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Transforming Indian Agriculture with Digital Technologies

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Agriculture continues to be the most important sector of the Indian economy and agriculture is a more or less a compulsion for livelihood of millions of farmers. Now-a-days, Indian agriculture faces several problems such as low yield, inconsistent product quality, lack of knowledge about domestic as well as international markets and poor access to diversified agriculture information. Farmers need location specific information at the time of all the cultivation stages of agriculture in their local language. To meet out these problems, adoption of digital technology is one which improves the information transmission speed, networking, communication at their doorsteps and provides quality information in an understandable way to the farmers. Digital communication technologies when applied to condition in rural areas can help to improve communication by increasing the participation and also disseminating various information to increase their knowledge and skills. Digital efforts are being tried out by different Governments for the betterment of the agricultural sector and farmers. The digital technology in India is now at the crucial stage. Various digital initiatives such as Digital green, mobile technology, e-Choupal, precision farming, agricultural drones *etc*. should be promoted

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at large scale to improve the adoption of new technology by farmers. By this we can solve the problems like low yield, inconsistent product quality, lack of knowledge about domestic as well as international markets and poor access to diversified agriculture information.

Keywords: Digital technologies; farmers; networking; mobile technology; digital green.

ABBREVIATIONS

KVK- Krishi Vgyan Kendra,
SAUs- State Agricultural Universities

1. INTRODUCTION

Agriculture provides livelihood for more than 72 per cent of people who live in rural areas and also gives largest concentration of poverty and food insecurity. Poverty as a result of low income is attributed to the low agricultural productivity, inadequate research, extension and farmer linkage. Hence, attempts to reduce poverty in rural area should therefore pay a special attention in transforming the agriculture sector. Access to information and improved communication is a crucial requirement for sustainable agricultural development. Efficient agricultural sector where extension services should play a key role in disseminating the agricultural technologies and information and also in linking farmers with other actors in the economy. In India, marginal and small farmers' average holdings size is about 0.38 hectares when compared to 17.37 hectares for large farmers, which cannot generate adequate employment and income from crop cultivation [1]. The small and marginal holding farmers cultivate around 44 % of the area, and they produce around 60 % of the total food grain production and over half of the country's fruits and vegetables production [2].There is growing demand for rapid input, service and information delivery among the farmers although, fulfilment of these demands solely by public extension system is limited [3]. These millions of small and marginal farmers and many of those are uneducated and have little or no access to resources to access modern technology in agriculture [4]. Information and Communication Technology has emerged as a tool for achieving meaningful societal transformation and it is an emerging tool for achieving meaningful societal transformation [5].

Digital communication technologies when applied to condition in rural areas can help to improve communication by increasing the participation and also disseminating various information to increase their knowledge and skills. ICT's (Information Communications Technologies) are the effective extension approaches which directly provide farmers with important information such as patterns in crop production new seed varieties, crop management and marketing related aspects in an effective manner, which in turn related to social and economic development of the rural people [6]. Modern Information Communications Technologies (ICT's) such as Internet, e-mail, mobile phone, Personal Digital Assistance (PDA), social networking such as You Tube, twitter, Facebook, Myspace, have extended the communication. In addition to e-governance initiatives which was introduced to facilitate speedy delivery of services as a part of the civil service reform processes has accelerated the access to public services. In modern times, the agricultural extension initiatives such as expert system, agri-portals, audio and video conferencing systems, Kisan Call Centers (KCC), Kisan Mobile Advisory Services (KMAS), e-marketing networks which have simplified the work of extension agency besides providing accurate information to the farming community [7].

1.1 Objectives

1. To know the concept of digital technology and its importance
2. To understand the digital technologies related to agriculture

1.1.1 Concept of digital technology and its importance

1.1.11 Digital technology

Digital technology is the branch of scientific or engineering knowledge that deals with the creation and practical use of digital or computerized devices, methods, systems, etc. Digital technology is a type of transfer that involves breaking a message or form of communication between two machines down into binary code. Binary code consists of all ones and zeros. Digital technology uses digital code to transmit signals and information between different devices.

1.1.2 History of digital technology

Techniques were based on the 17th-Century German Mathematician, Gottfried Wilhelm Leibniz Proposed a binary computing system that described objects with digits.

Digital includes Websites**,** E -mail marketing**,** Mobile web**,** Lap-top and computers**,** Mobile apps**,** Cable Networking**,** Social media**,** Simputers**,** Video and tele-conferencing, etc.

1.1.3 Importance of digital technology

1.1.3.1 Social transformation

- ✓ Easy access to people
- ✓ Welfare Services of the government, NGO's, Co-operatives, and so on
- ✓ Awareness creation about updated information in the science and technology institute.

1.1.3.2 Empowerment

- ✓ Expanding the use of govt. services
- ✓ Economic development
- ✓ Rural development
- ✓ Poverty alleviation
- ✓ Intermediary between the government and the people
- ✓ Women empowerment in rural area

1.1.4 Significance of digital transformation

A digital transformation will help the farmers in multiple ways.

1.1.4.1 Access to finance

In India farmer's faces acute shortage of money due to the many challenges highlighted earlier. Digital transformation helps the farmer in getting access to funds from various sources due to the awareness and exposure they get from being digital.

Fig. 1. American engineers – 20th century, discovered digital technology

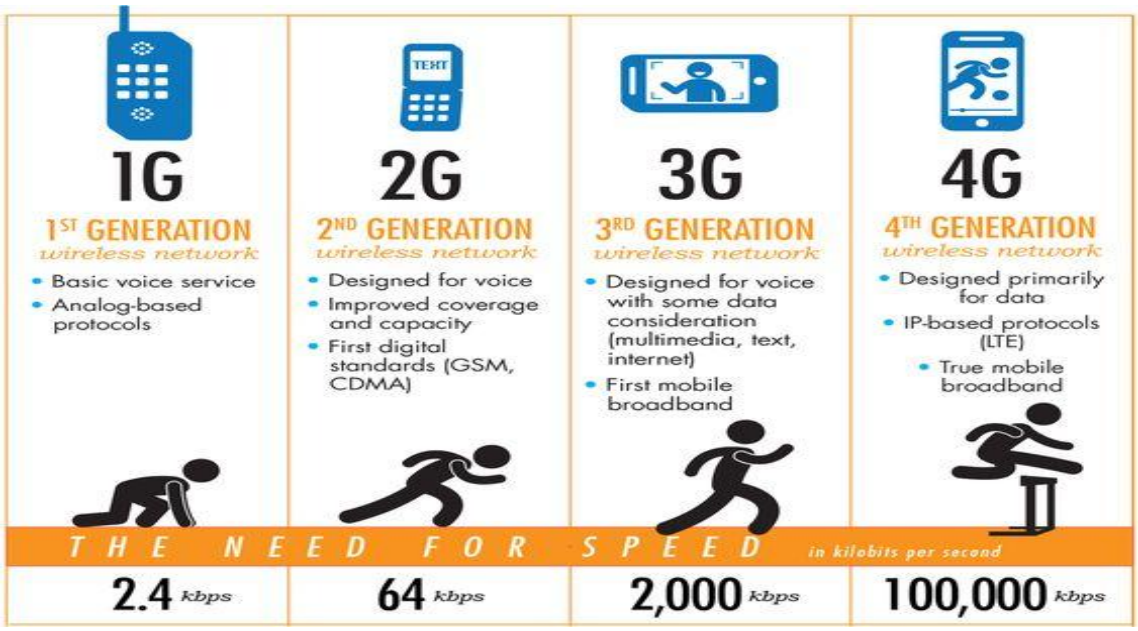

Fig. 2. Digital era: 1to G to 2G to 3G to 4G

1.1.4.2 Forecasts on climate change

In India having the right inputs on potential Climate Change will help the all the farmer to decide the right seed to grow, increase productivity and in turn fulfil the Market demand.

1.1.4.3 Access to farming equipment and new technology

In many countries, Robotics play a important role in agriculture sector. India is yet to see robotics advancement and hence there is a crucial need for this transformation.

1.1.4.4 Inputs for better soil fertility and soil structure

In India the farmer rarely does an investigation of the fertility of the soil and which kind of seed to grow. There is a need to have a more scientific method to agriculture.

1.1.4.5 Access to markets

Due to middle-men involved in the buying and selling of the farmer's products, the actual farmer gets a nothing compared to the profits that the middle-men make. There is a need for a platform which will enable the farmer to sell directly to the buyers.

1.1.4.6 Access to information

The farmer will have to try out new experiments based on the information available which will help them to produce more and get the right financial backing. The digital transformation is expected to handle this appropriately.

1.1.4.7 Small land holdings

Many farmers in India have very little land which does not help to grow the right crops. This needs to change if we need to overcome the challenges.

1.1.4.8 Predictive analytics

Using the latest new technology available in the market, if the agriculture sector is ignited with this digital transformation, the amount of information that would be available will help the farmer to grow the right crops at the right time. Thus the standard of living for the Indian farmer would go up, which would in turn encourage others to get engaged in farming. [8].

1.1.5 Initiatives of Digital Technology

1.1.5.1 Government of India

1.1.5.2 Agmarknet

It is one of powerful ICT initiative for Rural Empowerment, a Warehousing of "data-for-development" & a "free-trade-zone" on Internet. A step towards Agricultural reforms in India - Networking of APMCs for dissemination of Agricultural produces Market prices information - 735 APMCs by March 2002 and additional 2000 APMCs during 2002-07 and a road Map to cover 7000 APMCs. It's a well-known fact that Indian farmers rarely know the actual price and stock level of his produce at the mandis where they come to sell it. The portal providing agricultural marketing related information from a single window and helped to reach farmers who do not have sufficient resources to get adequate market information. It facilitates web- based information flow, of the daily arrivals and prices of commodities in the agricultural produce markets spread across the country. AGMARKNET information is helpful to access nearby markets as expressed by 60.00 %of the traders. Again 80.00 % of the traders are of the view that markets are integrated through AGMARKNET. Nevertheless, the said information is helpful in retention of stored produce expressed by 13.34 % of the traders as compared to 20.00 % traders undertaking horizontal and vertical integration of markets/business. However, only 6.66 % of traders have traded new commodities after receipt of information through portal [9].

1.1.5.3 Agrisnet

A NICNET based Agricultural Informatics & Communication to facilitate Higher Sustainable Agricultural productivity and establish "Indian Agriculture on-line" in the Country. A Central Sector Scheme for Strengthening ICT Apparatus for Agriculture &Cooperation in States & UTs Department of Agriculture & Cooperation Ministry of Agriculture.

1.1.5.4 ATIC (agricultural technology information system)

ATIC is a "single window delivery system" for different innovative and farm worthy technologies. ATIC established during the NATP (1998). The participating institutions/ SAUs are expected to provide support in terms of technological as well as methodological

backstopping for implementation of the project. A study conducted by [10] Punjab Agricultural University on Level of Satisfaction of Farmers from the Services Provided by Agricultural Technology and Information Centre (ATIC) Run by Punjab Agricultural University. The overall satisfaction towards ATIC services, findings of the study revealed that more than half (54.5 %) of the farmers had "high" level of satisfaction while one third (33 %) of the farmers had "medium" level of satisfaction and remaining percent of the farmers no satisfied with the services. These findings will provide useful guidance to the ATIC for designing effective extension strategy for delivering the services to the farmers in better and efficient way.

1.1.5.5 Hortnet (horticultural network)

This is launched on September 2009 and 372 districts were covered during NHM (2005). This network provide one stop nonstop solutions to the farmers, extension workers, bank officials etc. and render service to the farmers by government departments. Transparent field verification and authentication using mobile, GIS, GPRS technology. Education to even illiterate farmers to update skill and knowledge with the multimedia technology based modules.

1.1.6 State Initiatives

1.1.6.1 Gyandoot

Gyandoot is an Intranet based Government to citizen service delivery portal commissioned in Dhar district of Madhya Pradesh. Implemented in January 1, 2000 in Dhar district. The Computers in 21 major centers in five Blocks of the district were connected through an intranet network. This intranet has been named Gyandoot. These computers have been established in Gram PanchayatsSoochanalayas.

1.1.6.2 Bhoomi

Bhoomi is centrally sponsored scheme implemented by the government of Karnataka. The project was implemented in the year 2001. Bhoomi covers more than 20 million land records and more than 6.7 million land owners in the Karnataka state. Farmers today can obtain a print RTC copy for a fee of Rs.15 from a computerized land record kiosks (Bhoomi centers) located in 177 *taluka* offices. National Informatics Centre (NIC, Bangalore) developed the Bhoomi land records management software. Farmers can obtain copies of land records within a couple of minutes at the Bhoomi Land Records Kiosk.

1.1.6.3 E-sagu

E-Sagu is an IT-based agro-advisory system by IIT, Hyderabad:

- Personalized: Agriculture expert advice at the farmer's door-step.
- Query-less: Farmers need not ask a question
- Continuous: Advice is provided regularly (once in a week) from sowing to harvesting.
- Timely: Provides the advice within 24 to 36 hours
- Cost-effective

1.1.6.4 Akshaya Kerala

Primary contact point for residents, First district wide e-literacy project in India. 600 Akshaya Kendra's in 600 villages Working since 2002. The major services provided includes like Agriculture Information System, Implementation of Health Data Acquisition System, Government Services and E-Education. The study conducted on Effectiveness of Grassroots ICT Projects: A Case Study of the Akshaya Project of Kerala State, India [11]. The study found that although over half of the respondents had heard about the project, very few were aware of the project's services. The few who accessed the services did so mainly e-payment purposes. Thus, a communication strategy which combines interpersonnal and multimedia channels needs to be explored and implemented. It is suggested that before and after launching any ICT initiative, the information needs of the community should be thoroughly assessed. It is the people, not the project, who actually bring up the development.

1.1.7 NGO (non-government organization)

1.1.7.1 Digital green

Digital Green is a ne of the research project initiated by NGO that seeks to disseminate targeted agricultural information to small and marginal farmers in India using digital video. The unique components of Digital Green are (1) a participatory process for content production, (2) a locally generated digital video database, (3) human-mediated instruction for dissemination and training, and (4) regimented sequencing to

initiate a new community. Unlike some systems that expect information or communication technology alone to deliver useful knowledge to marginal farmers, Digital Green works with existing, people-based extension systems and aims to amplify their effectiveness. While video provides a point of focus, it is people and social dynamics that ultimately make Digital Green work.

Digital green, an origination that trains farmers in sustainable practices in developing a voice-enabled WhatsApp chatbar. The technology provide seamless market connection, enabling marginal and small farmers to improve their income and economic disrupted caused by COVID-19 [12].

1.1.7.2 Information village project

This projectimplemented by MSSRF in collaboration with International Development Research Centre (IDRC). Working since 1998 and important objective is providing demand driven and day to day relevant information.

1.1.8 Private

1.1.8.1 e-Choupal

*e-C*houpal is 'village gathering place' in Hindi and launched in June 2000. 'e-Choupal' services today reach out to over 4 million farmers growing a range of crops in over 40,000 villages through 6500 kiosks across ten states, Web-enabled, real-time data on crop prices gives farmers an accurate picture of the prices they can expect from ITC and different mandis. The states under the project viz, Madhya Pradesh, Uttar Pradesh, Andhra Pradesh, Karnataka, Haryana, Uttarkhand, Rajasthan, Maharashtra, Kerala and Tamil Nadu. ITCs e-Chaupal has proved to be comprehensive digital knowledge hub for farmers which has 6,100 installations covering 35,000 villages serving 4 million farmers [13].

1.1.8.2 Tata-Kissan Kendra's

Agro input retail outlets established by Tata Chemicals Limited in association with Rallis. Agro inputs like seeds, fertilizers, pesticides and irrigation and farm implements and covers Uttar Pradesh, Haryana and Punjab.

1.1.8.3 e-Krishi (UASB) agri portal

It provide information on agriculture, horticulture, sericulture, animal husbandry, fisheries, supplementary topics, farm mechanisation, ITK, District profile and training programmes and also provide Government programme information, krishi news weather report and question answer forum.

1.1.8.4 e-SAP (Electronic Solutions against Agricultural Pests):

It is adedicated hand-held devices provide field users with all the relevant information in their hands which can be accessed offline.

1.1.8.5 Advisory

- ✓ Image & voice assisted pest identification
- ✓ Detailed pest information
- ✓ Management schedules

1.1.8.6 Field device

There is real time expert connect to handle emergencies and unknown field situations

- Voice assisted feedback
- Image assisted feedback
- Real-time information transfer

1.1.8.7 Digital technologies related to agriculture

1. Computers and Websites
2. Broadcasting
3. Satellite
4. Mobile
5. Internet and Broadband
6. Sensor Networks
7. Data Storage and Analytics

2. COMPUTERS AND WEBSITES

A computer is a device that accepts information (in the form of digitalized data) and manipulates it for some result based on a program or sequence of instructions on how the data is to be processed**.** These provides us Agricultural information and market price information, Weather prediction**,** Record keeping**,** Farmer communication**,** GIS: Construct maps, Combine information, Make scenarios, Present ideas, Develop solutions, Soil conditions, Drainage conditions, Slope conditions, Soil pH., Nutrient status**,** Automated farm equipmentandE-Agriculture. A website is a collection of related web pages, including multimedia content, typically identified with a common domain name, and published on

at least one web server. A website may be accessible via a public Internet Protocol (IP) network, such as the Internet, or a private local area network (LAN), by referencing a uniform resource locator (URL) that identifies the site. All publicly accessible websites collectively constitute the World Wide Web, while private websites, such as a company's website for its employees are typically a part of an intranet.

2.1 Market Websites

e-mandi, Mandi trades applications, AgriMarket, Krishimaratavahini, Digital Mandi India, http://agmarknet.nic.in.

The Government wants to promote virtual agricultural market by providing common electronic platforms to farmers for selling their produce to buyers all over country. National Agriculture Market online trade portal has been created [14].

2.2 Indian Agricultural Web Sites

- www.ycmou.com/agri
- www.khetiwadi.com
- www.kisan.net
- www.krishiworld.com
- www.nic.in/agrico
- www.pravara.com
- www.agrinto.com
- www.nabard.org
- www.agriwatch.com
- www.ciks.org/agri.html
- www.agri.mah.nic.in

2.3 Broadcasting (Expertise Sharing and Advisory)

2.3.1 DD Kisan

This channel launched on 26 May 2015 and it is a Indian agriculture 24-hour TV channel, Owned by Doordarshan and broadcasting programmes on Agriculture and related sectors, new farming techniques, water conservation and organic farming.

2.3.2 Krishi Darshan

(Hindi and English: Agriculture Vision) is an Indian television
program on Doordarshan aimed at disseminating agricultural information to rural and farming audiences. It commenced on 26 January 1967 and is one of the longest running programs on Indian television. Timing of programme 6.30am morning. In Karnataka: DD chandana TV.

2.3.3 Annadata programme

ETV Kannada channel in Karnataka state. The program gives complete information on agriculture including various aspects like planting, seeds, the greenhouse effect and much more.

2.3.4 Community radio

Community radio is a type of radio service that caters to the interests of a certain area and broadcasting content that is popular to a local audience. Community radio is confined to a small geographical area. It depends on low power transmission covering not more than 20-30 km. radius. It serves a community which uses common resources for livelihood and food security, has common development issues and concerns, which are relatively localized, nevertheless connected to national and regional development goals. Community Radio gives a voice to the community they serve with programmes in local languages, respecting local culture, traditions and interests.

2.3.5 Satellite

Satellite is an artificial body placed in orbit round the earth or another planet in order to collect information or for communication [15].

2.3.6 Remote sensing

It involves gathering and recording data from great distances. Most remote sensors are located on satellites that orbit the earth. It is a valuable tool in evaluation, monitoring and management of land, water and crop resources. Producers use remote sensing to forecast the weather, locate natural resources, and detect crop diseases and captures satellite imageries.

2.3.7 GIS (Geographic information systems)

GIS is a computer system capable of capturing, storing, manipulating and displaying spatially referenced information. GIS is computer based technology capable of gathering, storing, analysing and retrieving geographically referenced data. GIS combines different kinds of data (map, tables, digital data and point data). GIS is an invaluable tool in planning and monitoring of natural resources like soils, land

use etc., it can be used in decision making tool in agriculture. It can take into account of soil fertility, gradient of lands, annual rainfall and availability of labour across the market.

2.3.8 GPS (Global positioning systems)

GPS is a system of satellites orbiting the earth at very high altitudes. GPS is common in cars, boats and cell phones. 24 satellites continuously broadcast position and time data to users throughout the world. The development and implementation of precision agriculture/farming or site-specific farming has been made possible by combining the Global Positioning System (GPS) and Geographic Information Systems (GIS). These technologies enable the coupling of real-time data collection with accurate position information, leading to the efficient manipulation and analysis of large amounts of geospatial data. Global Positioning System (GPS)-based applications in precision farming/agriculture are being used for farm/field planning, field mapping, soil sampling, tractor guidance, crop scouting, variable rate applications and yield/productivity mapping. Global Positioning System (GPS) allows farmers to work during low visibility field conditions such as rain, dust, fog, and darkness.

2.4 Weather Forecasting

It is the application of science and technology to predict the state of the atmosphere for a given location. Collecting quantitative data about the current state of the atmosphere at a given place and using scientific understanding of atmospheric processes to project how the atmosphere will change. Farmers rely on weather forecasts to decide what work to do on any particular day. For example, drying hay is only feasible in dry weather. Prolonged periods of dryness can ruin cotton, wheat, and corn crops. While corn crops can be ruined by drought, their dried remains can be used as a cattle feed substitute in the form of silage. Frosts and freezes play havoc with crops both during the spring and fall.

The Satellite based remote sensing combines the historical records with the real time observations and helps in predicting problems even before the real symptoms appear. Climate Smart Agriculture through Digital Platforms providing weather-based insurance; Use of ICT for dissemination of climate information based agro-advisories for pevelopment of decision-support tools for planning and investment. Emphasis on organizations as mechanisms for linking between national-level and community-level adaptation, and associated range of activities , Selection of technologies to local contexts, mapping local institutions and working in partnership across institutions, Gender and social inclusion in climate change adaptation and developing Success factors include participative and locally driven vulnerability assessments and tailoring of adaptation measures [16].

2.4.1 Mobile: advisory, sale, banking and networking

2.4.1.1 Mobile and internet penetration in India

According to Telecom Regulatory Authority of India [18] reported that, 71.84 crore of the subscribers found in year 2019 which increased to 74.319 crore by quarter ended March 2020. The total number of smart mobile phone users in India to rise to nearly 83 crore by 2022. The role of digital agriculture need to be considered within digital India b considering that nearly 58 % of rural households depends on farming as one of their most important source of livelihood. The use of ICT to support the transformation of local information and services working towards farming socially, economically and environmentally sustainable, while contribution to the delivery of economic and nutritious food for all and this comprises the digital agriculture. This also led to the rise and development of mobile apps which are helping government schemes programmes and other farming related-based information to reach farmers in rural India. The digital technology change is acting as a game changer for Indian farming condition [12].

Table 1. Number of Mobile Phones Used in Different Countries

Country	Number of mobile phones	Population	Phones per 100 citizens
World	620 crore	7.432 billion	87
Chin	120 crore	1.38 billion	89
India	86 crore	1.32 billion	79
USA	32 crore	324.1 million	103

([17], Source:-www.en.wikipidia.org August, 2016)

2.4.2 Mobile advisory services - public sector [19]

2.4.2.1 Farmer call centre (Kissan Call Centre)

The Department of Agriculture & Cooperation (DoA&C), Ministry of Agriculture, Government of India launched Kissan Call Centres (KCC) across the India on January 21, 2004, to deliver extension services to the farmers and farming community. The purpose or objective of these Kissan Call Centres is to respond to issues raised by farmers in their area, instantly, in the local/regional language. Queries related to agriculture and allied sectors are being addressed through these farmer call centre. It was accordingly proposed to make use of existing specialized infrastructure of Call Centres and make this communication backbone available to the Subject Matter Specialists (SMS) / Specialists of Agriculture, Horticulture, Animal Husbandry, Marketing, Sericulture and other related areas. The Farmer Call Centre/Kissan Call Centres consists of three levels – namely Level-I (the basic Call Centre interface, with high quality bandwidth and local language proficient Agriculture Graduate), Level-II (Subject Matter Specialists on concerned important crops and Enterprises, connected through good bandwidth telecom and computer Connectivity) and Level-III (The Management group to ensure ultimate answering and resolution of all the farmers' queries which are not resolved at Level-II, Connected on and off line mode). Kisan call centers (KCC) provide services to farmers where they can directly interact with the graduates or experts for their farming related queries. They are provided information through mobile phones with regard to suitable techniques needed to maintain the fertility of the soil to increase production is showing positive results [14].

2.4.2.2 Mobile advisory services by ICAR-KVKS

Mobile advisory services to the farmers by the Farm Science Centres (kvks) of the Indian Council of Agricultural Research (ICAR) have been operational since, 2008. The Farm Science Centre (KrishiViigyan Kendra -KVK), Babhaleshwar, India has pioneered in the IT-enabled service aiding instant messaging from Farm Science Centre to individual farmers for extending agricultural information through SMS alerts. Weekly SMS alerts are issued on various agricultural developments like weather forecast, disease forecast and Market information (http://www.kvk.pravara.com). KVK, Chhindwara, Madya Pradesh implemented a programme called "Kisan Mobile Sandesh" for giving Bulk SMS to the farmers. From the year 2010 onwards high amount of ICAR- KVKs have been disseminating farm related information by Kisan Mobile Advisory Services (KMAS) to the farmers.

2.4.2.3 SMS broadcast service by KVK, Babhaleshwar

The Farm Science Centre (KrishiViigyan Kendra -KVK), Babhaleshwar, India has pioneered in the IT-enabled service aiding instant messaging from Farm Science Centre to individual farmers for extending Agricultural information through SMS alerts in the year 2006. The service comprises sending Short Message Service alerts on cellular phones registered at Farm Science Centres by individual farmers. Weekly SMS alerts are issued on various agricultural developments like weather forecast, disease forecast and market information. The service is also being used as a medium to send information on important Trainings and other programmes to the members of the Farmers Clubs and SHG network under the Farm Science Centre.

2.4.2.4 Mandi on mobile service by BSNL

Uttar Pradesh farmers are able to know rates/price of agriculture commodities in any market in the State on their mobile phones, service was launched by the State-run telecom major Bharat Sanchar Nigam Ltd (BSNL) teamed up with the Uttar Pradesh Agricultural Marketing Board (Mandi Parishad) to launch the 'Mandi on Mobile' service for the farmers. The service would be voice-based. To know the rates/price of over 100 commodities including agricultural crops, horticultural crops, vegetables and other farming related items, the farmers need to dial/ call on a specific number from their BSNL cellular phones, and then follow the voice command subsequently [20]

2.4.2.5 VKVK (Virtual Krishi Vigyan Kendra)

It is a simple messaging system basedPlatform allows Agro-advisories to be sent to the farmers' cell phone using SMS alerts and voice-based advisory. vkvk is a platform that connects kvks with farmers through internet and mobile technology. A phone-based delivery system allows an agricultural expert to transmit a voice-based alert/advisory to be transmitted to farmers through a phone call. A recorded message can be transmitted via vkvk platform to all farmers under the guidance of KVK experts. This platform is currently being tested in some selected

districts of Uttar Pradesh, Uttarakhand and Karnataka [21].

2.4.2.6 mKISAN

The mkisan project has been launched with the support of mfarmer initiative challenge fund. The International Livestock Research Institute (ILRI), India is implementing the mkisan project in partnership with Handygo technologies, a mobile value adding service provider, CABI South Asia, and Digital Green, an NGO for video enabled extension. The project proposes to develop a comprehensive agro-advisory services for small holders with access to a mobile phone in India. The project has objectives such as to provide daily bulletins on agro-meteorology, crop pest and livestock diseases outbreaks, market information, and information on local service provision sources and information access to women farmers.

2.4.2.7 Kisan help line

Since 2012, Bihar Agricultural University, Sabour, has started a help line for the farmers of the region. The farmers can call on the helpline number 0641-2451035 and ask their queries to the agricultural scientists from different streams. The helpline works from 10 a.m to 5 p.m on all working day. Different Institutions related to farming sector such, as State Government's department of agriculture, State agricultural universities (SAUs), Krishi Vigyan Kendras (KVK), regional research institutions, farmer producer organizations (FPO), corporate/industrial/business houses and multinational companies engaged in manufacturing/production and distribution of farm inputs, farm equipment and machinery, rural financial institutions, insurance companies can contribute their professional knowledge to develop digital ecosystem for agriculture and make it available for farmers. [14]. The entrepreneurs with start-ups are exploring opportunities in the field of automation, cloud integration and communication. This trend is a positive indication for government sector and private sector jointly working through digitization to revolutionise agriculture by transforming its structure and reshaping it with the modern equipment and techniques.

2.5 Mobile Advisory Services by the Private Sector

2.5.1 Lifelines India

Connectivity by innovative mix of internet and telephony reaches 200 000 farmers in 2130 villages in four states of India (www.lifelines-india.net) with more than 400,000 questions and answers in their knowledge base and eight completed crop cycles. It operates in partnership mode with other organizations and NGOs. Lifelines India-Soochna Se Samadhan (Solutions through Information), is an initiative to use the power of voice as the primary means of information dissemination. It facilitates the exchange of critical and timely information among marginalized communities so that it helps in improving their quality of life. It aims to provide connectivity, content and capability via a phone-based service. Specifically, it will provide grassroot communities with access to wide information and knowledge pool.

2.5.2 IFFCO Kisan Sanchar limited (IKSL)

Through voice messages in local languages. 95 000 voice messages have been delivered and 81 000 Q&A repository with 5 000 feedback messages from the farmers have been received. 1.3 million active farmers are benefiting from IKSL's Value Added Services and IKSL enrollment has crossed four million with forty thousand cooperative societies operating as IKSL Retailers.Bharti Airtel Limited, India's leading integrated telecommunications services provider, and Indian Farmers Fertilizer Cooperative limited (IFFCO) launched a joint venture company IFFCO Kisan Sanchar Limited (IKSL) in 2008, that is set to provide a major boost to Indian agriculture and the rural economy at large.

2.5.3 Reuters market light (RML)

Micro-information Services designed specifically for the farming community was launched by RML in 2007. It currently covers over 440 crops and varieties with more than 1400 markets and 2800 weather locations of 15 000 villages in 13 States of India.

2.5.4 mKRISHI by Tata consultancy services

mKrishi successfully pilot tested in Maharashtra [22] and Punjab [23]. mKrishi is having three combination of services using Interactive Voice Response System (IVRS), mobile based and automatic weather station information integrated service to the farmers (http://www.tcs.com). Initially mKrishi was pilot tested among the grape growing farmers of Bargaon village in Maharastra state of India. Camera enabled mobile phones with mKrishiapplication software were distributed to the farmers.

2.5.5 Nokia life tools

Nokia Life Tools is a range of services which include agriculture, education and entertainment services designed specially, for the consumers in small towns and rural areas of the emerging markets. The service provides timely and relevant information customized to the user's location and personal preferences directly on their mobile phones. Nokia Life Tools Agriculture services aim to plug the information gaps and needs of farmers by providing information on seeds, fertilizers, pesticides, market prices, and weather (temperature, rainfall, wind conditions) via their mobile phones. Information on weather, agriculture tips and techniques, as well as market prices are provided to improve farmers' productivity and earnings. Farmers are empowered with tailored and reliable information in sync with the cropping cycles delivered regularly to their mobile phones.

2.5.6 KHETI (knowledge help extension technology initiative)

KHETI, has been implemented since August, 2008, by the Sironj Crop Producers' Company (SCPCL), which is a co-operative of small farmers from the villages around Sironj in Madya Pradesh State of India with the financial support from the UK Engineering and Physical Science Research Council. KHETI provided solutions by integrating mobile phones, the internet and desktop computers, and also by using Interactive Voice Response System (IVRS). The main features of KHETI solutions are: members' profiles, member land details, crop POP profiles, Short Dialogue Strips (SDS), synchronizing conversation of mobile with server and recording conversation by mobile, transfer of conversation from mobile to server.

Fasal is a free SMS based product connecting rural farmers to buyers andProvides them up-to-date price information. Fasal, which started in 2008, establishes buyer-seller connection using SMS. The service is currently available in Gujarat, Andhra Pradesh and Karnataka. Farmers can register by calling a toll free number to the local language call centres at 1800 102 8767 and a Fasal algorithms and creating an online marketplace. Farmers can also access the call centres any time at the toll free number [24].

The Private sector plays important role in expanding e-commerce and other platforms into food supply chain to standardise production, productivity, organise the farmers and logistics capacity building in remote areas [12].

2.6 Important Mobile Applications in Agriculture and Rural Development

1. Kisan Suvidha
2. MGNREGA M-platform
3. e-mandi
4. M-Kisan
5. Mandi trades application:
6. KrishiGyanSagar and KrishiVani
7. e-KrishakSahyogi
8. Crop Insurance mobile app
9. AgriMarket
10. Digital Mandi India
11. Crop Info

The Government has launched a many mobile application to help farmers by providing agriculture related information live crop production, insect-pest management, disease management, crop management, weather forecasting and how to take care of livestock which wil help them to plan accordingly and increase social-economic status. For digital farming to success in India the innovation must focus on lowering the cost of technology so that it is available and affordable for the small farmers [25].

3. INTERNET AND BROADBAND

Table 2. Internet Users of different countries

Country	Internet users
China	300 million
USA	207 million
India	205 Million

Among 205 million internet users 110 million mobile internet users of which 25 million in rural India. Among social media sites Facebook stands first followed by WhatsApp, Youtube and Twitter. Google is the most popular search engine, accounting for 90 per cent of all searches in India [26].

The internet penetration is increasing in rural India with ~57% of rural users accessing the internet for 15 to 30 minutes daily17 With this, farmers are getting timely weather alerts along with historical data about crop diseases, standard best practices and output forecast [27].

3.1 Social Media

It is the era of internet and social networks as it helps every individual in obtaininginformation

from any nooks and corners of the world. The farmers can also access it as andwhen they require any information. So farmers can get a variety of technologies and voluminous information from the internet. These are all social media helps in spread information to the farming community in a very fast manner. Farmers become digitally empowered [28].

Fig . 3. Social Media

3.1.1 Sensor networks (real time information, better data quantity and quality and decision making)

Sensor network consists of a large number of sensor nodes and nodes deployed either inside or very close to the sensed phenomenon and mainly used for collecting, storing and sharing sensed data.

Applications in Forest fire detection**,** Bio-complexity mapping of environment**,** Flood detection**,** Precision Agriculture**,** Air and water pollution etc.

3.1.2 Some of sensor networks

A. Agricultural Drones
B. Hotspots (Wi-Fi)
C. National Knowledge Network

3.1.3 Agricultural drones

It is havingadvanced sensors and imaging capabilities are giving farmers new ways to increase yields and reduce crop damage [29].

3.1.4 Drones can help farmers

- To optimize the use of inputs (seed, fertilizers, water),
- To react more quickly to threats (weeds, pests, fungi).

3.1.5 Some of the benefits of agriculture drones are

- Increased Yields - Identify issues with crops immediately and take action.
- Time and Cost Savings - Drones can achieve the results you want fast, and cut down on the number of personnel required.
- Return on Investment - Identify issues and resolve them quickly and increasing yields.
- Ease of use - At rise above we can provide training and support on all systems we sell. All drones come with GPS functionality and auto return home to land function.
- Integrated GIS Mapping - All our agriculture systems have the ability to perform mapping functions via PIX4D software.
- Crop Health Imaging - Using Infra Red, Thermal, NVDI and multispectral sensors allows direct visibility over the health of your yield. View things such as sunlight absorption rates, transpiration rates, crop health and more.

3.1.6 Hotspots (Wi-Fi)

A Hotspot is a geographical area that has a readily accessible wireless networkthis is Government initiates during 2015.BSNL aims to spread high speed Wifi connectivity across University campus, Schools, Colleges, Hospitals, Public places, Post office, Government Office, Park and Tourist Places, Hotels, restaurants, Airport, Malls, shops, railway stations etc,.

3.2 National Knowledge Network

The purpose is to provide a unified high speed network backbone for educational institutions in India and mainly apply in Health, Education, Science & Technology, Bioinformatics, Agriculture and Governance [30].

4. DATA STORAGE AND ANALYTICS

4.1 Precision Agriculture

is a farming management concept based on observing, measuring, and responding to inter and intra-field variability in crops. The farmer's and/or researcher's ability to locate a precise position in a field lets him create maps of the spatial variability of as many variables as can be measured (e.g. crop yield, terrain features/topography, organic matter content,

moisture levels, nitrogen levels, pH, etc.). These variables are at the heart of precision agriculture and are key to defining amendment strategies, or 'recipe maps

4.1.1 Precision agriculture has been enabled by technologies like

crop yield monitors mounted on GPS-equipped combines; variable rate technology (VRT) like seeders, sprayers, etc.; an array of real-time vehicle mountable sensors that measure everything from chlorophyll levels to plant water status; and multi- and hyper-spectral aerial and satellite imagery, from which products like Normalized Difference Vegetation Index (NDVI) maps can be made [31].

Precision agriculture through drones equipped with sensors that take images of crops and apply fertilizers and pesticides according to crop requirement. Geo-tagging helps to trace the farm produce detecting places from where the raw materials or goods are bought and customers want to know the details of the raw materials used in the final product. Likewise, various techniques can merge field data with crop/weather/soil data useful both to the farmers and agribusinesses as well [14].

4.1.2 Advantages of digital technology

- ✓ It saves money, time and effort.
- ✓ It will be information rich and interactive.
- ✓ It will offer instant reach.
- ✓ It enables immense amounts of information.
- ✓ Digitization also quickens data transmission speed.
- ✓ Better Marketing exposure and pricing.
- ✓ Reduction of Agricultural risks and enhanced incomes.
- ✓ Better awareness and transformation.
- ✓ Improved networking and communication.
- ✓ Facility of online trading and e-commerce.
- ✓ Digital technology has transformed how people communicate, learn, and work.

4.1.3 Disadvantages

- ➢ Higher incidence of poverty in rural India.
- ➢ Less systematic study or evaluation.
- ➢ Difficult to independently validate expertise.
- ➢ High development cost.
- ➢ E-Illiterate.

5. CONCLUSION

It can be concluded that considerable digital efforts are being tried out by different Governments for the betterment of the agricultural sector and farmers. The digital technology in India is now at the crucial stage. Various digital initiatives such as Digital green, mobile technology, e-Choupal, precision farming, agricultural drones *etc*. should be promoted at large scale to improve the adoption of new technology by farmers. By this we can solve the problems like low yield, inconsistent product quality, lack of knowledge about domestic as well as international markets and poor access to diversified agriculture information.

DISCLAIMER

Application of Study

Digitization gives opportunity for democratization of information, knowledge. Agro-ecology is a knowledge intensive system in which information and data should be specific to the local area. In process of achieving the transformation there is need to address the Strategies and approaches for sustainable agricultural development through Digital approaches for organic farming and adoption of Smart approaches for technology Assessment and dissemination.

ETHICAL APPROVAL

This article does not contain any studies with human participants or animals performed by any of the authors.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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