Technological Advancement in Digital Farming and India's Present Scenario: A Review

Vidyasagar Yashvardhan[1*], Ram Pyare[2], Ram Batuk Singh[3]

[*1]M.Sc. Scholar, Department of Vegetable Science, Chandra Shekhar Azad University of Agriculture and technology, Kanpur (UP) India - 208002

[2, 3]Professor, Department of Vegetable Science, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (UP) India - 208002

*Corresponding Author

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Abstract**—** *Technological advancements in agriculture practices for improving the crop overall life cycle is essential requirement for countries like India. In order to compete day to day increasing food demand for growing population and also to strengthen the economy, advancement in agriculture practices has become immensely necessary. In India, same practice use differently because of its highly variable climatic and geographical condition. Agriculture practices in India faces many problems like, small land holding, climate change, agroclimatic variation in different states, uneven rainfall, conventional (old) practices, traditional knowledge and political and economic tantrum unavailability of storage and transport facilities, inspite of this economic losses also occur due to the lack of indispensable information to the farmer.*

To overcome these obligatory problems we have to acknowledge technological advancements and digitalization in agricultural practices. Some of the furtherance like Sensing, Geoinformatics, mobile applications and data analytics which will provide us the useful information about moisture percentage, soil health, fertilizer doses requirements, disease and pest management and exact prediction of the crop nutrient demand and also helpful in making appropriate schedule and storage arrangements to decrease the post harvest losses. We can also make marketing strategies according to the data we get and can convert old farming practice into high profitable enterprise. To make this review paper possible we went through vast literature, data, websites, journals, magazines and research papers directly or indirectly related to the agriculture advancement and digital progression.

With the help of available information we tried give our reader an brief and Hi-tech understanding of Digital Technologies like Artificial Intelligence, Internet of Things, Big Data Analytics, sensors, companies, Satellite Imagery and Remote Sensing, Machine Learning, Robotics Unmanned Aerial Vehicles (Drones) and their mobile Applications like mKisan, Meghdoot, Damini etc.

Keywords**— *Digitalization, Internet of Things, Sensors, Drone, Artificial Intelligence.***

I. INTRODUCTION

Number of research based documents, websites, journals and papers were explored to get an in depth understanding of the concerned heading. Genetic diversity and architecture for climatic adaptation in different crop like cole group of vegetables, roots crop, bulb vegetables. Vegetables are a key factor in their availability in different season spite of photo thermo sensitive in nature. Area under protected cultivation across the world has increased many folds in the last one decades and presently estimated more than 5.0 million hectare. Several innovative technologies have been developed over time in different areas viz.; green house structure and environment control energy saving, precision input control technology, fertigation, Abiotic management, mechanization and use of nutrient management sensors, robotics, processing management, harvesting, marketing and farming plus advance storage. In contrast to conventional agricultural technique, using digital Data can escalate resource and Cost efficient, decrease negative environmental impact, modern data technique to be adapted to a specific field, integration of smart Agricultural technologies and to ensure an production process. The application of IT support in farming to make informed decision based on solid data.

1.1 Why we need advancement?

The average farm area in US is 179.20 Ha, in Australia, it is 433.121 Ha and in Europe, 161.22 Ha while that in India, it is 1.0823 Hectares. Farmers average income in India is estimated at Rupees 77, 97625. 70% of farm time is just managing and monitoring. "Smart Agriculture" need arises due to this demand where management is main concern not the actual field work. As privatization is bringing in, Given the volume of agricultural products consumed in India, Indian agriculture will progress toward digitization. Contract farming operations are in line with the evolving food needs of modern consumers, and as a result of interconnected agriculture value chains, not only are farmers but also all other players in the value chain, such as input suppliers, traders, consumers, and processors, are given digital empowerment.

II. LITERATURE REVIEW

Miller et al. (2013)[5]:"Reported that in their paper, the authors emphasised the usefulness of timely information, mobile phone availability, financial inclusion, and crisis organisation information services, among other factors, in creating more efficient and resilient agricultural value chains".

Hrustek (2020)[6:] "Observed in the timely dissemination of information, personalised product development based on customer needs, traceability, proper policy implementation, and an overall connected agriculture value-chain that results in an environment-friendly and sustainable form of agriculture, the role of digital transformation in agriculture has been highlighted".

Mane et al. (2018)[7]: "Noted that in their research, the authors underlined the fact that GPS and camera services are currently the most popular features found in mobile applications. In addition, applications for conferences, market intelligence, farm information, illnesses and pests, and other apps were developed for mobile devices".

Raj et al.(2020)[8]: "Reported that in their paper, discuss how different mobile apps are being developed to create a farm-to-fork connectivity in the agriculture value chain, where different farmers are connected to their potential customers to meet their needs and simultaneously address the problems of fair prices, waste, and middlemen".

Saxena (2020)[9]:"He noted in his article that by 2022, smart agriculture will have a global market worth of roughly 23.14 billion US dollars. The agriculture sector has a variety of mobile applications that deal with peer connectivity and information exchange, online loan services, e-marketplaces, weather forecasting, GPS tracking, value-chain process traceability, and animal management services. These applications have a variety of features, such as chat capabilities, cloud support, machine learning, payment gateways, information stacks, and weather predictions".

Ohlan (2020)[10]: "Mentioned in her research that Bengaluru-based agritech firms raised the most money in 2016, followed by Delhi in second place and Mumbai in third.50 percent of the start-ups established in the previous five years did so between 2015 and 2016".

Choudhary et al.(2016)[11]: "observed for farm management and other related objectives, farmers are given 24/7 access to their soil-related, weather-related, and other types of data using devices that have cloud accessibility. Without having to personally visit the farms, other system participants such as specialists, consultants, and researchers can also obtain this data, saving both time and resources".

Biberacher(2018)[12]: "Illustrated in his post how IAAS, PAAS, and SAAS may be used in the agriculture industry. SaaS applications include big data analytics, artificial intelligence, information, and monitoring software. PaaS applications include technology like drones, satellites, robots, and sensors. IaaS applications include high-tech farming infrastructure".

Elijah et al.(2018)[13] "The authors of this study focused that the use of wireless sensors for IoT and data analytics based approaches to increase agricultural activity productivity and efficiency and adopt smart agriculture. Along with wireless sensors, IoT also uses technology like cloud computing, radio frequency identification, and similar ones. Through web-based platforms, farmers can schedule education and training sessions on topics such as production methods, market analysis, post-harvest procedures, customer preferences, weather forecasting, input availability and credit availability, early warning systems for pests, diseases, and the like".

Kour et al. (2020)[14]:" Showed how supply chain management, crop monitoring, crop management, irrigation, and disease monitoring are some of the ways that the agriculture business is using the Internet of Things more and more".

Pawar (2020)[15] " Illustrated about applications of cloud computing in agriculture, like crop data, crop monitoring, soil data, region specific farming data, and agricultural marketing".

Talaviya et al. (2020)[16] "Observed image recognition and perception, chatbots, robotics, and autonomous systems in the form of automatic plant irrigators, soil moisture sensors, vision-based weed detection technology, weed prevention robots, and drone technology applications for pesticide spraying, crop monitoring, yield mapping, yield calculation, and similar tasks are just a few of the many applications of artificial intelligence that are discussed in their paper".

ICT Madan et al.(2020)[17:]" Highlighted in their report that despite having the second-largest area of arable land in the world, we are still lagging far behind when it comes to adopting more advanced digital technologies. They cited mainstream areas like policy implementation to make farming a futuristic industry with guaranteed livelihoods".

Beriya (2020)[18:] "Argued that because the majority of technologies being created in India are still based on foreign models, Indian farmers cannot afford them. Additionally, the significance of pay-per-use technology and leasing business models is emphasised. In his research, he also makes note of the crucial role that FPOs play in financially and technologically assisting small and marginal farmers. Artificial intelligence, the Internet of Things, big data analytics, and other digital technology applications are examples of current and emerging trends. The Indian agriculture sector's overall issues and future opportunities are also discussed".

III. RESULT AND DISCUSSION

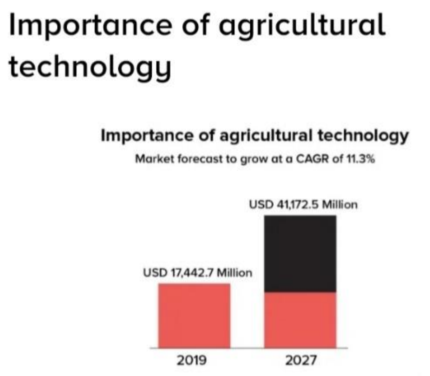
Average Monthly Income of Agriculture Household

SAS 2021	**Rs . 10218**
SAS 2014	**Rs. 6426**

In their work, **Kumar et al. (2011)** emphasised the importance of knowledge transfer and how it must be pushed forward to precisely meet the demands of farmers so that their previously amassed body of knowledge can also be used in the future. In order to create belief, knowledge must also be shared in a way that is transparent and factual, taking into account all the barriers connected to culture, language assurance that Indian farmers have demonstrated.. **Shukla et al.(2018)**[2] mention in their report that most Agri start-ups offer IOT based solution, AI, big data analylitic in the value-chain.

Countries	Total Arable land (million hactare)	Cereal production Million tonnes	Average farm area in hectares	Farmers average income in rupees	Contribution in total GDP
India	159.7	314.51	1.08	122616	19.9
USA	152.2	467	179.20	13148960	5.9
Russia	79.95	116.46	150	511284	3.9
China	126	612	0.6	1330165.2	7.3
Netherland	0.53	1.34	41.7	1575546	1.58
World average	1574.93	_	_	_	6.4

The future of food is undoubtedly digital, and the future of digital is unavoidably AI (Artificial Intelligence). AI applications are being established throughout different parts of agriculture, from gene sequencing in seed development and sensors that create data to image recognition tools that assay and grade crops and commodities." The year 2019 (**Gurumurthy and Bharthur**)[3]. "A New Indian Model of ICT-led Growth and Development, " a project from Columbia University and The Energy and Resources Institute (TERI). The project looks at the possibilities for a new model of research and development in India's agriculture industry that is led by information and communication technologies and aims to give recommendations on how India might move the development process forward.



Involvement of Multinational Companies.

The largest agricultural firms have applications that now cover millions of acres of farmland and ask farmers for data in exchange for suggestions and discounts on how to use their products. The largest seed and pesticide manufacturer in the world, **Bayer**, claims that work on their app is already underway and moving in this direction.

The good news is that agribusiness is following the trend of supplying data to farmers via their cell phones so they can receive "advice" from them.

E. tech from Japan On a plot of land outside of Hanoi, **Fujitsu** constructed a test vertical farm. The high-tech farm, which resembles a factory more than a farm, grows lettuce on stacked shelves in an enclosed high-tech greenhouse under the control of central computers in Japan. Computers are linked to a cloud that Fujitsu runs in collaboration with **Aeon**, one of the biggest grocery merchants in Japan.

For instance, **Microsoft** is attempting to promote a digital farming platform called **Azure FarmBeats** that utilises the company's enormous, worldwide cloud computing platform**, Azure**.

The platform is intended to give farmers real-time data and analysis on their soil and water conditions, the current situation with pests and diseases, the growth of their crops, and weather and potential climatic changes. The usefulness of this knowledge and guidance depends on the quantity ad quality of data that Microsoft can gather and employ algorithms to analyse.

The largest seed and pesticide manufacturer in the world, **Bayer**, has an estimated 24 million hectares of land under cultivation in the US, Argentina, Canada and Europe.

E. Walmart made a splash in India in 2016 when it paid US$3.3 billion to acquire the online retailer **Jet.com**. In 2018, it acquired **Flipkart**, the country's largest online retailer, for US$16 billion. Amazon is following closely. Today, roughly two thirds of India's internet retail market is controlled by **Walmart and Amazon**. The largest cloud service platform in the world is **Amazon Web Services (AWS**), surpassing Microsoft, Google, and Alibaba.

One of the agri-tech startups supported by Microsoft's 4 Afrika programme is **Twiga Foods**. Founded by a US scholar who saw the possibility for connecting farmers directly to small vendors and avoiding the dominant cartels while researching Nairobi's wholesale markets. Twiga Foods developed a successful business with the assistance of the World Bank, Microsoft, and other venture investors.

Multinational company	Total Turn over in USD
Amazon	$386 Billion
Microsoft	$192 Billion
Walmart	$13.9 Billion
Bayer	$20.6 Billion
Monsanto	$14.6 Billion
Aeon Japan	$77 Billion

In order to acquire food from farmers outside of Nairobi and distribute it directly to a network of small vendors in the city, Twiga Foods developed a fleet of trucks. All of the transactions, including payments, are managed through mobile devices and are powered by the cloud services of **Azure** and the **Microsoft digital platform**.

Ubamarket, a UK company founded by **Will Broome**, creates a shopping software that lets users make lists, scan products for ingredients and allergens, and pay for purchases using their phones.The more you shop, the more the AI learns about the kinds of items you enjoy. AI technology tracks people's behaviour patterns rather than their purchases. Farmers in Karnataka, India, started utilising **Twitter** to interact and broadcast videos of their harvest.

Monsanto claimed then that “data science” could be a $20 billion revenue opportunity beyond its Core business.

Looking Into The Advancements

Artificial intelligence (AI), which may be divided into three basic divisions, is steadily becoming more prevalent in agriculture as a result of technical advancement.

- Agricultural Robots - Robots will take over labor-intensive human duties in this industry.
- Computer vision and deep learning algorithms can be used for crop and soil monitoring.
- Predictive Analytics: Create and apply machine learning models to track and forecast the effects of numerous environmental factors, such as weather fluctuations, on agricultural productivity.

ISAAA, 2019 Global Status of Commercialized Biotech/GM crop

Countries adopted biotech in agriculture	Biotech Crops used in cultivation
China	Cotton, Papaya
Vietnam	Maize
Philippines	Maize
Indonesia	Sugarcane
Australia	Cotton, Safflower, Alfalfa
Myanmar	Cotton
Bangladesh	Brinjal
India	Cotton
Pakistan	Cotton
Sudan	Cotton
Ethopia	Cotton
Malawi	Cotton
Eswatini	Cotton
South Africa	Cotton, Maize ,Pea
Nigeria	Cotton
Brazil	Pea, Maize, Cotton, Sugarcane
Paraguay	Pea, Maize, Cotton
Uruguay	Pea, Maize
Argentina	Pea, Maize, Cotton, Alfalfa
Chile	Maize, Canola
Bolivia	Pea
Colombia	Maize, Cotton
Costa Rica	Cotton, Pineapple
Mexico	Cotton
Honduras	Maize
USA	Maize, Pea, Cotton, Canola, Alfalfa, Sugarbeet, Potato, Papaya, Squash, Apples
Canada	Canola, Pea, Maize, Sugarbeet Alfalfa, Potato
Portugal	Maize
Spain	Maize

With the help of **Information Communication Technologies (ICTs)**, **Innovative Practises (IPs)**, and **Decision Support Systems (DSS), Resource Conserving Technologies (RCTs)** and innovative practises are targeted at precise levels with the highest accuracy to achieve more precision in the application of inputs like seed, fertilisers, pesticides, irrigation, etc. at the farm level. This is known as smart agriculture.The practise of applying inputs what is required, when and where they are required is known as smart or precision agriculture.

Agriculture 1.0, "Mechanization", This is seen as a time when agriculture required a great deal of physical labour, roughly from antiquity until the 1920s. Now, the emphasis is shifting toward mechanisation.

Agriculture 2.0, "The green revolution with its genetic modification", Machines, fertiliser, and improved seed let farmers produce more with less labour from the 1920s to 2010. pushed agriculture to its financial limit and compromised food security.

Agriculture 3.0, "Changing the narrative around agriculture from subsistence to sustainability", The integration of high-tech sensors, cloud computing, specialised software, and the internet of things into farming is a sign that we have reached a new era.

Agriculture 4.0. "Integrated internal and external networking of farming activities", As including advances in post harvest processing using AI and data analysis help a lot in farming more efficiently.

Agriculture 5.0, " Robotics and (some sort of) artificial intelligence will serve as its foundation", A multidisciplinary overview of the most recent advancements in the field of smart farming is provided by artificial intelligence information technology and machine learning. Continuous industrial innovation has made it possible. It's likely that the European Commission has officially declared 2021 to be the start of an era. 5.0 Industry

Country	Agricultural GDP (%)	Level of Mechanization
USA	1	95
Western Europe	<5	95
Russia	4	80
Brazil	5	75
China	10	48
India	14	40

European Agricultural Machinery Association (CEMA) defines, All farm sectors and operations exist in digital form, connection with external partners, such suppliers and end customers, also happens online and data transfer, processing, and analysis are (mostly) automated. The processing of enormous volumes of data can be facilitated by the usage of Internet-based portals. Digital agriculture is the combination of precision agriculture and smart agriculture.

In the agriculture sectors of nations including the USA, Australia, and Israel, digital technologies like Artificial Intelligence, The Internet Of Things, Big Data Analytics, Satellite Imagery and Remote Sensing, Machine Learning, Unmanned Aerial Vehicles (Drones), and Robotics are finding extensive use. With changing consumer needs and behaviours, India is also making room for these technologies, albeit it is still relatively early in this change.

Sensors in Farming

Additionally, sensors called **ISE (Ion Selective Electrode)** and **ISEFT (ion-sensitive field effect transistor)** have been employed to track ion intake by plants. The demand of the plant, which is based on the rate of growth and the condition of the plant's nutrient content, determines the rate of nutrient uptake. Its numerous uses include disease detection and diagnosis, fertiliser calculation, soil and water analysis, crop needs estimation, crop production readiness analysis, and identification of temperature and humidity (for horticulture crops).

AgroPad: Farmers can monitor the health of their soil and water with the use of AI technology. AgroPad10 is a paper gadget created by **IBM** that is roughly the size of a business card. In less than ten seconds, the microfluidics chip inside the card performs a chemical analysis of the sample on-the-spot.

Plantix and **WhatsApp** for agricultural disease identification.Plantix is a mobile application created by German startup **PEAT** that contains a sizable database of images of plant diseases that can be used for comparison.Users only need to send an image of the infected leaf to the Plantix WhatsApp number, and the diagnosis is immediately messaged back to them via WhatsApp. Many farmers in India use this service.

Pay per use based farm tech and mechanization:

Trringo13 and **EM3 Agriservices** are the two pioneers of farm equipment rental service, have successfully replicated the uberisation of renting farm machinery and tractors in India.

Grain Bank Model of 'Ergos':

Ergos has one of the most unusual models on the Agri-tech market. Small and marginal farmers can use their **"Grain Bank model"** which provides doorstep access to end-to-end postharvest supply chain solutions, to transform their grains into tradable digital assets, obtain credit against those assets through associate NBFCs and Banks, and increase the price of their produce. The Ergos concept gives farmers the choice of storing or withdrawing one bag of grain.The network of scientifically run micro-warehouses that Ergos maintains at the farm gate allows farmers to store even one bag of grains.

AgNext19 developed the technology platform **Qualix** to assess trade quality and safety criteria for a range of commodities (grains, pulses, tea, spices, herbs, milk, and honey, among others).

It serves as a platform to quickly introduce quality assessments into the agricultural and food value chains utilising technologies like **AI-based spectral** and **AI-based image analytics**.

Digital tools for agriculture farm monitoring and risk management:

Yuktix Technologies

The technologies are powered by the hardware and software platform known as **GreenSense** IoT devices and GreenSense dashboard. **Yuktix GreenSense** is an off-grid remote monitoring and analytics system for farming. In order to gather information from many sources, utilise existing indigenous knowledge, mix it with research, and give a digital tool that let them disseminate crop-specific recommendations to a group of tribal farmers, a network of Yuktix micro-weather stations was implemented in Odisha. Dashboard-equipped GreenSense nodes are a useful monitoring and DPI (Disease, Pest, and Irrigation) management tool.

Leaf Colour Chart:

A plant's nitrogen status can be reasonably accurately predicted by the colour of its leaves. By matching the supply of nitrogen to the crops' observed needs, nitrogen utilisation can be maximised. The **International Rice Research Institute** in the Philippines created a leaf colour chart that might be helpful to farmers since leaf colour intensity correlates with leaf nitrogen status in a rice plan, which is always simple, straightforward, and affordable. According to studies, following the leaf colour scheme can help conserve between Ten to fifteen percent of nitrogen.

NDVI Sensors:

According to **Bijay Singh et al. (2015)**[4], Normalised Difference Vegetation Index (NDVI) sensors can reduce nitrogen use by 15-20% without affecting yield. This increases farmer profit margins.

SPAD Rating:

A cheap, rapid, and portable diagnostic tool called SPAD (Soil Plant Analysis Development)can be used to monitor the nitrogen (N) status of rice leaves and to better time the application of N topdressing. Farmers can afford SPAD, a low-cost chlorophyll metre. Lower leaves were considerably better than upper leaves at separating N levels, if total N was employed as an indicator, so measuring SPAD readings leaves in lower places may be more appropriate to serve as testing sample for N status diagnosis. The management of nitrogen using SPAD metres appeared to be more effective and wiser.

A Nutritional Expert (NE)

Nutrient decision support system, based on site-specific nutrient management (SSNM) principles, has been created by the **International Plant Nutrition Institute (lPNl)** in partnership with CTMMYT. This system uses a methodical strategy to gather site-specific data that is crucial for creating a suggestion for a particular area. Compared to previous fertiliser recommendations, higher production, and farm profitability in the nation's key maize-growing agro-ecologies.

Automated irrigation System:

System of automatic irrigation Farmers will only be able to interfere when absolutely essential by integrating these irrigation systems with more sophisticated **Internet of things (loT)** enabled sensors to continuously monitor moisture levels and plant health.

Artificial lntelligence And Automation In Weed Management:

The most important components of plant growth and development that can be flawlessly managed by autonomous robots are weed and pest management. Only a few prototypes are currently being created. Future integration of powerful machine learning technologies, including artificial intelligence (Al), may eliminate the need for humans to physically weed or monitor crops. The drones are equipped with sensors, cameras, and sprayers to identify pests and apply insecticides, allowing them to perform crop spraying herbicides, fertilisers, and pesticides more accurately, efficiently, and with less waste thanks to a combination of GPS, laser measurement, and ultrasonic positioning.

Precision land levelling, which utilises a laser-guided device to create perfectly level fields, is another resource-conserving technology.

Internet of Things (IOT) In Agriculture Merket Size, 2021 to 2030 (USD Billion)

Years	Market Size
2021	12.5
2022	13.7
2023	15.02
2024	16.46
2025	18.05
2026	19.78
2027	21.68
2028	23.77
2029	26.05
2030	28.56

Drone Technology in Farming:

The industry for using drones in agriculture is predicted to develop from a $1.2 billion (USD)market in 2019 to a $4.8 billion market in 2024.Drone-collected data from farms is frequently utilised to better guide agronomic choices and is already a component of the system typically referred to as "agriculture" in large-scale precision farming operations. combining geospatial mapping with sensor data to provide information on the density, moisture, and nutritional content of the soil. For use in sowing and planting, prototype drones are being developed and tested. These drones have the ability to shoot seed pods with fertiliser and nutrients directly into the ground using compressed air.

❖ **Scouting/Monitoring Plant Health**

Keeping an eye on plant health. The Normalized Difference Vegetation Index (NDVI), a specialised imaging tool used by drones, uses precise colour data to assess the health of plants. While satellite imaging may provide accuracy down to the metre, Drone imaging can produce millimeter-level accuracy in image placement.

❖ **Monitoring Field Conditions**

Nitrogen level in soil using improved sensors is also offered by some agricultural drone vendors and service providers. This makes it possible to apply fertilisers precisely, removing troublesome growth areas and enhancing soil health for years to come.

❖ **Planting & Seeding**

Drone planting makes it possible to replant inaccessible locations without putting workers in danger. With a crew of two operators and 10 drones that can plant 400, 000 trees each day, they are also able to plant considerably more effectively.

❖ **Spray Application**

South Korea uses drones for about 30% of its agricultural spraying, and spray treatments are already common in south-east Asia. Drone sprayers spare workers from carrying backpack sprayers through fields, which can be harmful to their health. To improve productivity and reduce chemical costs, drone sprayers offer very fine spray treatments that can be targeted to particular locations. Currently, laws governing drone sprayers vary greatly between nations. They are not currently authorised in Canada since further research is required to fully understand the effects of spray drift.**Yamaha** leases spray drone services that include licenced operators but does not sell the spray drones they make.

❖ **Security**

It is more efficient to use drones to frequently check on difficult-to-reach areas of a farm rather than having to travel there in order to do so. Instead of adding more security people, surveillance drones can be used to keep an eye on the perimeter and fence of more important crops, including cannabis. By finding lost or hurt herd animals in distant grazing regions, drone cameras are also being used in innovative ways to protect farm animals. Today, remote area monitoring tasks that once required hours of travelling may be finished quickly.

❖ **Drone Pollination**

One of the most publicized and often functionalized uses in pollination drone technology. Researchers in Netherland and Japan are developing small drones capable of pollination.

❖ **Drone in Irrigation**

Using microwave sensing drones are able to capture a very accurate soil health information including moisture level and can effectively apply irrigation spray.

Global Agriculture Drone Market 2015-2021(USD Million)

YEAR	REVENUE
2015	673.79
2016	690.90
2017	995.80
2018	1230.89
2019	1656.76
2020	1988.78
2021	2978.69

Remote Sensing

Fundamentally, remote sensing entails inspecting terrain using sophisticated equipment from a great distance. The physical qualities of a plot of land are checked. By calculating the radiation that is produced and reflected by the land, the method builds a picture of the land and enables experts to assess certain areas of it.

❖ **Use**

In a competitive market, growers frequently take advantage of the most latest technology available to enhance crop development and maximise production. Farmers need their harvests to be in the best possible health in order to provide the highest output. The use of remote sensing in agriculture makes it substantially easier to monitor the size of harvests across a large area. Precision growing is supported by the data obtained during the process, enabling farmers to increase harvest yields.

❖ **Specifically For Area Estimation Of Sown Crop**

A crucial application of remote sensing in horticulture is the evaluation of the area where crops are sown. Aerial and satellite sensor data provide a precise study of planted areas and aid in the risk assessment process in the event of a disaster or catastrophic event.

❖ **Identification Of Crop Disease**

Gis remote sensing in agriculture makes it easier to spot insect infestations and contaminations in crops over large areas at the beginning of their life cycles. This allows farmers enough time to use any defensive strategies to protect their harvests from severe losses. Through the use of satellite inspection and imaging, this is made possible.

❖ **Properties Of Soil**

The right support of soil is perhaps the most important factor in ensuring a good yield of harvests. It has a direct impact on the harvest. Any improvements in farming practises or farm management alter the soil, which in turn affects the soil's ability to produce. Remote sensing can be used to identify characteristics including soil salinity, soil pH, organic substance level, and soil texture. This data can then be processed to carry out any substantial soil treatment. With the use of soil moisture mapping, any improvements to the design of the irrigation system can be made with greater accuracy.

❖ **Flood Impact And Catastrophic Disaster**

Agriculture remote sensing can help with evaluating current and predicting Natural Catastrophe dangers. utilising the data sent by sensors and the actions of typical dangers. This calls for risk mapping and evaluating hazards, which are completed using computer-simulated disaster models. In order to give areas with a high potential for flooding with high hazard ratings, remote sensing maps that were created with the help of historical data and current data collected from various sensors are helpful. This helps farming since it prevents planting in areas with higher risk ratings and allows for greater flood protection the next season.

❖ **Crop Damage Assessment Using Drone Image Analysis**

Invasions, tree counting, and crop damage assessment are all done using drone picture analysis. As accurate as the input spatial resolution is the drone imagery. which might be raised based on the situation.

India's Effort:

"In order to advance digital agriculture, the **Ministry of Agriculture and Farmers Welfare** signed 5 Memorandums of Understanding (MOU) with commercial businesses "**www.Krishi jagran.com**

Digital agriculture is described as "the use of **ICT (Information and Communication Technologies)** and **Data ecosystems** to support the development and delivery of timely, targeted information and services to support farming profitability and sustainability while delivering safe, wholesome, and affordably priced food for all**. "AgriStack**:A collection of technology-based agricultural interventions called "AgriStack" is being developed by the Ministry of Agriculture and Farmers Welfare. In order to provide farmers with end-to-end services along the agriculture food value chain, it is will establish a unified platform for them.

The mission for digital agriculture has been set for 2021–2025.

Unified Farmer Service Platform (UFSP): The UFSP combines core infrastructure, data, applications, and tools to facilitate smooth interoperability between multiple public and private IT systems in the nation's

National e-Governance Plan in Agriculture (NeGP-A): A Centrally Sponsored Scheme, it was initially launched in 2010-11 in 7 pilot States.

To develop a strong digital infrastructure in the nation that includes market data, land records, agricultural patterns, soil health information, satellite imaging, and more.Digital Elevation Model (DEM), Digital Topography, Land Use & Land Cover, Soil Map, etc. are some methods for improving data efficiency.

Government agri expenditure and share of PM Kisan Scheme:

YEAR	PM-KISAN BUDGET IN CRORE	AGRICULTURE BUDGET IN CRORE
2019	1241	53620
2020	54370	109750
2021	75000	142792

Budget Allocation For Agriculture Over 10 Years

Years	Budget Allocation (Rs. Crore)
2009-10	12,256
2010-11	14,103
2011-12	16,316
2012-13	18,715
2013-14	19,819
2014-15	31,063
2015-16	24,910
2016-17	44,485
2017-18	51,026
2018-19	57,600

Hi-Tech agriculture companies on digital platform

An automated agronomy service called **Mothive** assists farm managers in increasing productivity, cutting waste, and improving crop predictability and management.

Their technology, the **Mothive Ladybird**, automates farm operations based on current crop requirements, anticipates diseases and improves yields, and tells farmers about the best time to harvest and related logistics.

Cropx, an ag. analytics company, develops cloud-based software solutions with integrated wireless sensors to boost agricultural output and save water and energy.

"The Arable **Mark** is the first integrated weather station, crop monitor, and irrigation control tool with IoT capabilities. It has cellular connectivity, constant field visibility, and solar power. Arable is a company that offers agricultural analytics and data. It is the only device that collects over 40 pertinent plant and climatic data streams, including precipitation, chlorophyll content, radiation, reflectance, temperature, and humidity. This gadget uses modern, patented technology, including an **acoustic disdrometer** and a **seven-band spectrometer "**www.science direct.com The main services provided by **Gamaya,** a Swiss company engaged in smart farming, include growth monitoring for fertilisation optimization, yield prediction, early disease and insect identification, stress detection and diagnostics (mechanical damage, nutrient shortage, water stress, and soil compaction). Farmers can realise significant financial gains thanks to the Gamaya solution, including a 30% increase in yield, a 40% drop in costs, and a 70% decrease in disease-related risks, all of which encourage the development of high-quality goods and minimise negative environmental effects.

AgriData digitises agriculture by offering a method for tracking assets for perennial crops (trees and vines, aka high-value crops).

Agrowatcher employs multispectral imaging and computer vision technologies to identify different types of crops and identify water stress, pests, infestations, and diseases. Images are processed using a custom computer vision algorithm and machine learning, and a precise treatment (watering, pesticide/herbicide application, etc.) is then applied right away.

Rise Of Mobile Phones

Access to markets, information, mobile banking, and weather-related intelligence are just a few of the ways that ICTs can help farmers. Additionally, since mobile and smart phone usage has grown across agricultural populations, more people may now easily access the afore mentioned services without having to spend money on desktops, laptops, or other similar bulky hardware components. In addition, social media platforms like **Facebook** and **YouTube** offer inexpensive and simple ways to share information in the form of photographs and other media, enabling greater communication between farmers and other groups including politicians, academics, and specialists.

In his research, **Yared (2015)**[19] emphasised the importance of mobile financial services, one of the most promising areas for agriculture-based mobile applications where governments can contact farmers notably those who come from a low-income background and use a variety of credit facilities to better their lives.

Yared (2015)[19]: The importance of mobile financial services, one of the most promising fields for agriculture-based mobile applications where governments may get in touch with farmers, especially those from modest backgrounds and take advantage of a range of financing facilities to better their life.

Belakeri et al. (2017)[20]: Emphasised in their article how farmers may now receive timely market information and travel cost savings thanks to mobile phones, which is especially helpful for perishable goods. Additionally, because mobile applications come with a full suite of audio, video, graphic, text, and animation-based elements, they are a highly engaging way for farmers to stay up to date with current discoveries in the agricultural area as well as mobile applications centred on agriculture.

In their paper, **Brugger (2011)**[21]: Detailed the numerous mobile applications used in agriculture. Market intelligence, trading platforms, operation tracking and monitoring, quality control, logistics management, financial services, and data surveillance and collecting are some of these uses.

In their paper, **Mane et al. (2018)**[22] noted that GPS and camera services are currently the most popular features found in mobile applications.

In addition, applications for conferences, market intelligence, farm information, illnesses and pests, and other topics were developed for mobile devices.

Raj et al. (2020)[23] discussed how different mobile applications are being developed to bring about a farm-to-fork connectivity in the agriculture value chain, where different farmers are being connected to their potential consumers to serve as per their demands and overcome the challenges they may face.

Uses of ICT tools by the farmers (Expressed in percentage) (N=100)

ICT Tools	Percentage of farmers having access to the ICT tools including out sourcing	Percentage of farmers use tool on production purpose
Television	100	50
Radio	57	13
Computer	47	47
Mobile phones	90	70

Game Changing Applications.

In India, there were roughly 320 million mobile phone users in rural areas.As a result, phones serve as the ideal platform for information sharing and the simplest method of communication. Using this information, the government and the commercial sector launched agriculture apps to help farmers by giving them information, training, and support.

mKisan Portal:

All national and state government organisations in the agricultural and related sectors are empowered to provide information or services to farmers regarding agricultural practises through the SMS gateway known as mKisan, which was created by the Hon'ble President of India specifically for farmers. Unstructured Supplementary Service Data, or mKisan USSD, is what IVRS uses.Pull SMS and (Interactive Voice Response System) are value-added services that have allowed farmers to allowing other parties to access web-based services on their devices, in addition to broadcast messages.without access to an internet connection.

Meghdoot Portal:

- Meghdoot is a collaborative project between the **Indian Council of Agricultural Research (ICAR)** and the **Indian Meteorological Department (IMD)** that aims to provide farmers with high resolution weather forecast-based agricultural advises in their native tongue Every Tuesday and Friday, Agro-Mate field units deliver pertinent district- and crop-level alerts. Farmers and other interested people can easily obtain these alerts with the Meghdoot App.
- Whenever possible, advisories are also released in the native tongue. Besides crop warnings, the app also offers weather data and forecasts.

Damini

The Damini Lightning App was created by ESSO and IITM-Pune. The software keeps track of all electrical activity taking place solely in India. Additionally, it sends you a GPS warning when lightning hits within 20 and 40 kilometres of you.

- Applications in lightning-prone areas come with specific instructions and safety precautions.
- Strictly adhered to dos and don'ts in particular circumstances when lightning hits nearby with the intention of your security.

Kisan Suvidha

Prime Minister Narendra Modi introduced this app in 2016. It offers data on the present weather, a forecast for the next five days, market pricing in the nearby town, and knowledge of fertilisers, seeds, machines, etc. The software has a very user-friendly interface and is available in many different languages.

Pusa Krishi

The Indian Agriculture Research Institute created this app, which the Union Agriculture Minister unveiled in 2016. (IARI). It informs farmers about novel crop types created by the Indian Council of Agriculture Research (ICAR).

IFFCO Kisan

This application was released in 2015. Users can access a number of information modules, such as weather forecasts, market prices, and a library of texts, audio files, photos, and videos in certain languages that pertain to agriculture.

Kheti Badi

Kheti Badi is a social initiative app aimed to promote and support organic farming in the country`

Plantix

An agriculture app called Plantix links the world's farmers. The app enables farmers to take images of their ailing plants and receive advice from the global community. Along with professional farmers, the software also empowers private farmers that engage in farming as a pastime or plant researchers.

MyAgriGuru

MyAgriGuru is a digital platform for farmers, an initiative by the **Mahindra Group**.The app is aimed at creating an integrated network in the agriculture community in India.

Mobile Application	Number of farmers using	Advisories
mKisan portal	51376458	436847
Meghdoot Portal	200000+	42000000
Damini app	10 lakhs +	-
Kisan Suvidha app	10 lakhs +	3423234
Pusa krishi app	50000 +	232331
IFCCO Kisan	5 lakhs +	-
Kheti Badi	1 lakhs +	232322
Plantix	10 million +	-

Purpose of Use Of Mobile Phones(Expressed in Percentage) (N = 100)

Purpose	High	Moderate	Low	Total
Communication with other	50	40	10	100
To know about Marketing	7	43	27	77
To get higher price of produce	0	13	10	23
To get new information on agriculture	37	50	13	100
To get general information	56	37	7	100
To get health information	0	0	30	30
For increasing production	0	27	43	70
To know improved skill on agriculture	0	50	20	70

IV. CHALLENGES AND LIMITATION

Through the efficient use of inputs, sustainability in production, and increased resistance to risks, shocks, and long-term climate variability, the transformation of Indian agriculture must be more productive. In order to simultaneously address the concerns of food security and climate change, Climate-smart agriculture (CSA) is one of the three pillars of sustainable development, according to the FAO (economically, socially, and environmentally).

1) Steadily raising agricultural output and revenue;
2) 2)Adapting to climate change and fostering resilience;
3) Reducing and eliminating emissions of greenhouse gases.

Around 80% of farmers in India are small and marginal farmers with access to modest land holdings, and the average farm size in that country is 1.08 Hectares.As a result, Indian farmers don't need more sophisticated technologies like farm robots and drones, etc.

Inability to target small and marginal farmers with limited land holdings was noted by **Blommestein et al. (2006)[24]**.

Madan et al(2020)[17]:

Stated that first and foremost, the technologies under development must be strengthened to better withstand the unpredictable nature of farming and make judgments in real time to fulfil the varying needs of an agricultural field. Second, the solutions must be more reasonably priced so that a typical farmer with less literacy may access them and use them on a daily basis.

Birner and others (2021)[25]

Stated some of these difficulties include a lack of funding, a smaller market that makes it difficult for companies to satisfy their individual development expenditures, high development costs for embodied technology types, and an unfavourable business environment. The primary obstacles to the digital growth of agriculture were noted by **Bayne et al. (2021)[26]** in their report. The issues include inadequate power, electricity, and telecommunications networks; inadequate regulations and procedures to be governed by government agencies and a lack of digital literacy and skills among agricultural populations.

V. CONCLUSION

In a nation of 1.4 billion people, each with own language, religion, and way of life. Half of the population works in agriculture, thus there is opportunity for improvement and a need for expansion.

Digital platforms with regional language interfaces, low input and high output investments, easy communication routes, on spot solution based software could be driving factors and with a positive acceleration can become reason for the Indian farm sector's digitalization.

Digitalization in present world is in great demand as it makes farming more precise and high profit orient business which is very essential for a country like India with huge population.

From Drone technology, Remote sensing, Mobile phone applications, Internet of Things, Mechanized processing post harvest units and Artificial intelligence are some examples manifesting the advancement recently emerged,

Enhancing the ordinary regular, day to day farming practices into accomplishing enterprise.

As one of the member of the developing country India needs to make obligatory changes in agriculture policies making it more open to international market and easily reachable for local young entrepreneur and foreign multinational to make pertinent investment in Indian markets. Therefore, we can say in clear words that while completing the journey from agriculture 1.0 to 5.0, mechanization, digitalization, use of various agriculture portals, Industrialization are fully adopted in farming activities. As a result advancement in farming income will eventually double, employment to educated youth increase, it will be helpful in increasing the GDP of India to a greater extent. It will not be too late for India to become a Golden Bird again.

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