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17. Digital Farming in Agriculture

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Abstract:

Digital technology helps the farms to become more resilient and sustainable while satisfying global food demand. The adoption of new technology in agriculture, such as the Internet of Things (IoT), Artificial Intelligence (AI), robotic systems, RS (Remote Sensing), and drones, which operate automatically and semi-automatically performing operations and gathering data aimed at increasing the efficiency and predictability in agriculture thus digital farming is the key to meet the growing food demand and farm resource availability.

Digital agriculture offers enormous potential to advance agricultural growth by lowering the amount of labor needed to raise crops and managing more effectively. The study provided evidence of the successful application of digital technology, such as AI, drones, and RS technology in agriculture, which can help to reinvent and reshape farming to fulfil the world's food need. Many farmers across the world, particularly in industrialized nations, rely on the application and management of smart agriculture. To end hunger in the current circumstances, digital farming has to be expanded.

Keywords:

Digital farming, agriculture and food security.

17.1 Introduction:

Global connectivity has increased significantly. One of the most potent technologies that has significantly accelerated globalisation and changed the global industries is digital tools. However, according to United Nation Department of Economic and Social Affairs there will be a huge increase in the demand for food as the world's population approaches 7.5 billion and projected to reach over 9.6 billion in 2050. Over 2 billion people still lack of an adequate nutrition, including 8% people living in Northern America and Europe (FAO, 2019). A large portion of the world's undernourished people live in Asia (381 million) and Africa (more than 250 million), where the number of malnourished people is increasing at a quicker rate than in any other region of the world, according to FAO's report (2020).

Increasing agricultural productivity, networking, and sharing agricultural information with farmers are ways to address the present food crisis by reducing farmers' risk. Digital farming can act as a strength in the agriculture to achieve significant development and meet the food need of the global population.

Digital connectivity and data are key components of a new agricultural revolution. Artificial intelligence, analytics, networked sensors, and other cutting-edge technologies have the potential to increase agricultural yields and enhance the efficiency of farm input management. Digital technology helps the farms to become more resilient and sustainable while satisfying global food demand. "Digital agriculture" refers to the use of digital technology to manage crops, animals, and other farm tasks related to developing and maintaining agricultural resources. For farmers to receive timely information that will improve agricultural output, promote food security, and improve rural livelihoods.

Digital farming contributes towards social connection, farmer empowerment, and involvement. The following benefits of digital advancements in agriculture are highlighted:

- Cost-effective, wide-scale transmission of relevant data is made possible by digital technology.
- Farmers can use digital technologies to plan and track the use of their farm equipment as well as to locate buyers and sellers for the goods they use and generate.
- Pests and diseases can be located remotely (using digital imagery from drones and satellites), and soil monitors allow for effective water management. Mobile applications also aid in farm management.
- Digital tools assist farmers in understanding and implementing best practices in agriculture, including those related to crop selection, input management, land preparation and selection, finance, transportation, packaging, and marketing of agricultural products.
- It provides a global network for the agricultural industry, bringing together farmers, scientists, researchers, and administrators to work towards a shared objective and fostering the growth of agricultural activities.

The adoption of new technology in agriculture, such as the Internet of Things (IoT), Artificial Intelligence (AI), robotic systems, RS (Remote Sensing), and drones, which operate automatically and semi-automatically performing operations and gathering data aimed at increasing the efficiency and predictability in agriculture thus digital farming is the key to meet the growing food demand and farm resource availability.

17.2 Artificial Intelligence (AI) in Agriculture:

John McCarthy first used the term "artificial intelligence" (AI) in 1956, and since then, it has been given many different definitions. However, it is defined in the rational approach as a system that automates intelligent behavior or acquires intelligence over time using computational programming and produces rational outputs to carry out specific tasks without human engagement (Bhagat *et al.* 2022).

The agriculture sector is evolving as a result of encouraging the usage of artificial intelligence. Due to advances in technology innovations, AI is already replacing the majority of manual which could simplify even the most challenging tasks to routine work and improve our quality of life. With the use of artificial intelligence (AI), we can collect and analyses enormous amounts of data on a digital platform. Using this real-time data, farmers can identify crops that require fertilizer, irrigation, or pesticides.

In India, the Saagu Baagu pilot partnership with the Government of Telangana through the World Economic Forum's Artificial Intelligence for Agriculture Innovation (AI4AI) initiative has made as first Indian state to implement a framework for scaling up emerging technologies and improving productivity, efficiency, and sustainability in the agriculture sector. By January 2023, over 7,000 farmers had signed up for the trial programmed, which mostly targeted growers of chili (World Economic Forum, 2023). AI can evaluate satellite and drone images to assist farmers in managing their livestock and agricultural crops. Farmers won't need to constantly check their crops because AI technology will inform as soon as something appears out of the norm. Using aerial imaging can also increase the efficacy and accuracy of pesticide application. By integrating AI into farming design and operation, several aspects of agriculture can improve. The following agricultural processes can benefit from artificial intelligence:

- **Soil management**: AI may be used to develop soil maps which show the interactions between the soil landscape and the quantities of soil sub surface. It is frequently employed in identifying and modifying soil factors that offer a favourable environment for the crop.
- **Market information:** AI can simplify crop selection and help farmers choose the most profitable commodity. It enables farmers to be informed about current market trends, yearly results, and customer wants, enabling them to efficiently maximise crop returns.
- **Risk management:** Farmers may lessen the risk of operational errors and crop failure with the use of AI forecasting and prediction. The probability of plant diseases is reduced by obtaining data as early as possible. Farmers can automate to detect the plant diseases and pests.
- **Plant protection and management:** AI technology assisted in choosing the most superior crop varieties and have even enhanced the selection of hybrid seed options that are most suited for farmers' requirements. AI is capable of finding and eliminating weeds, detecting and even foreseeing ailments in plants, and recommending effective pest control techniques.
- **Plant irrigation and monitoring:** We can irrigate crops more intelligently through AI, which boosts farmer output. AI is helpful for predicting the best combination of different agronomic factors, determining the best irrigation schedules and fertiliser application times.

17.3 Drones in Agriculture:

Unmanned Aerial Vehicles (UAVs) known as drones is one of the latest technologies, guided autonomously by remote control offering substantially greater range and endurance than equivalent manned systems. Drone is an aircraft with no human pilot on-board controlled by remote system (FAO and ITU, 2018). Drone are available with different camera sensors to provide detail information on what to observe in the human eye. Sensors available in this technology are RGB (red, green blue), NIR (infra-red near), RE (red edge), Thermal infrared (Aydoğan, 2018). This technology has a huge potential in agriculture in supporting evidence-based planning and in spatial data collection. In agricultural sectors UAVs can be used in crop monitoring, agricultural development site photography, variable rate applications and livestock management. It works by scanning with different sensors in a vast area at low cost to provide a wide range of information.

Drone is used for assessment of plant health, monitoring for plant and livestock's, mapping for crop identification, irrigation scheduling, spraying pesticides and fertilizers. It is a cheap and economical way to manage farming, it helps to reduce human labour and time consumption of the farm task. Drone provides a high technologies makeover to agriculture industry that drones marketplace may reach $200 billion by year 2023. Due to rapid growth of technology, it is reported that growth of Drones technology is increasing 25-32% every year especially in the area of Agriculture (Rana and Mahima, 2020).

Drone allow farmers to monitor crop with special imaging equipment called Normalized Difference Vegetation Index (NDVI). It give detailed colour information to indicate plant health, it helps farmers to take decision fast enough to save the plants. Drone can plant more efficiently by planting 400,000 trees a day with a team of two operators. South- east Asia with South Korea already used drones for approximately 30% to apply spray treatment in agriculture. Another report said that agriculture drones can spray 40-60% faster than manual spraying with saving 30-50% in chemicals and able to conserve up to 90% of water usage for agriculture (McNabb, 2020). Drones also successfully manage the seed planting process in the soil. The system of drone allows farmers to75% rooting, reducing 85% of planting costs and increasing sustainability (Food and Society, 2018). Utilization of drone in agriculture avoids the significant labor costs traditionally associated with planting activities. According to Sense Fly (a drone manufacturer specializing in agriculture) the utilization of drones by the Ocealia group resulted in a 10% average increase in crop yields. Drones with the equipment's like LiDAR (Light Image Detection and Ranging) and RADER (Radio Detection and Ranging) make them well-suited for crop spraying and some experts argue that crop spraying by drones may be up to five times faster than with regular machinery (Probst *et al.* 2018).

UAV has a huge potential in the improvement of sustainable agriculture. Drone use in the agricultural sector is expanding as part of an efficient strategy for managing agriculture sustainably. UAV technology enhanceed the cultivation and reduce the human energy requirement as the technology can perform monitoring, spraying missions, collecting information and planting thereby optimizing the efficiency of the pesticides and detecting pests and diseases (Radoglou-Grammatikis *et al.* 2020).

In India, Dahanu-Palghar tribal villages of Maharashtra have learned to use drones for organic farming, fish farming, crop rotation, bio-control, hydroponics, bio-waste management, beside also using drone-based technologies on their orchards and farms (Pathak *et al*. 2020). There are many organizations have been working continuously in order to integrate smart technology that enable transforming agriculture with cost efficient, time saving, support farmers decision and provide on demand information to the farmers and the stakeholders. Therefore, smart farming has a real potential to deliver more productive and sustainable agriculture.

17.4 Application of Drones in Farming:

- Drones assists farmers with providing an accurate real-time images and data, enabling massive crop monitoring. Additionally, it can help farmers detect issues like drought stress, nutritional deficiencies, pests, and illnesses early on.

- Drones reduce the amount of labour and time needed for farm operations by spraying pesticides, herbicides, or fertilisers to crops. This method is especially useful if the top ography or soil make it difficult to use conventional planting techniques.
- Since drones can fly close to the ground and can apply pesticides more precisely than traditional methods, they cut the amount of chemicals needed and limit runoff and drift.
- As a result of their multispectral or hyperspectral sensors, drones assist farmers identify damaged and pest plants more rapidly than they could by eye.
- Drones with thermal cameras can collect data on field moisture, and farmers may use this data to alter irrigation practises to improve crop water efficiency.

The following are a few advantages of deploying drones in farming:

- Drones save farmers time by providing real-time data and covering large areas in a single flight.
- Reduced costs for investment, early identification of pest diseases and other dangers enables farmers to take preventative measures and thus cost lower on pesticide purchases. Spot treatments on specific areas are also possible.
- Drones offer precise data and detailed, high-resolution imagery.
- Since drones can execute tasks that humans find challenging, they lower risk for farmers.
- Drones produce digital data that is simple to store and examine.
- Drones can contribute to an overall improvement in the health of crops by making crop monitoring and management more effective and accurate.

17.5 Satellite and Remote Sensing:

The development of remote sensing makes possible to collect data and analyse a phenomena or item without being in contact. According to Union of Concerned Scientists (UCS), there are 2,666 satellites actively satellites orbiting the Earth, out of this 1211 satellites are used for communications, 884 for earth observation, 312 for technology demonstration, 148 for navigation, 93 for space observation, and 18 for earth science. Satellite data might be quite helpful since it can be utilized to learn new, insightful information about several aspects of agriculture. Satellite data and photographs can be used for farm planning, evaluating crop production or field condition, whether management, mapping irrigated and non-irrigated vegetation sections. Remote sensing (RS) is a field of study that uses electromagnetic radiation as a medium of interaction to identify earth surface objects and estimate the geo-biophysical attributes (Roy *et al.* 2017). RS tool provide a valuable information about crop growth monitoring, land use pattern and changes in land cover, water resources mapping and water status under field condition, monitoring of diseases and pest infestation, forecasting of harvesting date and yield estimation, precision farming and weather forecasting purposes along with field observations. Images captured by remote sensing are used to identify weed infestations, hail damage, wind damage, pesticide harm, and plant populations. In India, Ministry of Agriculture and Farmers' Welfare effectively uses satellite remote sensing to gather crop statistics information required for the planning and decision-making of agricultural inputs. RS provides data on crop acreage estimation, crop yield and production estimation, crop condition estimation, data collection on soil parameters, cropping system research, experimental crop insurance, and other areas of agricultural

production. In four distinct states-Haryana, Karnataka, Maharashtra, and Madhya Pradesh-about 250 Crop Cutting Experiences (CCEs) were completed. These initiatives give farmers an ability to make important choices during the growing season, practically prior to crop harvest (Solomom, 2020). Several applications, including automatic irrigation and greenhouse farming, are controlled with the help of these sensors technologies that are put in the fields. Through a variety of sensors, plant illnesses are identified and soil quality is tested. Farmers may produce the crop more efficiently from the information receive. According to Anilkumar *et al.* (2020), an image processing approach using MATLAB is used, for instance, to identify weedy patches and plant illnesses and users can obtain the information base on the requirement.

The following are advantages of using remote sensing for farming:

- Crop categorization, crop acreage calculation, and yield evaluation are all crucial fields in which remote sensing is highly effective.
- With the use of remote sensing, scientists and farmers can anticipate crop output in a certain area and calculate how much crop can be obtained in an area.
- By offering timely spectral information to monitor crop status, damage, and progress, remote sensing can play a significant role in agriculture.
- Crop yield estimate and modelling, which enables farmers and professionals to forecast the anticipated crop output from specific field.
- Remote sensing is now a crucial technique for assessing crop stress and for detecting pest and disease infestations.
- Farmers may obtain soil moisture data through soil mapping and soil moisture estimation, which helps them evaluate the amount of moisture in the soil and the sort of crop that can be planted there.
- The weather patterns in a certain area may be tracked using remote sensing equipment. It keeps track of the drought and monitors it.

17.6 Conclusion:

Digital agriculture offers enormous potential to advance agricultural growth by lowering the amount of labor needed to raise crops and managing more effectively. The study provided evidence of the successful application of digital technology, such as AI, drones, and RS technology in agriculture, which can help to reinvent and reshape farming to fulfil the world's food need. Many farmers across the world, particularly in industrialized nations, rely on the application and management of smart agriculture. Drone and remote sensing technology for agriculture are effectively utilized to boost farmer revenue and cut down on agricultural inputs. To end hunger in the current circumstances, digital farming has to be expanded. In addition, there are significant limitations on how to use, buy, and operate digital technology. Farmers have successfully accepted this technology, but there are also rules and license requirements, as well as a high initial cost. There are many significant obstacles to implementing digital technologies, including their high initial costs and the need for legislative changes to make them more user- and farmer-friendly. In contrast to farmers in industrialized nations, those in underdeveloped countries are less likely to favor such technology due to minimal landownership and poor economic conditions of the framers.

And such technologies are mostly used by the professional, big landholder farmer and experts for data collection, crop mapping, crop monitoring and spraying. Use of AI, RS and drone are required skills and demonstration on how to use the technology.

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