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Emerging Agricultural Technologies for Sustainable Development of Indian Farmers and their Challenges

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Abstract:
Purpose: The purpose of this review paper is to identify the possible aspects of Information and Communication Technologies (ICTs) in Indian Agriculture sector. The paper also discusses the existing and upcoming digital technologies in the agriculture sector across the globe and the challenges for implementation in Indian Scenario. It also focuses on the multidimensional approach to overcome the challenges of penetration of digitalisation and sustainable development of farmers.

Approach and Methodology: The author reviewed the digital technologies used in farming, Initiatives taken by Indian Government for awareness & implementation of ICT, the contribution of NGO's and Private entities. The author also analysed the challenges of implementation of ICT in Indian agriculture. Moreover, it also proposes suggestions for increasing the penetration of digitalisation among farmers.

Findings: Indian Government has taken many initiatives to provide internet facility, at the village level in nominal rates, so that ICT has become accessible & affordable for the majority of the population. During the literature review it was observed that there are numerous mobile applications and informational websites and so on in the field of agriculture are implemented for assisting the farmers but, as a one of the significant gap, it is accessed only by a few handful farmers. The data reveals only 3% of Indian farmers are using these applications to some extent. The literature also listed the challenging factors for the implementation which are as follows: lack of IT infrastructure, lack of digital knowledge, adoption hitches in farmers, void between government policies and their implementation and week public-private participation channels.

Value: ICT is the most cost effective, time effective and effort reducing tool to support small and medium scale farmers as an individual and contribute towards sustainable development of the nation. The authors suggest a framework to overcome the present scenario for execution and strengthen of different government channels and development of public-private partnership using different ICT models. Further, still, much research has to be done in the field of penetration of digitalisation in the agricultural sector.

Keywords*: Digitalisation, Information & Communication Technologies, mobile applications, Agriculture and Sustainable Development.*

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1. Introduction

The agriculture sector is one of the major pillar of the Indian economy, contributing about 17 per cent of national Gross Domestic Product (GDP). About two-thirds of Indian population is relying on agriculture and allied channels for their living. However, the agricultural yield in India is actually low in comparison to the countries like Brazil, China and the United States which are top producers (Shalini R & Biswas (2017).

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Apart from the decline in agricultural land holdings presently following issues are affecting agriculture productivity:

- Increasing dependence on the monsoon
- Lack of water for farming
- Decline in soil fertility due to uneven use of soil nutrients
- Defined procurement of food grains by government agencies
- Issues in remunerations which includes technological limitations like limited online banking, inadequate or negligible access to modern technology, negligible access to the internet or digital technologies, adoption hitches by the farmers, the high cost of the digital tools.

Information Communication Technology (ICT) is any device, tool, or application that facilitates the exchange or collection of data through storing, interacting, transmitting and displaying the information in electronic form. ICT considered as a potential tool, for the large scale of farmers. This technology is benefiting most easily and smartly by providing information to farmers and is one of the fastest two-way communication between the provider and the receiver.

This review paper covers the potential aspects of Information and Communication Technologies (ICTs) in Indian Agriculture sector. The paper also discusses the existing and upcoming digital technologies in agriculture sector across the globe and the challenges of implementation in Indian Scenario. It also focuses on the multidimensional approach to overcome the challenges of penetration of digitalisation and sustainable development of farmers.

2. Objective & Methodology

The objective of the research paper is to know about the digital technologies in agriculture and how it accelerate the development of Indian agriculture sector. The paper mainly aims at the strengthening agriculture sector through information communication technology and the new emerging technologies coming in the future for Agriculture Sector in India.

The research is descriptive and conceptual. For research, the secondary data was reviewed from various Government Sources, company websites, newspapers and journals.

The paper mainly focuses on the technologies adopted by Indian farmers and the upcoming technologies across the globe to feed the critical needs of the farmer through digital transformation. The significant benefits of the technologies are as follows:

a) The better technologies to save time and energy

b) Access to Markets

c) Predictive Analytics

d) Access to finance

e) Forecasts on Climate Change

f) Access to Farming Equipment and New Technology

g) Inputs for Better Soil Fertility and Soil Structure

3. Discussion

In India, noticeably two-thirds of the working population earn their living through agriculture works. Moreover, other sectors have fizzle out to achieve much of employment opportunity for the growing working population. Post-independence, many revolutions in the agriculture and allied sector has arrived to accelerate the rate of production and contribution to the country's economy. The milestones in the Indian agricultural development over the years were as follows:

- In the year 1968, Green Revolution had made a tremendous change through The introduction of high-yielding varieties of seeds. There were three essential elements in the methods:

  - Continued expansion of farming areas;

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- Double-cropping existing farmland;
- Using genetically modified seeds.

- In the year 1996, Evergreen Revolution included productivity improvement without harming ecological and social aspect.
- In the year 1985, The concept of blue revolution in the rapid production of fish and marine product through package program. This revolution had brought development in aquaculture by adopting new techniques of fish breeding, rearing, marketing, and export of fishes.
- In the year 1970, Dr Verghese Kurien, Father of the White Revolution in India, started cooperative structure for milk to make India self reliant.
- In the year 1986, the Yellow Revolution started which mainly deals with the boost, advancement and adoption of new varieties of oilseeds and technologies to double oilseeds production.
- Biotechnology Revolution had started in the year in 2006, which mainly deals with the use of living organisms or enzymes in the technically regulated production of organic substances.
- IT Plan for Agriculture Sector (AGRISNET) was submitted to the Ministry of Agriculture in the year 1997 to establish "Indian Agriculture on-line", and thereafter it was revised in the year 2000 in line with the technology advancements.

India is an agricultural nation, and despite of so many revolutions, the country has still not achieved the respectable figures. The second advanced estimates released by the Central Statistics Office (CSO), reveals that the share of agriculture and allied sectors is approximately to be 17.3 per cent of the Gross Value Added (GVA) during the year 2016-17 at 2011-12 prices (Agriculture in India, 2017). According to Shalini & Mahura (2017), because of exponential growth rates in industrial and service sector the agricultural share of Indian economy has decreased to less than 15%.

In India the agricultural yield (quantity of a crop produced per unit of land) is lower as compared to other top producing countries Shalini & Mahura (2017).

The report Rajasthan Agriculture Road Map Meeting of NITI Ayog (2016) shared that the workers living off the land remains substantial at 54.6 per cent of the workforce, but the movement of labour away from agriculture has gathered momentum in recent decades. The census in the year 2011 depicts that the farmer population has diminish by nine million between the year 2001 to year 2011.

Apart from biotic and abiotic factors related to agriculture; climate change; other anthropogenic activities and the void between farmers and information and communication technologies are major aspects, which are creating a barrier in the advancement in the agriculture sector in India.

Over the years, farmer have produced crops, raised livestock, they have collected information among for getting more production, best seed quality, raising livestock and so on. Subsequently it shifted to the economic aspects, e.g., the better paying market, land acquisition, the input of agriculture in economic growth, government schemes etc. As technology advancements, the farmers are also seeking the information on weather, soil health, plant diseases and other related aspects. Even the technological advancements, farmers find it difficult to get answers for frequent questions related to the weather, soil health and plant diseases. Over the years, changing weather patterns, soil conditions have changed the perception towards resistance of crop, epidemics of the pests and diseases of the crops. Providing the information using technologies allow the farmers to deal with these changes and even get benefitted by them.

To provide the knowledge using the technology can be challenging in India. However, because the deeply confined geographical nature of agricultural, information must be designed explicitly to different conditions and places using technologies. In past, the green revolution has enhanced agricultural

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productivity. In spite of this revolution, there is a need for a new revolution that will help in "smart" agriculture, and contribute farmers to increase their production and income. Many public and private sectors are searching various solutions for addressing both the temporal and spatial challenges in the agricultural sector, which includes sharing of vital information among the farmers.

Information communication and technology (ICT) is one of the facilitator which has great potential to improve agriculture in developing countries. With the prospering usage of smartphones, wireless networks, and internet, ICT has found a distinct space even in small farmers house. It is an umbrella term which includes the radio to satellite imagery to mobile phones to electronic money transfers (Braun, 2012).

These ICTs has gained traction even in penurious regions. The primary factors include affordability, accessibility, and adaptability which resulted in their immense use in the rural sectors of India. New, small devices such as smart mobile phones and nanotechnology for food safety, infrastructures such as mobile telecommunications networks and cloud computing facilities and financial applications for transferring the money or track the consignment moving through a global supply chain has mushroomed as significant ICTs in the agricultural sector. For solving queries related to markets, weather conditions in the faster manner and increased accuracy, ICTs plays a major role.

The different dimensions of agriculture where ICT contributes to the development were:

1. Agricultural Research
2. Agro-Meteorology
3. Marketing & Mandis
4. Agricultural Engineering & Food Processing
5. Agricultural Technology
6. Credit and Banking
7. Crop production & protection
8. Manure & Fertilisers
9. Irrigation System
10. Livestock, Dairy Development & Animal Husbandry
11. Soil Management
12. Watershed Development
13. Wasteland Development for agriculture purpose

By the year 2030 the goals set by united nations sustainable development for the development in the agriculture sector, various steps need to be taken place across the globe and developing countries like India by using various technologies; Database Technology, Remote Sensing and Geographic Information System, Image Processing, Artificial Intelligence, Robotics and so on. These technologies are related to natural manufacturing and agricultural. These technologies work beneath the significant three key areas:

1. Sensors
   Diagnosis of crop, livestock and farm machine and real-time traceability states is facilitated by Sensor technology.
2. Automation
   Automation will help agriculture via large-scale robotics and micro-robots which analyse and control crops at field situation.
3. Engineering
   Engineering is the art where new areas and means are explored for the agriculture use such as synthetic biology.

Zappa (2014) examined that the technical viability of agricultural includes three different terms: firstly; scientifically viability, which includes the literature of regulatory and university development. Secondly; mainstream viability emphasis on when would be the technology will be available to the end users. Moreover, Thirdly: financially viable; which includes an investment of the venture capital and investments of the startups. Based on these three factors: the technologies further classified as:

1. Air & soil sensors:

The technology is one of the key aspects of automated farming. The Air and soil sensors help in understanding the real-time situation of farm.

Table No 1: Validity sheet of Air & soil sensors

S. No.	Particular	Year of Viability

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1	Scientifically viable	2013
2	Mainstream viable	2015
3	financially viable	2015

2. Livestock biometrics:

These include Global Positioning System(GPS), Radio Frequency Identification (RFID) and biometrics, which can mechanically analyse and store RFID information about the livestock in real time. These biometrics will help the farmers to identify the diseases and other issues in real time.

Table No 2: Validity sheet of Livestock biometrics

S. No.	Particular	Year of Viability
1	Scientifically viable	2017
2	Mainstream viable	2020
3	financially viable	2020

3. Crop sensors:

High-resolution crop sensors includes application equipment how much of the fertiliser to be used in filed. Crop health can be determined through optical sensors and drones in the field by using infrared light.

Table No 3: Validity sheet of Crop Sensor

S. No.	Particular	Year of Viability
1	Scientifically viable	2015
2	Mainstream viable	2018
3	financially viable	2019

4. Genetically Designed Food**:**

This technology mainly deals with generating the new combination of genetically designed food for animals and humans in order to address better the biological and physiological needs.

Table No 4: Validity sheet of Genetically Designed Food

S. No.	Particular	Year of Viability
1	Scientifically viable	2016
2	Mainstream viable	2021
3	financially viable	2022

5. Variable Rate Swath Control**:**

Swath control helps in reducing overlapping of seed, minerals, fertiliser and herbicides. It analyses the overlapping and gives instructions to the automated machines to reduce overlapping which ultimately reduces the loses of farm owner.

Table No 5: Validity sheet of Swath Control

S. No.	Particular	Year of Viability
1	Scientifically viable	2013
2	Mainstream viable	2014
3	financially viable	2016

6. Rapid Iteration Selective Breeding**:**

This technology helps in analysing the end-result more quantitatively and provide the valuable suggestions for improvements in agricultural sector.

Table No 6: Validity sheet of Rapid Iteration Selective Breeding

S. No.	Particular	Year of Viability
1	Scientifically viable	2014
2	Mainstream viable	2017
3	financially viable	2017

7. Agricultural Robots**:**

Agricultural robots are also known as “agbots”. These are utilised to mechanize farming like agricultural processes, such as picking up the fruits, harvesting, maintenance of the soil, ploughing, weeding, planting, irrigation and so on.

Table No 7: Validity sheet of Agricultural Robots

S. No.	Particular	Year of Viability
1	Scientifically viable	2018
2	Mainstream viable	2020
3	financially viable	2021

8. Equipment Telematics**:**

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Equipment telematics are the mechanical devices which identifies the warn out time of different machines through digitalcommunication.

Table No 8: Validity sheet of Equipment Telematics

S. No.	Particular	Year of Viability
1	Scientifically viable	2013
2	Mainstream viable	2015
3	financially viable	2015

In future years the scenario of the agricultural sector would change the Decision Support Systems for Agriculture such as Integrated Nutrient Management, Integrated Pest Management, Demand-Supply Projections, Soil-Water balance, Credit Management, Inter-cropping systems and Bio-fertilizer management among with the above technologies. In India, the development of agriculture will help to enhance technological aspects of the farmers, but also contribute the more extensive section of the rural population who are directly embedded in agriculture allied sector. The increase in production stabilized prices, more income from agriculture would create a more comfortable environment for the development of the economy as a total and rural population in particular in India.

For strengthening the Indian agricultural system, the small and marginal farmers need to empower through digital education, technology update and sustainable development. Creating awareness and updating new models and technologies in production and marketing will help in the augmenting of the sector and also improves the economic position of poor farmers. The action plan needs to support agriculture in India through Information Communication which will help to save time money and efforts of the farmer.

Rao (2006), Kaka (2014), and Seth (2017) listed out the challenges faced by agricultural industry in implementation of digitalization in rural India which are as follows:

1. Low level of digital literacy
2. Lack of formal and informal education on ICT
3. Lack of digital infrastructure provided by the Government
4. Technology cost is high and still beyond the reaches of small farmer (which constitutes 51% of the population)
5. Climatic conditions
6. Inadequate agriculture extension services
7. Insufficient agro-met-enviro-rural data
8. Electricity grids and supplies.
9. Inadequate data storage channel
10. Vulnerability to world commodity prices, challenges of integration of value chains, super markets.
11. Smaller access to extension services and technology
12. Issues handled by government related to digitalization in agriculture
13. Current farming technology costs is much more than most farmers can afford

To overcome these challenges, the Indian government has an implemented integrated multi-dimensional approach for the sustainable development of Indian agriculture and attainment of United Nation Development Programme (UNDP) - 2030 goals (Statistics Times, 2017). Some initiatives of the Indian government are as follows:

A digital India campaign started in the year 2015 by the government of India. The goals of the campaign were to make the government services accesible to citizens electronically in remote areas, by enhancing online infrastructure and by multiplying Internet connectivity. The mission of the program is to take the nation forward digitally and economically.

According to Vinod Bothale, Director, Maharashtra Remote Sensing Application Centre (Dept. Of planning, Govt. Of Maharashtra) emphasized that the Digital India campaign is majorly through the collaboration of government, private, non-governmental organisation (NGO) and universities and institutions at the research level.

- **Government initiated projects**

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Many states in India, has taken different steps to promote Information Communication technologies through different government departments such as Indian Meteorological Department (IMD), Indian Space Research Organisation (ISRO). These departments are working on the implementation of information technology so that the farmers and other citizens were benefited through their research. Some of the government initiatives are *Gyandoot* in Madhya Pradesh, Lokvani Project in Uttar Pradesh, Project FRIENDS in Kerala, e-Mitra Project in Rajasthan, e*Seva* in Andhra Pradesh, e-Procurement Projects – India, Village Knowledge Centres-India, Village Resource Centres – India, Integrated pest management- Advisory, Agris, Krishi Dhan and the researches going on in Regional Remote Sensing Service Centre- Indian Space Research Organisation, Indian Metrological Department, Indian Space Research Organisation,

- **Private initiated projects**

Other than government initiatives, many private entities are also playing the key role in helping farmers to understand the digital technologies. The private company aim is to promote their products and their company's presence through the corporate social responsibility. Sharma P (2011) described the private initiated projects which are e - Choupal (powered by ITC Limited, http://krishiworld.com/, Mahindra Kisan Mitra, Kisan India, i Kisan (run by Nagaarjuna Group), I Community :Kuppam (run By Hewlet Packard(HP), Drishtee, which is present in 5 States etc.

- **Role of universities and institutions towards the sustainable development**

Universities and institutions plays a different role in ICT, they are the one of key pillars which help to innovate through research work in field of Agriculture. They provide the bridging platform to government and private sector for implementing the technologies. Some of the examples of the initiatives carried out by the universities and institutions are Agro Sense IIM Kolkata, Geo-ICT &WSN Based Crop Informatics – IIT Mumbai, eSagu –IIIT Hyderabad, ICT AGRI era net etc.

- **Role of Non-Governmental organization (NGO)**

Non Governmental Organization (NGO) plays a role of advocacy and implementation of ICT. They are one of the strongest pillars which are directly attached to the farmer of rural India. They provide the guidance and updating knowledge for the farmers. The major initiatives of the NGOs may help farmers through formal and informal learning. Such NGOs are N- Lounge : TeNET group of IIT Madras, Information in Villages of Pondicherry: Run by M S Swaminathan Research Foundation (MSSRF)

Other than these four pillars many other international agencies such as The United Nations Educational, Scientific and Cultural Organization (UNESCO), World Bank, United Nations (UN), World Health Organization (WHO) also plays a integral role in upgrading the knowledge of the farmers.

- Recently, UNESCO has started to implement a model which helps farmers get answers for the questions raised by them.
- UN has initiated the various steps for pest control to reduce the risk of health and environment in the agricultural sector.
- The major initiative of the WHO is spreading the message about Nutrient Management.

Despite these significant initiatives, information communication technology is lacking in the major scenarios in the agricultural sectors, which are: adapting of the technologies which is slow and uneven, the lack of documented economics, lack of information-intensive knowledge, improper effective operational planning between the governmental labs to the farmers and improper linkages in empowering in government departments.

4. Conclusion

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This research paper highlights the major digital revolution was taking in the agriculture sector across the world. There are many emerging technologies coming up in the agriculture sector Developing country like India is still facing the challenges for proper implementation of information communication technology in the agriculture sector. The challenges are due to lack of IT infrastructure, lack of digital knowledge among farmers, adoption hitches in farmers. Information communication technology is one of the most cost effective, time effective, effort reducing, and lower risk tool to support small and medium scale farmers.

The present research paper emphasis that policies need to reframed for changing digital scenario of India to ensure for overcoming and leading to increased efficiency of the farmer and his social and economic growth. ITC plays a crucial role in raising incomes of smallholders to contribute to sustainable development.

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