Application of Information and Communication Technology (ICT) in Agriculture Value Chains in India

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Abstract

Information and Communication Technology (ICT) has led to ease of operations in the value chain of the agriculture sector, where the number of actors in the value chain is holding it back in the realisation of its full potential. These inefficiencies arise due to the non-adoption of technology in certain stages of the value chain. This issue of inefficiencies can be resolved with the help of an end to end solution in the total supply chain. Certain recent initiatives of the government and the private sector in India towards using Information and Communication Technologies (ICTs) in terms of market information, input availability, and post-harvest management like geotagging of agri warehouses, reefer vehicles and cold storages are a step in the right direction. Further, to address the issue of access to these technologies by smallholders, certain innovative pilot projects are being developed. Non-profit as well as private sector initiatives in this space are also highly encouraging. An attempt has been made in this paper, to evaluate opportunities and constraints associated with the use of ICT to enhance the productivity of agriculture and associated sectors in India.

Keywords: ICT, Value chain, Agricultural Marketing.

Introduction

The Indian agriculture sector (US$ 370 billion) plays a vital role in the Indian economy. The country's total geographical area is 328.7 million hectares with a cropping intensity of 143.6 per cent. India has 15 agro-climatic regions and 46 types of soil. India ranks first in terms of production of spices, pulses, milk, tea, cashew, and jute, and stands second in

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the production of wheat, rice, fruits and vegetables, sugarcane, cotton, and oilseeds. Further, India is the second largest producer of fruits and vegetables and is the largest producer of mango and banana. The contribution to GDP by the agriculture sector is likely to be 19.9 per cent in 2020-21, increasing from 17.8 per cent recorded in 2019-20 (Economic Survey 2020-21).The government has taken many initiatives to aid and enhance the agriculture sector with proven farming technologies and supportive policies. The evolution in digital technology for farming will further accelerate growth by ensuring higher crop yields. It will also help to enhance sustainability by reducing water consumption and the use of agrochemicals (Goutam, 2014).

Conflict of Interest in Agricultural Marketing

The farmers always expect higher production and maximum price for their harvest. On the other hand, the traders, retailers and manufacturers expect to get high quality raw material at a low purchase price with a higher margin. The consumers desire to get good quality and fresh produce at a reasonable price at their doorstep. This conflict of interest of different players in the agricultural value chain is a result of the fragmented supply chain prevalent in Indian agriculture. There are two ways to overcome this problem; firstly all the supply chain activities have to be brought under a single umbrella and second, we need to take the help of the advent of ICT to design an end to end solution. Against this backdrop, an attempt has been made in this paper to analyse various initiatives of ICTs in agriculture in general and Agricultural Marketing in particular (Chatarjee & Kapur, 2016).

Characteristics of Conventional Marketing System

In the conventional agricultural marketing system, farmers prefer to sell their commodities at the village level. Around 80-90 per cent of perishable commodities, 40-80 per cent of cash crops and 20-60 per cent of food grains are sold in the local markets. The main reasons for this distress sale are indebtedness, inadequate transport, small surplus, inefficient supply chain, perishability of produce, information gap, etc. It is essential for farmers to know the market and accordingly plan their produce and then grow it. The trend has been shifting now from production led to market-led extension.

Integration of Agricultural Production and Marketing

It is vital to integrate the production and marketing activities for agricultural produce. There is a need to disseminate knowledge on basic dimensions of agricultural marketing

viz., market-oriented production planning, and preparation of produce for marketing, storage/preservation techniques, infrastructure and transport facilities, market information and integration of marketing networks.Market oriented production planning like what to grow, when, where and how to grow is very essential at the farmers' end, followed by preparation of the produce for marketing, through grading sorting, packaging and labeling which has to be done to secure the maximum price. The next step is storage/preservation techniques, to add value to the produce, after which it is essential to ensure infrastructure and transport facilities to reduce the post-harvest losses. Additionally, the use of market information in terms of arrivals and prices and integration of marketing networks like direct sale, wholesalers etc., is necessary to secure better prices by farmers (Darekar & Gummagolmath, 2021).

Need for the study

ICT based initiatives are using different technologies, but with a limited reach to the intended stakeholders. This limited reach is mainly on account of tele-infrastructure, lack of awareness, literacy level and information needs of the farmers. However, in the recent past, the predominance of tele-infrastructure, availability of internet facilities and advent of social media has minimized inefficiencies in the value chain of agriculture. However, the reach of ICT to all the stakeholders is a far cry.

Hence, it is essential to analyze the extent of the reach of both public and private ICT initiatives in agriculture.

Digitalization of Agriculture

Over the years, the government has taken major steps to aid and enhance the agriculture sector with proven farming technologies and supportive policies. The recent evolution of digital technology in farming will further accelerate growth by ensuring higher crop yields and enhance sustainability by reducing water consumption and the use of agrochemicals. Digital technologies, such as the Internet of Things (IoT), Machine Learning (ML), Artificial Intelligence (AI), Remote Sensing, Big Data and Blockchain are modernizing operations and transforming the entire agricultural value chains. Although several countries, such as the USA, Netherlands, Israel and Australia have successfully adopted digital solutions to revolutionise agriculture, their adoption in India is still in a nascent stage. The future adoption of digital agriculture in India is anticipated to nurture under the Public-Private Partnership (PPP) mode.

Information and Communication Technologies (ICTs)

Information and Communication Technologies (ICTs) is an umbrella term that includes any communication device or application, encompassing: radio, television, mobile phones, computers and network hardware and software, satellite systems and so on, as well as the various services and applications associated with them, such as video-conferencing and distance learning. ICT is simply an electronic means of capturing, processing, storing and disseminating information. It comprises those networks, mobiles, devices, services, and applications that aid the processing, management, and exchange of data, information, or knowledge with a target audience. They include a broad range of converging technologies, including traditional telecommunications, television and video, radio, CD-ROMs, cell phones and smart devices, and several modern technologies such as computers and the internet, sensors, Geographic Information Systems, satellites, and the like. Essentially, the purpose of ICT is to transfer information from one point to another (Adhiguru & Devi, 2012).

Why ICT?

ICTs have largely revolutionised the way people, governments, and businesses, both large and small, function in the modern world. Close to 60 per cent of the global population has access to the internet, and mobile internet is now the most widely-used channel for internet access worldwide. The tremendous adoption of ICTs has made it possible to facilitate better communication and ensure the delivery of services and information to people who previously lacked access. The infusion of new, advanced technologies has allowed the global agriculture sector to surge ahead and transform the way producers cultivate, harvest, and distribute agricultural commodities. The use of ICT in agriculture, or e-agriculture, has accelerated agricultural and rural development by adopting innovative ways to improve the existing information and communication processes. It has particularly revolutionised smallholder agriculture in several agrarian economies and has helped address several challenges associated with the traditional form of agriculture. ICTs are meeting information, communication, and knowledge needs of farmers, agribusinesses, governments, and society through different features like e-collaboration, distance neutral, interactive, mobility, market transparency etc. (Deshmukh and Patil, 2021).

What ICT Can Deliver?

ICT has many potential applications in delivering agricultural extension and can bring new

information services to rural areas by reaching every corner of the country. All stakeholders of the agriculture industry need information and knowledge and ICT can play a significant role by creating an interface for the farmers to the outside world. The collaborative business modules can offer entrepreneurship opportunities and also deliver information regarding the prices of commodities in various mandis (agricultural markets). ICTs are cost effective and ensure timely as well as accurate information dissemination amongst the stakeholders. ICTs can also be linked with other governance services to be delivered in rural areas.

Table 1: Successful ICT Initiatives in India

The list of few successful ICT initiatives in India is given below.

S.No	Initiative	Details
1.	e-Extension (e- Soil Health card Programme)	Dept. of Agriculture, Gujarat State has one of the ambitious programmes which aims to analyze the soil of all the villages and provide guidance
2.	AGRISNET	It uses state-of-the-art broadband satellite technology to establish the network within the country by MOA&FW. It is a comprehensive web portal, to broadcast relevant information to farmers, which was initiated and funded by the Ministry of Agriculture, Government of India. The AGRISNET serves farming community by disseminating information and providing services through use of ICT.
3.	AGMARKNET 2000	A comprehensive database which links together all the important agricultural produce markets in the country for dissemination of market information by DMI. It aims in empowering decision-making ability of the farmers regarding selling of their produce. This portal was developed to pace up the agricultural marketing system through broadcasting information about influx of agricultural commodities in the market and their prices to producers, consumers, traders, and policy makers transparently and quickly.

4.	Kisan Call Centres (KCC) 2004	KCCs were commenced by the Department of Agriculture and Co-operation with the main intent of delivering extension services to the farming community in the local languages. The queries of farmers are answered by agricultural graduates on help line, toll free number in their local language. The agricultural scientists also visit the field in person to get an idea about complex agricultural problems to resolve them. It is delivering extension services to the farming community
5.	Tata Kisan Kendra	This private initiative by TATA chemicals ltd. started with an objective of providing the farms with infrastructure support, operational support, controlling farm activities etc. with the advent of ICT.
6.	e-Choupal	This is ITC's Agri Business Model, a conglomerate, to link directly with rural farmers via the Internet for procurement of agricultural and aquaculture products like soybeans, wheat, coffee, and prawns.
7.	AKASGANGA (Meaning "milky way" in Hindi)	It demonstrates the potential of information technology to impact livelihoods in poor, rural communities. This ICT project makes possible milk collection, fat testing, and payment in a timely and user friendly manner. It augments the income generation of dairy farmers through incorporation of advanced technology.
8.	Global Positioning System (GPS)	A satellite-based navigation system that can be used to locate positions anywhere on the earth
9.	Remote sensing (RS)	It is the science of making inferences about material objects from measurements, made at distance
10.	Geographic Information System (GIS)	It is a technological tool that analyzes and presents information tied to a spatial location
11.	ICTs in Weather Forecasting	These disseminate meteorological information and weather warning, climate change

12.	Digital green	It is an international organization, which works with a participatory approach by engaging the rural community to improve their livelihood using a digital platform. Interactive and self-explanatory videos are prepared for farmers by progressive farmers with the assistance of experts. These videos are shown to the farmers at individual level or in groups. The videos are prepared keeping in view the requirements and welfare of the rural masses.
13.	Warana (1998)	The Warana "Wired Village" project was initiated with the objective of providing agricultural information and services to farmers for increasing productivity. The information about prices of agricultural outputs, employment schemes of the government of Maharashtra and educational opportunities is transmitted to the farmers in the local language. The information is disseminated through information kiosks with the help of operators, who are the main linkage between the farmers and the agricultural experts.
14.	IFFCO KISAN SANCHAR LTD (IFFCO Kisan) (2012)	It delivers relevant information and custom-made solutions to the concerned farmers through voice messages on mobile phones. The farmers can also communicate directly to the agricultural experts on explicit themes via 'phone-in' programmes.
15.	Digital Mandi	It is an electronic trading platform for facilitating farmers and traders to sell and procure agricultural produce beyond the geographical and temporal limitations effortlessly. Various financial institutions also participate in online trading of agricultural output to remove cash crisis.
16.	eArik (2007)	It aims to disseminate climate smart agricultural practices and to achieve food security. It is an integrated platform to enhance the accessibility of agricultural information and technology in north-eastern India. It delivers agricultural

		specialist advice on crop cultivation, crop management and marketing. Farmers can also obtain information directly from the portal but field workers also help farmers to access ICT- based information or to consult with other agricultural experts.
17.	aAQUA (Almost All Questions Answered)	It is a multilingual online system that facilitates farmers by advising them, solving their problems and answering their questions related to agriculture. Farmers have to register on aAQUA platform online or telephonically. After that, they can post their queries on the portal, for which they get answers shortly.
18.	Fisher Friend Mobile Advisory KCC	The Fisher Friend Programme (FFP) of M S Swaminathan Research Foundation was launched in 2009 to protect fisher folk from occupational hazards and to empower their livelihoods. The relevant information on wave height, wind speed and direction, potential fishing zones, relevant news, government schemes and market price is provided to fishermen in the local language. The FFP covers marginalized coastal communities in Tamil Nadu, Puducherry, Andhra Pradesh, Kerala, and Odisha, and is operational in English, Tamil, Telugu, Malayalam, Odiya languages.
19.	Reuters Market Light (RML) (2007)	It was initiated to deliver customized information to the registered farmers via mobile-SMS. It disseminates information in eight local languages in 13 states.
20.	SMS Portal/mKisan Portal	This portal aims to serve farmers in three ways - to disseminate information about diverse agricultural activities, provide seasonal advisories and to provide various services directly to farmers through SMSs in their local languages. The SMS Portal has a platform for amalgamation of service delivery under different sectors viz. Agriculture, Horticulture, Animal Husbandry and Fisheries.

21.	Mahindra Kisan Mitra	This portal provides information to the farmers on price of commodities, weather forecast, crop advisories, loans, insurance, cold storage and warehouses along with success stories of progressive farmers.
22.	Village Knowledge Centers (VKCs) 1998	Village knowledge centres of MS Swaminathan research foundation were initiated in Pondichery as a gateway to technical information related to agricultural inputs, price of outputs, crop rotation, use of fertilizers and pesticides. Information is disseminated through public address system.
23.	Agronxt	AgroNxt platform is a multitasking platform for the farmers where farmers can get inputs, agriculture advice, weather condition etc. AgroNxt thrives to contribute to agriculture industry by delivering farmers usable, reliable and timely information that maximizes farm profitability. It assists in upholding agricultural productivity and sustainability.

Importance of Market Information

The market information about arrivals and prices of agricultural produce is very vital to the farmers for taking proper production and marketing decisions. Well-analyzed historical market information enables farmers to allocate their resources among different crops in line with the urban consumer demand, including those related to new crops and regulate the flow of produce to markets. The traders can rationally take a call on when and where to buy and sell, plan for transport, storage etc., while consumers can make informed decisions to purchase the produce by knowing the market forces. Finally, market information can also assist the government in planning, management of the economy, formulation of price policy, watching its execution, discovering trends and deciding the future course of action to keep the market prices within desired limits. It also acts as an Early Warning system by highlighting food shortages which are reflected by higher prices.Hence, a key to achieving both operational and pricing efficiency in the marketing system is the dissemination of complete and accurate market information (Shalendra et al., 2011).

Essentials of Market Information and Flows

Market information can be regarded as a public good, particularly where there are a number of small farmers who are unable to pay for information. The availability of timely, analysed, accurate and applicable information to all interested parties is therefore essential, irrespective of source. The need to provide up-to-date price information is particularly essential in the case of perishable produce and where price fluctuations are frequent. Many countries have attempted to provide market information at the national level, but their success rate has been poor. Market Information Services have repeatedly proven to be unsustainable and where they have endured they have often failed to provide commercially useful advice, confining themselves to the gathering of, frequently unused, data.

The supply chain in agriculture not only means the flow of the commodity but also that of information. The term market performance refers to the economic results that flow ranging from the seed/pesticide supplier, farmers, transporters, storage, markets, processing, packing, retailing to consumers. ICT offers new opportunities for decision-making, adaptation to the environment and efficient operation.

Table 2: Current Initiatives under Digital Agriculture in India

The list of current Initiatives under Digital Agriculture in India is given below.

S.No	Year	Initiative
1	September 2021	Govt of India announced the initiation of the Digital Agriculture Mission 2021-2025, while signing five Memorandum of Understanding (MoUs) with Jio Platforms Limited, Ninjacart, CISCO, ITC Limited and NCDEX e-Markets Limited (NeML), to take forward digital agriculture through pilot projects. It aims to support and accelerate projects based on new technologies, like blockchain, AI, Remote sensing and GIS technology and use of drones and robots.
2	June 2021	An MoU with Microsoft to run a pilot programme for 100 villages in 6 states. Under the MoU, Microsoft is expected to create a 'Unified Farmer Services Interface'

		through its cloud computing services. This is a major part of the ministry's future plan to create 'AgriStack' - a unified platform to provide end-to-end services across the agriculture food value chain to farmers. Govt. is planning to create unique farmer IDs for farmers across the country to integrate it with various government schemes and create digital agricultural ecosystems.
3	Mar 2021	ITC has proposed to create a personalized 'Site Specific Crop Advisory' service to turn conventional crop-level generic advice into a personalised site-specific crop advisory for farmers, using a digital crop monitoring platform, hosted on ITC's e-Choupal 4.0 digital platform. The pilot project will be at Sehore and Vidisha (Madhya Pradesh).
4	February 2020	The Jio Agri (JioKrishi) platform launched, digitises the agricultural ecosystem along the entire value chain to empower farmers. The advanced functions use data from various sources, feed the data into AI/ML algorithms and provide accurate personalised advice. The pilot project will take place at Jalna and Nashik (Maharashtra).
5	August 2019	An Agricultural Digital Infrastructure (ADI) solution developed by CISCO to enhance farming and knowledge sharing. It is likely to play a vital role in the data pool that will be created by the Department of Agriculture under the National Agri Stack. The pilot project will take place at Morena (Madhya Pradesh) and Kaithal (Haryana).
6	April 2016	National Agriculture Market (eNAM) is a pan-India electronic trading portal that links the existing Agricultural Produce Market Committee (APMC) mandis, to create a unified national market for agricultural commodities. eNAM helps farmers sell products without the interference of any brokers or mediators, by generating competitive returns from their investment
7	January 2013	Direct Benefit Transfer (DBT) Central Agri Portal is a unified central portal for agricultural schemes across the country. The portal helps farmers adopt modern farm machineries through government subsidies

Need of the Hour

Agriculture is facing new challenges but the stakeholders involved in the agriculture sector are yet to benefit from ICT. There are different tools to access essential information regarding quality seeds, agriculture finance, irrigation, livestock care and market prices. The service providers shall also charge for value-added premium services for demand driven information instead of offering it free. The collaborative business modules over the single supplier, multimedia supported information than text services and cost effective innovative solutions would have added benefits than costly technology. The need of the hour is to use modern media over traditional media and share localised and crop specific information than the generic one.

Information Management across the Agri value chain

The biggest obstacle of a farmer-centric and farmer-driven economy is first and last mile connectivity as it requires a lot of time and resource management. Information management plays a key role from crop production, procurement, storage and logistics to the marketing of agricultural produce. The well connected agri value chains can offer an incentive for members of the entire agri ecosystem and food supply. A continued engagement with farmers creates multiple inputs and revenue streams for businesses. The current condition can be leveraged to use ICT and develop robust agri value chains in India. Indian agriculture needs to grow more on a systemic basis from the pandemic. It is the right time to build connectivity within the value chains by driving investment and creativity in digital agriculture. The connected agri value chains need to be developed with the help of ICT. This needs more effort and strong alliances between the Centre and state governments, private players, and farmers.

ICT Uses in Agribusiness Value Chains

ICTs play an important role in agricultural value chains and have a diverse impact. The different types of ICT having different strengths and weaknesses can be applied to particular interventions. Although ICTs have positive impacts, many rural farmers still do not have access to or the capacity to use ICT. Given the importance of the context and the rapid development of technology, it can be difficult to determine whether the appropriate tool now will continue to be the appropriate tool in the future. ICT can be applied in various

agribusiness enterprises like Agri-tourism, Agri-banking, Agri-Hubs, Food Traceability and Online Farmers' Markets.

Driving Forces in ICT Market Integration

Many a time the government policies and frameworks are one of the driving forces behind digitalization as it creates an enabling environment for competitive digital markets and e-services. The use of social media, rapid technological advances, the discovery of new sources of competitive advantages, the pursuit of first mover advantages, need for real-time engagement and need for value chain coordination are the driving forces behind the ICT market integration.

e-Value Creation in Agribusiness: Product & Service Transformations

Digital platforms are new economic institutions functioning in a new reality characterized by being transaction intermediaries while giving rise to new economic ecosystems and new value creation logic. A fragmented digital agriculture ecosystem has been linked to the slow scale-out of digital platforms and other digital technology solutions for agriculture. The agribusiness products and services can be transformed by creating e-value through automation of farm production, access to market information services, food supply chain traceability and customization of e-agriculture services (Saravanan & Darekar, 2020).

Impact of ICT in Agriculture

The effective distribution of ICT can increase agricultural attractiveness by reducing transaction costs, raising production, efficiencies and farmers' incomes, by providing more information and value to stakeholders. In recent years, information and communication technologies have been introduced in agriculture projects and have provided fruitful results in rural and agriculture development (Meena & Singh, 2012). For instance, information and communication technologies can be used for distance learning programs and help the farmer in learning about new approaches and technologies for agricultural development in developing countries. Such technologies can provide information on weather, prices, and profitable income. ICT offers the opportunity to enhance smallholder marketing in the following ways. It is evident that those farmers who have used the information and communication technologies in agriculture have increased their production information

and knowledge. Similarly for those who have used the e-services, e-commerce applications also increased their income. ICT has its impact at the household as well as the national level. ICT has helped in resolving market failure and given access to food and financial markets. The new early warning systems have helped climate change management. Due to income growth, food access, food security improvements have been witnessed. ICTs have helped in alleviating rural poverty, developed knowledge and improved value chain performance through regional/global market integration (Satapathy, 2015).

* Better production management and data analytics: ICT solutions are providing better farm management and data analytics solutions to improve marketing capabilities. Farmers can take informed decisions and plan their production accordingly.

* Finding Buyers/Market: Identifying additional buyers and having multiple buyers available is advantageous with the help of ICT.

* Using market information for sales planning: There are dozens of ICT solutions to deliver market information to small farmers, which helps in planning resources as well as sales.

* Better traceability: Commercial buyers like wholesalers and exporters find it challenging to source from smallholders, as the quality and safety standards are often compromised. ICT offers a solution through complete traceability and blockchain technology.

Agriculture e-Challenges

There are several challenges involved in marketing of agricultural produce. The literacy level among the farmers is low, there is limited access to market information, multiple channels of distribution etc. Most of the small farmers still depend on the local moneylenders who charge high rates of interest. There are several loopholes in the present legislation and there is no organized and regulated marketing system for marketing the agricultural produce. To summarise, the major challenges faced by ICT initiatives in agricultural marketing are institutions and policy implementation lags, policy and incentives, affordability, airtime, Internet café charges, irrelevant e-content, language barriers, poor infrastructure,

low transmission signals, load shedding, less awareness, local culture, information overload, information credibility, accuracy, reliability, misinformation, effective use, sustainability, optimal use, etc. (Mohammadi, 2011).

Table 3: List of Agritech Startups leveraging ICT for robust value chain in India

S.No	Name	Description/ Solutions offered
1.	SourceTrace	It offers solutions on Farm Management, Farm Advisory Services, Certification, Monitoring & Evaluation, Traceability, Supply Chain Management, Market Linkage, and Financial Services.
2.	Farm ERP	It offers solutions on Farm Management Software, Small Farm Management Software Platform, and Science based intelligent advisory solutions and services to agribusinesses, financial data management and analysis.
3.	KANCHI	It offers solutions on Farm Data Repository, Farmer Investor Service, Inventory and invoice Management of Input shops, Farm Equipment Leasing, Produce Aggregation, and Market Access.
4.	CropIn	It offers solution on complete Farm Management Solution, Risk Mitigation and Forecasting Intelligence Solution, Pack house Solution for Traceability & Compliance, CRM & Input Channel Management Solution.
5.	pay Agri	It offers solution on forward and backward linkage, Tech Driven Products (Farmer credit Appraisal, Farmer Financial Report, Inclusive Fintech Solutions, Agri AI & Expert System, Agri Decision support system.
6.	Kalgudi	It connects farmers, traders, input dealers, logistics providers, academia, institutional buyers, POs, government departments and consumers on a gratification model. Interactions such as information, help, advice, buy, sale and service happen between them solving each other's problems and benefitting together.

7.	DigiAgri	It provides holistic as well as specific solutions for all the ecosystem players of Agriculture by keeping farmers at the center.
8.	eFresh	It envisages empowering 1000 farmer producer organizations/ agripreneurs with quality agri inputs and technology solutions for crop production, market linkages and introduction of quality management systems in business operations.
9.	DeHaat™	It provides a marketplace for farmers to sell produce to large institutional buyers directly without the intervention of middlemen or commissioning agents. The company also provides last-mile connectivity for easy logistics and storage services.
10.	Crofarm	It delivers fresh fruits and vegetables to both online and offline retailers after procuring it directly from the farmers. It uses an AI-based demand prediction system to study the historical data to make its procurement. The system also helps in keeping track of the inventory by its shelf life, which sends an alert in case of an aging inventory. Further, Crofarm also uses CRM tools built on WhatsApp to manage customer interactions.
11.	AgriBazaar	It is an online platform which helps connect farmers, traders, banks, enterprises and governments. Modelled on the traditional Mandi system, the startup provides a digital platform for small farmers and merchants to directly sell and buy farm produce without the involvement of middlemen. In this case, the farmers receive payment directly in their bank accounts via e-wallet AgriPay. Apart from connecting the sellers and buyers, AgriBazaar also provides last-mile logistics support. The startup uses AL and ML to offer services such as crop advisory and credit-on-click. Looking forward, AgriBazaar aims at mapping and tagging every farm and 'becoming the Google Maps of the Indian agri-sector'.

12.	KrishiHub	KrishiHub procures fresh vegetables directly from farmers and delivers them to businesses such as restaurants, canteens, and hostels. The startup uses an AI-powered supply chain to undertake farm-to-doorstep delivery. Other services of KrishiHub include machine learning-enabled weather forecasting, precision agriculture using satellite, and regional language supported discussion forums for the farmers.
13.	NinjaCart	NinjaCart procures fresh produce from the farmers and delivers to the businesses, including Kiranas and private retailers, in 12 hours. NinjaCart uses analytics to take control of the supply chain to solve asymmetries, inefficiencies, and disorganisation of a traditional system.
14.	Samudra Network	It offers solution on FPO Digitization like, shareholder data management, inputs stock and sales tracking, shareholder crops and outputs sales tracking, FPO business and operational metrics dashboards, market network.
15.	Intello Labs	Intello Labs offering deep learning solutions to assess the quality of farm produce. It is recognized as a de-facto business for expert AI capability in solutions that satisfy real world challenges in near real time. It has invented a pioneering first-in-the-world app & equipment to test, grade and analyse the visual quality parameters of agri commodities.
16.	BigHaat	It is bringing accessibility of quality agricultural products and personalized advisory by leveraging its technology offering for farmer empowerment. It is providing a wide choice of quality inputs to farmers at their doorstep.
17.	WayCool	WayCool has adopted a tech-enabled supply chain approach, merging the physical and digital worlds for a "phy-gital" business model. The company utilizes robotic process automation, artificial intelligence, and machine learning technologies to provide value to their suppliers and clients.

18.	Ujjay	Ujjay is enabling farmers to improve their ROI by providing them a one stop solution for all their farming needs through their platform - a technology enabled platform complimented by physical presence. They are one of the fastest growing start-ups in the Agri Tech sector and one of the few companies providing end-to-end solutions to the farming community in India.
19.	KHETHINEXT	KHETHINEXT Platform enables digital agriculture transformation, and is a product of PALS AGRI eCONNECT Private Limited. This platform supports small farm holding farmers to reduce their cultivation costs, connect with financial institutions, obtain higher remunerative prices and improve their crop productivity through virtually connecting with the rest of the agriculture ecosystem, like input agencies, financial institutions, produce buyers, agriculture experts, policy makers and government extension officers.

Suggestions for Effective ICT Application

Many stakeholders who are part of the agri value chain are already using ICT to streamline and enhance their marketing functions, ranging from using social networks to complex customer management tools (Jensen, 2007). A few suggestions for effective application of ICT are -

- Ease of access to Portals - consumer friendly
- Up-to-date content and coverage
- Layout design and consistent themes
- Easy navigation and higher interactivity
- Access through multiple media
- Higher use of non-textual information

- Multiple local/vernacular language
- Low cost of transactions
- Effective linkage with extension techniques

Conclusion and Way ahead

Agriculture contributes significantly to the Indian economy. ICT can revolutionize agriculture in many ways. ICT projects are yet to make any breakthrough in agricultural information dissemination and other areas. Deployment of ICTs needs to be stressed more. ICT for agricultural projects needs to be compared and evaluated precisely. Robust and economical mobile infrastructure is imperative for the exchange of vital information between farmers and service providers. Further, the use of smartphones and tabs for information dissemination is more efficient and tailored for the users as it facilitates in installing software applications for getting advanced risk mitigating strategies such as early warnings and advisory information. It also helps in integrating the supply chain with GPS which provides mapping functionality.

Thus, ICT innovation empowers farmers by facilitating timely access to localised and personalised information for greater control of their production, risks and thus market their produce to the identified market opportunities. It is the need of the hour to obtain apposite information through ICTs and to deploy advanced ICTs in agriculture, one of the indispensable sectors in our country. It is a well-known fact that ICT can revolutionize agriculture in many ways. There is a need to strengthen the physical infrastructure (storage, logistics), regulatory mechanisms (APMC Act, agri input/marketing licenses); and socio-economic conditions (financial inclusion, aggregation). A professionally managed ICT platform can bring the various pieces of the agri value chain together and act as a catalyst for agricultural growth. The solutions must be mobile based approach to maximize on-ground adoption and impact. Effective use of social media in Supply Chain Management is necessary for the benefit of all stakeholders. The high potential for ICT integration in agribusiness value chains must be tapped.

References

Adhiguru, P. and Devi, S.V. (2012). ICT in Indian Agriculture: Learnings and way ahead. International Journal of Extension Education. 8:1-4

Chatarjee, S. and Kapur, D. (2016). Understanding Price Variation in Agricultural Commodities in India. India Policy Forum.

Darekar, A. and Gummagolmath, KCG. (2021). Refurbishing a Wrecked System of Agriculture Marketing In India. International Journal of Social Science and Economic Research. 6(5):23-27.

Deshmukh S. and Patil, S. (2021). Transformation of Indian Agriculture with Digital Marketing. International Journal of Agriculture System, 13(10):10928-10931.

Goutam, H. (2014). Agricultural Development: The Road Ahead. Kurukshetra, 62(8): 47-51.

Jensen, R (2007). The Digital Provide: Information (Technology), Market Performance, and Welfare in the South Indian Fisheries Sector, Quarterly Journal of Economics, 122:3 (879-924).

Meena, MS. and Singh, K. (2012). ICT Enabled Extension in Agricultural Sector. Social Science Research Network.

Mohammadi, R. (2011).Challenges and Implications of ICT Application for Improving the Marketing of Agricultural Products. ARCC Journal, 31: 161-166.

Saravanan, R. and Darekar, A. (2020). Farming 2: Digital Agri Value Chain. Kurukshetra. 69:(2) 33-37.

Satapathy, S. (2015). ICT in Agriculture: An Effective Tool for Agricultural Development. P.G. Dissertation, P.G. Department of Commerce, Utkal University, Bhubaneswar.

Shalendra, K.C. Gummagolmath and Sharma P. (2011). ICT Initiatives in Indian Agriculture- An Overview, Indian Journal of Agricultural Economics. 66 (3).