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DIGITAL FARMING-A SECOND GREEN REVOLUTION IN INDIA-A REVIEW

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Abstract:

India is the seventh biggest country in geographical area and the second most populated country after China. To feed the ever-growing population of India after Independence, the green revolution played a tremendous role, leaving behind some harmful effects on the environment due to over usage of chemical fertilizers and plant protection chemicals which eventually declined the soil fertility necessitating the adoption of eco-friendly farming methods like organic farming, natural farming to restore the environmental health and provide food security of the nation. With these new techniques taking care of every aspect of the crop is difficult which can be made easy by the emerging digital agriculture tools such as Precision farming, IoT, Artificial Intelligence and machine learning, etc. These tools make farming easy and interesting at the same time facilitating easy and continuous monitoring, irrigation water management, weather forecasting, pest and disease identification and spraying operations. The Present study focused on the genesis of digital agriculture in India, contributions by the government, the application of public-private partnerships in digitalization, some important digital tools, and the scope of digitalized agriculture in India by giving some successful examples.

Keywords: Digital agriculture, IOT, Artificial Intelligence, Precision Farming, Forecasting

Introduction:

"Our ancestors used to play with snakes, we are playing with mouse", a quote by Shri Narendra Modi reminds us that we are living in a digital era where everything in human life starting from food to medicines is connected to the virtual world. Being the backbone of the country agriculture sector needs drastic changes to meet the growing needs of the country. India stands first in the production of paddy, wheat, pulses, and spices. Agriculture employs over 42% of the population in India and contributes to 20 percent of the GDP. The majority of the Indian farms are marginal rain-fed, making it difficult for them to adopt new technologies because of their high unit cost. Food grain production in India should lift to 333 million tonnes by 2050 to meet the needs of its growing population. Over the last few decades, agriculture has developed by leveraging technology, modifying crop genetics, and mechanization. Research by NITI Ayog revealed that to maintain an annual growth rate of 8-10%, agriculture production must expand at 4% or more per annum.

To provide sufficient food for the ever-increasing population scientists encouraged chemical fertilizers and high-yielding varieties of crops and focused only on strengths (encouraged high-yielding areas) ignoring weaknesses during the green revolution which triggered indiscriminate use of chemical fertilizers and chemical pesticides which made agriculture the second biggest contributor to pollution due to emissions of methane and CO_2. Chemical emissions into the environment are triggering climate change which is causing crop losses in sensitive areas. The prime reason for reduced food production is the lack of proper planning, unpredictable weather conditions, improper harvesting, and post-harvest care, selection of wrong irrigation techniques, and mismanagement of livestock *(Abhinav Sharma et al. 2020)*.

Conventional farming practices such as mono-cropping, indiscriminate use of chemical fertilizers, and soil erosion lay stress on agriculture production, leading to gradual yield reduction due to declining soil fertility, putting the nation's food security at stake. To increase production to meet the needs of a growing population, combat climate change variations, and attain food security and sustainability in the nation digitalization of agriculture can be the best solution as it optimizes resource utilization and allows better monitoring of the farm. Remote sensing systems generate a large volume of spectral data due to high resolutions. Data processing techniques like Big Data analysis, artificial intelligence, and machine learning draw useful information from the vast amount of available data *(Kamilaris, A. et al. 2020)* Cloud computing systems store, process, and distribute/utilize this data for practical field applications. These advanced data acquisition and processing techniques are used worldwide for decision-making in agriculture, horticulture, floriculture, and livestock.

Digital Agriculture alternatively known as smart farming/e-Agriculture brought a completely new era in agriculture which digitally or electronically integrates Artificial Intelligence, robotic technology, unscrewed aviation systems, sensors, and communication networks across the supply chain from sowing to the consumer. Digital farming includes a range of technologies such as precision farming, drone technology, yield mapping,

GIS, GPS, e-commerce services, machinery hiring apps, and diagnostic apps, etc had evolved to assist farmers but are not reaching every corner of the country while some are still in the process of rising. It assists farmers in day to day management of farms and improves automation, regular monitoring, observability of the farm, choosing better crop varieties or hybrids, to increase the resilience of crops to climate and energy efficient farming system to increase farm productivity to get better yields. Digital tools act as catalysts between Famers and climate by way of giving climate hazard warnings to farmers which allow farmers to take corrective measures in time. In this technology-driven era, with techies turning farmers who are well equipped with knowledge of digital tools promotion of 'Digitalization in Agriculture' becomes an easy task. Over 1000 agri-tech start-ups have emerged in the recent past in India to assist farmers and to stand their chance in the evolving digital farming industry. Recently Acharya N G Ranga University started a drone pilot training programme named APSARA (Centre for A.P. Sensors and Smart Applications Research in Agriculture) and is the first in the country to get permission to conduct Authorized Conventional Remote Pilot Course (CRPC) to train drone pilots.

The genesis of agriculture digitalization in India:

- Digitalization of agriculture in India started on 26 January 1967 when Krishi darshan was premiered on DD national. Later on, some TV channels started to dedicate some programs to agriculture.
- ETV was the first television channel to start a special programme dedicated to farmers named "Annadatha" which will be telecasted every day from 6:00 AM to 6:30 PM for 30 min since its inception in 1945. Other channels like Doordarshan have broadcasting paalu-chelu since 1978, and TV5 is broadcasting "Annapoorna"
- Introduction of the internet in India happened in the 1980s
- Introduction of mobile phones in the late 1990s
- FRIENDS in Kerala and CARDS in Andhra Pradesh were started for the digitalization of government documents and land registration documents
- First automated milk collection system AKASHAGANGA was started in 1978 in Gujarat
- In the early 2000's some initiatives like e-chaupal were initiated by ITC, and e-sagu by IIIT, Hyderabad.
- Information village centers by MANAGE and village resource centers by MSSRF have been started as pilot projects which succeeded in bringing change in the areas where they were implemented.

Later on, the government started digitalization by taking initiatives like KVK mobile app, Pusa Krishi, Kisan sarathi, KISAAN, uber for tractor, Kisan rath, jaivikkheti portal, agAgrinvestments, agAgriarket, by IMD and ICAR, mamonsoony IMD, IITM (Pune ICRISAT & DAY (digital agriculture and youth), Gemini by ISRO & INCOIS and many more locally started services like Annapoorna Krishi Prasara Seva in Andhra Pradesh – a short messaging service from DAATTC.

Some important digitalization tools:

Artificial Intelligence:

Many companies developing robots simulate humans in their absence to monitor the field, collect real-time data and take management decisions if well-designed and trained robots can be utilized for harvesting vast volumes of produce. AI sensors can detect weeds, pests, diseases, and moisture levels can provide suggest protection chemicals, and also can forecast the weather based on their feed. AI machines can cut down the expenditure on plant protection chemicals and can protect the soil from degradation and chemical leaching by way of reducing the number of chemicals used. It can also save the amount of water used by reducing irrigation wastage and cutting down the water usage for spraying.

Internet of Things:

IoTs are integrated whole of digital devices, mechanical objects, humans, and animals with unique identifiers that can transfer data over a network without any manual support. It's a network control tool in a hyper-connected world and makes people work smart as it automates processes, cut extra costs, increases transparency in transactions, etc. IoT helps farmers in many dimensions, one of them being weather data collection including rainfall, humidity, temperature, soil content, and real-time monitoring. It gives farmers control over the field as they get information starting from soil data to weather data. This will reduce the burden on human labor which can be utilized elsewhere where it is much needed.
Examples: wearable devices like smartwatches, home security systems, GPS devices, and internet connections.

Drone technology:

The drone has two literal meanings namely a **'male bee'** and **'a monotonous sound'**. Drones are unstrung aerial vehicles which are remotely controlled using sensors and a Global Positioning System. In conventional farming, a man/woman takes four hours per acre to spray a plant protection chemical using a knapsack or power sprayer whereas a drone can do it in 6-7 minutes by saving 25 percent chemical and a large amount of water. Drones operated by certified drone pilots might be costly at the start but are cost-effective for the time being. Some of the benefits of drones include:

1. Crop and field surveillance: Crop surveillance is continuous monitoring of the crop right from the field preparation, and sowing till harvesting of the produce. Drones help a farmer in continuous field monitoring for pest and disease diagnosis and identifying plant growth stages for fertilizer requirement and maturity symptoms. Practically a human can't check the whole field for pests and diseases unless it shows symptoms or signs. By the time crop shows symptoms insects might have crossed damaging levels. Drones help in diagnosing disease or pest occurrence well in advance by close monitoring of the crop from time to time.

2. Sowing: Drones aid in sowing which will not only save time but also save labor, and cut down the fuel costs for machines thereby reducing pollution in the environment.
3. Spraying operations: These aircraft aid in spraying pesticides and fertilizers in a very little period with 25 percent less chemical and 90 percent less water compared to human-operated sprayers which require 200 liters of water per acre.
4. Weather forewarning: Storm drones are being utilized to predict weather conditions which will help farmers to take care of the crops in time.
5. Geological fencing: Drones with cameras can detect animals and tress-passers coming inside the field thus helping in guarding the fields, especially at night.

Precision farming:

It is a modern farming technique for crop management using information technology and sensors for efficient utilization of resources to raise production thereby raising income. Indian farmers in one area or village usually cultivate similar crops with the almost same package of practices and reap at the same time which sometimes impacts the demand and price of the product due to a lack of awareness of crop variability and other remunerative alternatives. Through this crop management technique, real-time data of soil moisture, temperature, weather, and all stages of crops can be collected through sensors installed for the same and this data can be critically studied to plan detailed package of practices for remunerative and climate-friendly farming by planning suitable crops based on soil type and climate, by eliminating unpredictable climate risks, minimizing the harmful impact on the environment, minimizing chemical usage and effective water and waste management, etc. This farming is remunerative in India when it is followed on the community level considering the small and marginal land holdings of the majority of the Indian farmers as the initial investment is high and their capacity is less.

Public-Private Partnership for digitalization:

Due to the shortage of extension workers per unit size of the population, their work boundaries, shortage of funds, and packed up schedule extension workers couldn't reach every corner of the country to solve farmers' queries. On the other hand, private firms don't have many boundaries and restrictions in their line of work. They provide farmers with the best advice in the market and provide quality inputs. Youth are getting attracted to farming and are farming with new technologies while some are inventing new techniques to make farming smart. Engineers who became farmers are experimenting in their way to make farming interesting. Government alone can't promote digitalization because of the lack of trust of citizens and its fund and staff limitations. The Action of private firms should be encouraged to ensure remote reach of benefits of digital agriculture because intensive work is possible if work is less.

By considering the advantage of fewer boundaries and an increasing number of educated young farmers India should encourage PPP in the digital agriculture sector. PPP (Public Private Partnership) helps farmers get innovative solutions, continuous monitoring, and energy-efficient machines for their farms. The majority of agri-tech start-ups are emerging day by day aiming to provide solutions to various problems such as monitoring and increasing farm efficiency by reducing the wastage of produce in the supply chain for better crop management to get better yields and protect the environment. PPP is critical for enhancing the synergy between the government sector and agri-tech companies where the government can provide funds and the private sector can utilize these funds in the best possible way to come up with new-age solutions to resolve farmers' issues.

Recent Government initiatives to promote Digital or Virtual Agriculture:

1. *Direct Benefit Transfer*: A unified central agriculture portal launched in 2013 for all the agriculture-related schemes in the country which helps farmers to get government subsidies directly to their bank accounts.
2. *e- NAM (electronic-National Agriculture Market)*: A pan-India electronic trading portal launched in 2016 for linking the existing APMC mandis across India to create a unified market for selling the product by eliminating middlemen.
3. *UFSI (Unified Farmers Service Interface)*: Developed by Microsoft in collaboration with the government of India this interface is useful to handle many types of transactions in the digital agriculture space which allows stakeholders to exchange data efficiently in an organized manner.
4. *Digital Agriculture Mission*: The Government of India launched DAM 2021-2025 in September 2021 aiming to leverage a wide range of technologies ranging from Artificial Intelligence, and Blockchain technology to drone technology in an attempt to improve the overall performance of the agriculture sector with a value chain starting from crop selection, crop protection till marketing. Under this mission 5 MOUs were signed with cisco, Ninjacart, jio platforms Ltd, ITC Ltd, and NCDEX e-markets Ltd to popularize digital agriculture.
5. NITI Ayog in partnership with IBM (International Business Machines) created a crop production forecast model supported by AI to assist in enhancing yields, soil health, controlling input usage, and pest and disease forewarning.
6. Agricultural Digital Infrastructure solution created by cisco in august, 2019 for improving farming and exchanging knowledge played an essential role in the data pool of the department of agriculture created under the National Agri Stack.
7. *The Jio Krishi platform* launched in February 2020 digitalized the agricultural ecosystem along the value chain to educate farmers.
8. *SENSAGRI (Sensor-based Smart Agriculture)*: Under this programme drones are being utilized to scout over land areas, get information, and communicate the data to needy farmers.

Scope of Digitalization in India:

Being 2nd most populous country supporting 16.7% of the world's population with only 2.45% of the world's geographical area India should embrace digital tools in Agriculture to feed its growing population. Innovations in the digital world are assisting farmers from seed to seed. AI tools such as swarm intelligence-inspired autonomous systems are useful for the growth and health monitoring of crops. Unmanned Aerial Vehicles like drones can be utilized for real-time field and livestock monitoring through computer vision and Deep Learning algorithms and simultaneously used for spraying pesticides and fertilizers in the infected crops. UAVs with installed cameras can measure the greenness of the foliage for judging the harvesting maturity and disorders and an automated irrigation system can be built in large agriculture fields. Mobile robots in the agriculture fields automate tasks such as the identification of weeds and their management and harvesting, etc. Node location for sensor placement in the soil can be done at a low cost by meta-heuristic algorithms.

To assist the farmers without mobile phones or internet connectivity which is the usual case in India, offline chat systems can be developed which will assist farmers by providing timely expert advice to resolve their issues. Renewable energy plants automated using AI can be installed in agricultural lands to maximize the power output of clean energy in unpredictable weather conditions which leads to the sustainability of the farm by capturing the excess energy that could go to waste. Artificial intelligence has excellent scope in vertical and soilless agriculture as these technologies practice controlled environments (3). In the coming year AI systems, robotic technology, and smart sensors will assist in automating the entire farming process starting from sowing to harvesting, packaging, and marketing if it is implanted at the community level as Indian farmers are mostly small and marginal landholders.

Shreds of evidence:

1. Automatic irrigation controller operated by soil moisture sensors in wheat:

It schedules irrigation based on indications received from sensors in the soil. The PIC microcontroller is the heart of the controller circuit. To measure the volumetric water content, the dielectric constant of the soil is found through two dielectric capacitance sensors attached to the controller and based on this decision to whether to irrigate or not is taken.

2. Use of IoT in Hydroponics:

Hydroponics is basically done in a controlled environment. Sensors for humidity measure the moisture content in the air, sensors for p^H assess soil p^H, light sensors measure light intensity and the operator can decide what can be done to control the temperature.

3. HARITHA PRIYA- A digital ground nut crop advisory based on IoT:

Ministry of Agriculture, Government of India launched HARITA-PRIYA (Harmonized Information of Agriculture, Revenue and Irrigation for a Transformation Agenda-Precision Technology in Agriculture) during 2014-15 which is a C-DAC pilot study to use cutting-edge sensor-based technologies for the Real-time monitoring and collection of micro-climatic data from farmers' fields, timely assessment of crop status and providing personalized Agro-advisory services to farmers.

4. Drones:

Drones are the most popular digital agriculture tools which assist in crop surveillance, weather forecasting, spraying, etc. Drones are surveying 20 million hectares of cotton crop in China (4). Drones are able to see the things that humans can't because of their ability to fly and observe from heights.

5. Mobile applications:

Diagnostic mobile applications such as plantix detect the symptoms of the plant and provide solutions by identifying the cause. Some applications work without an internet connection which is help farmers take better decisions for crop management.

Challenges for digitalization:

- Most of the Indian farmers are small landholders and illiterate which makes it difficult to reach them and make them adopt it due to high costs.
- Low level of digital literacy at the village level, fragmented land holdings, lack of communication infrastructure, and lack of access to formal financial sources, etc come in the way of digitalization.
- Difficulty in understanding the complexity of crop environment, soil and climatic conditions and crop growth pattern, etc along with storing the data under the digital umbrella.
- Artificial Intelligence models need a vast amount of data to work efficiently which is difficult to collect.
- Use of digital tools in agriculture requires professional skill and expertise.

Suggestions to speed up digitalization:

- Providing easy access to digital agriculture tools besides enhancing government investments with targeted funds along with encouraging private investments.
- Informing the people at the grassroots about the benefits of digitalization of agriculture.
- Ensuring high-quality services with low costs as most of the Indian farmers are small landholders.
- Fragmented land holdings make it difficult for farmers to buy machinery. Inventing and popularizing portable machinery and providing it through subsidies can make farming profitable.

- Recently an initiative by the government of India provides farm machinery for rent at every panchayat. This kind of facility can be made available all over India.
- National and state agriculture institutes should make concerted efforts to take benefits of digitalization to farmers.

Conclusion:

Being described as the least digitalized sector by McKinsey analysts, India must speed up the digitalization of agriculture to reach its goal of doubling the farmer's income and sustainable food production. Nowadays, digital tools like IoT, Cloud computing, drone technology, precision farming, and many more have emerged, making farming interesting. Although there are overwhelming benefits like sowing or planting, continuous field monitoring, reducing chemical and water requirements, and protecting the environment, some challenges like small and fragmented land holdings, high initial costs, lack of propaganda, and digital illiteracy, etc come in the way of digitalization. To reduce the burden on the government it should encourage multi-stakeholder participation by providing subsidies and funds to private individuals. Digitalizing the farm can be costly at the start but it will surely give returns for what we have invested. Indian farmers are still reluctant to accept and implement digitalization due to their beliefs and less affordability but if it is implemented on a community basis it will be remunerative.

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