspects can be communicated to the farming community as well as extension workers. Based on a detailed information need assessment the subject matter is made as short technical messages and were disseminated *via* SMS for the officials of Department of Fisheries of states and farmers in vernacular languages**.**

#### (i) Kisan Call Centre

The Department of Agriculture & Cooperation, Ministry of Agriculture, Govt. of India launched Kisan Call Centres across the country to deliver extension services to the farming community. A Kisan Call Centre consists of a complex of telecommunication infrastructure, computer support and human resources organized to respond to queries raised by farmers in their local language. The subject matter specialist using telephone and computer, interact with farmers and answers the queries at the call center (1800 180 1551) [30].

#### (ii) Kisan Suvidha

It provides information on current weather and also the forecast for the next five days, market prices of commodities/crops in the nearest town, knowledge on fertilizers, seeds, machinery etc. The option to use the app in different languages makes it more widely accessible [31].

#### (iii) IFFCO Kisan Agriculture

The user can access a variety of informative modules including agricultural advisory, weather, market prices, agriculture information library in the form of text, imagery, audio and videos in the selected language at profiling stage. The app also offers helpline numbers to get in touch with Kisan Call Centre Services [32].

#### (iv) RML Farmer – Krishi Mitr

It provides agricultural advice and news regarding the government's agricultural policies and schemes. Users can choose from over 450 crop varieties, 1300 mandis, and 3500 weather locations across 50,000 villages and 17 states of India. It works with the help of specific tools designed to analyze or provide information on different aspects of farming habits.

#### (v) Pusa Krishi

The app also provides farmers with information related to new varieties of crops developed by Indian Council of Agriculture Research (ICAR), resource conserving cultivation practices as well as farm machinery and its implementation will help in increasing returns to farmers [33].

#### (vi) AgriApp – Smart Farming App

It provides complete information on Crop Production, Crop Protection and all relevant agriculture allied services. It also enables farmers to access all the information related to "High value, low product" , crop varieties, soil/climate, harvesting and storage procedures. An option to chat with experts, video-based learning, the latest news, online markets for fertilizers, insecticides etc. are also available in this app. [34].

#### (vii) Kheti-badi

It is to promote and support 'Organic Farming' and provide important information/issues related to farmers in India. Agriculture today is heavily dependent on genetically modified seeds, chemical pesticides and fertilizers; this app helps farmers to switch their chemical farming into organic farming. However, this app is currently available in four languages viz., English, Hindi, Marathi and Gujarati [35].

#### (viii) Agriculture Marketing

Farmers can get information related to prices of various agricultural commodities in the market within 50km of their own device location using this mobile application [36].

#### (ix) iKisan

It is the ICT based information system initiative of the Nagarjuna group of companies, the biggest private entity supplying farmers' agricultural needs. iKisan.com website provides agricultural information online to diagnose, analyze and advise about insect pests. This is a web based information system Provides crop production information for 20 crops, namely rice, chilli, cotton, soybean, maize, groundnut, turmeric, banana, citrus, coconut, tomato, red gram, Bengal gram, green gram, black gram, sunflower, sugarcane, castor and mango [37].

(x) **Kisan Mandi**

Kisanmandi.com is free online Agri-Market service for the farmers to buy or sell or advertise fruits, vegetables, farm machinery and tools and other agricultural products [38].

(xi) **Artificial Intelligence (AI) based Mobile APPs**

Apart from several mobile apps in the field of agriculture, Artificial Intelligence based mobile apps have been developed recently and it is in wider use of the farming community.

**Table 1.** List of AI based mobile applications

| S.No | Name of the Mobile application | Usage | Weblink |
|---|---|---|---|
| **1.** | **Plantix** | Plantix is being used for mobile diagnostic tool for fruits, vegetables and field crops. | https://plantix.net |
| **2.** | **PlantNet** | It helps to identify plant species from photographs, through a visual recognition software. | https://identify.plantnet.org/ |
| **4.** | **iNaturalist** | iNaturalist helps you identify the plants and animals | https://www.inaturalist.org/ |
| **5.** | **ripeSense** | Intelligent sensor label that changes colour to indicate the ripeness of fruit. | https://product.statnano.com/product/6730/ripesense |
| **6.** | **CropIN** | CropIn is an intuitive, intelligent, self-evolving system that delivers future-ready farming solutions to the entire agricultural sector. Digitizing every farm with capabilities of live reporting, analysis, interpretation and insights. | https://www.cropin.com/ |
| **7.** | **Agribotix** | Agribotix provides the agricultural intelligence services that provides fully supported, user-friendly, drone-enabled technologies and services developed exclusively for agriculture. | https://agribotix.com/ |
| **8.** | **eNirog** | This innovative mobile app is specifically designed to assist in diagnosing pests and diseases that commonly affect the important crops of Bihar, India | https://play.google.com/ |

## (VIII) The Barriers in ICT Implementation in India

Educating and catering to the farmers with precise agricultural knowledge across nearly seven lakh villages in India indeed sounds unrealistic as this would require immense financial investment. A one-time major investment in establishing communication technologies in the required places restrict the government's objective of covering more people regularly because of insufficient power availability in rural areas, poor ICT infrastructure, ICT illiteracy, non-availability of timely relevant content, non-integration of services, poor advisory services and lack of localization, and in particular non availability of agricultural information kiosks/ knowledge centers at the grass root level.

Moreover, farmers sometimes become averse to adopting technology as they think that it might result in their traditional methods of cropping practices. They simply do not want to use such systems, even if the cost incurred is negligible. Therefore, the attitude and mindset of farmers needs to be changed first. There is a need to win their confidence and create awareness about the benefits of ICT in agriculture.

## (IX) Conclusion

The present study will explain about present scenario of agriculture globally and in India and also the effect of information and communication technology in developing the sector with its different tools and aware the farmers with new technology for good management, site selection, diagnosis of pest and diseases, harvesting and marketing, etc., and other strategies. Though the use of Information and Communication Technology in agriculture is in a promising phase in India, ICT has huge potential to standardize and regulate agricultural processes and address the needs of farmers. It will therefore definitely serve as an important tool for agricultural development in the near future. It is concluded that the present study will help in enhancing the knowledge about ICT in agriculture and its great hand for its improvement in Indian agriculture.

## (X) Future Scope the Study

This study helps to prospective researchers to know various initiatives taken by government & corporate which are undergoing a paradigm shift from being a regulatory requirement or a social obligation to being a viable business proposition. Further this study helps to get an insight about the certain issues of agricultural development with special emphasis on challenges for India to implement the same. The objective of this research paper is to know various initiatives taken by the government, corporate, NGOs, etc. related to development of information and communication technology (ICT) which are in the forefront for agricultural/rural development in India. Despite the huge potential of harnessing ICT for agricultural development, only a few isolated projects have been initiated in India and in other parts of the world. Interestingly, many of these projects were initiated by NGOs, private organizations, cooperative bodies and government organizations rather than by government-established agricultural departments. This shows the apathy of agricultural development departments towards incorporating ICT in their day-to-day activities. To formulate a strategy for overall agricultural development, isolated ICT projects need to be studied and the experience gained must be documented in order to draw lessons for the future. On the other hand, the need to market agricultural produce at competitive prices will also change the farmers' attitude towards the usage of ICT. ICT will thus help to sustain Indian agriculture.

A mission mode of ICT programmes for extension services integrating with research-extension-farmer-inputs and marketing need to be planned and implemented at the State level for technology dissemination in agriculture and allied sectors will be a fruitful solution in Indian agriculture.

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