SMART AGRICULTURE: A DIGITAL AG-TECH INNOVATION FOR SUSTAINABLE FARMING

Abstract

The agriculture and allied sectors has undergone a massive modern digital transformation during the last decade. New digital tools and technologies are reshaping the way we farm which is changing for the better. Such ground-breaking deviations from the conventional methods are unsettling current approaches in agricultural industry. The growth in the use of digital devices and internet paved the way for agriculture to be smart which is possible by combined implementation of digital technology solutions to be what called as Third Green Revolution. The change brought by the modern digital interventions of data-backed technologies, such as sensing technologies, remote positioning technologies Unmanned Aerial Vehicles (UAVs or drones), big data analytics, robotics, block chain technology, internet of things, machine learning, artificial intelligence etc. The future of Smart agriculture has tremendous potential to promote an efficient, technologically advanced and sustainable agriculture which is more precise and effective way to fight world hunger, poverty and malnutrition.

Keywords: Smart agriculture, Sustainable farming, Digital technology

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I. INTRODUCTION

The agricultural industry in India acts as a vital sector in enriching its socio-economic conditions as it provides livelihood to about 47% of the country's work force. According to the UN projections it is going to be one of the most populous countries in the world by 2027 and by 2050 there will be 9.7 billion people across the globe and ensuring food and nutritional security for such a large mass is a daunting task. Agriculture is on the edge of challenges due to growing demand for food, increased population, lower margin of agricultural goods and commodities, shortage of skilled workers and increased cost pressure. The rise in population and change in consumption pattern have created a huge pressure on the existing land. Farmers are struggling hard to keep up with the crop yields level off, tackling water shortages, preventing biodiversity declines and mitigating natural calamities which have become more frequent in the recent era. The current scenario poses severe challenges to the UN members of the states with consideration to the 2030 Agenda, and with specific concern about SDG 2, which targets to end hunger across the world by providing equal accessibility to food for all individuals especially for the malnourished, poor and vulnerable groups in the society including small children, to nutritious and healthy food. Additionally the agriculture industry is responsible for about 30 % consumption of the world's total energy use while it contributes 22 % emissions of greenhouse gas to the environment resulting in global warming. Thus, the problem is not just related to food production in order to feed the growing population but also doing it in a sustainable way. The changes in Agricultural sector is enormous which may include the plants and animals domestication before thousand years or improvements in technical farming practices before hundred years, or may be the "green revolution" which includes the utilization of hybrid varieties along with inorganic pesticides and chemical fertilizers before a few decades. But now it is undergoing a significant change due to the advancement in modern technologies which signifies the transformation of modernization and organization of agricultural and allied activities. The change in technology has redefined farming and technological advances have affected the agriculture sector. The shift is driven by modern new technology a data backed approach which is essential for efficient crop growth abilities from limited farm area thereby enhancing production and improving productivity of crops sustainably. Smart farming has arisen as to be the need of the hour. It is about the utilization of digital innovations which are emerged at the begriming of evolution in the sectors of agriculture and allied Industries. It involves the application of modern digital technologies such as sensors, remote sensing, digital communication tools, IoTs, machine learning along with their software functions for integrating various digital and physical infrastructures in farming activities to optimize the quantity and quality of crop production by efficient resource utilization and minimising the environmental degradation. It is much more efficient than the traditional methods of farming and can help in the transformation of agri-food systems in an effective way by mitigating the detrimental effects of climate changes on crop growth while producing food in a sustainable manner. Smart farming involves increase in agricultural growth, output and income in a sustainable approach, resilience in adaptation and capacity building to address the climate change and emissions reduction of various greenhouse gases for clean environment. Its implementation promotes farmer for effective production and management of crop growth in order to meet the peoples growing demands and at the same time developing an eco-friendly environment. Thus, there is an immediate need for smart agriculture in a country like India where government is finding ways to enhance agricultural efficiency and farmer's profitability. It has taken several measures for emphasizing the needs of small and marginal

farmers and is slowly adapting the change towards smart agricultural techniques which will help in boosting the nation's economy, employment opportunities ensuring food security and sustainability.

II. SMART AGRICULTURE

The term "smart agriculture" is quite broad and is relatively a new concept in the agriculture and allied sectors. It is a modern farm management concept which focuses on developing the agricultural sector with the latest infrastructure leveraging the advanced technological interventions. It integrates various digital interventions along with information and communication technologies in the farming activities starting from sowing, irrigation, application of fertilizers, pesticides, herbicides till the final harvesting. The Smart farming systems constitute the combination of both machinery parts such as sensors, drones etc. and software segments like programs and digital mobile applications which work together in an interconnected way. While the other part of this complex system gives farmers accessibility to the various data received from the digital devices which allows them to configure accordingly and helps in making the most effective decisions by adjusting their actions in real-time conditions.

The Different Phases of the Smart Agriculture Includes

1. **Data collection:** various sensors are installed at the field level at critical places utilized for collection of information with respect to soil conditions, water availability, humidity and temperature.

2. **Observation:** The data from the crops are collected by the sensors and are recorded for further process.

3. **Diagnostics:** The recorded data from the sensors are updated to the IoT platforms which are cloud-hosted for analysis using algorithm and different models of cropping for obtaining the conclusions that are derived by identifying any problems, needs or deficiencies.

4. **Decisions:** After identification of the critical issues the software platform along with artificial intelligence and machine learning components determine the necessary predefined course of action that are needed to be taken.

5. **Action:** After evaluation at the end-user and implementation of modified action, the cycle repeats itself from the beginning.

III. SMART AGRICULTURE TECHNOLOGIES

The development of latest modern technologies impacts all spheres of human livelihood including the agricultural sector. The technical breakthrough that has been experiencing in the agricultural industry can change the essence of smart agriculture with the intervention of digital technologies. The spread of smart agriculture is inextricably linked with the technology development which is taking place at such a rapid pace. Smart agricultural technology offer farmers access to modern tools and

techniques to optimize every step of their farming activities and provide extensive control, monitoring, planning, and exploration capabilities to get better results. Automation in agricultural sector is an emerging change across the world it favourably compares with older analysis methods, as they take into consideration a large number of parameters simultaneously thereby minimizing the likelihood of error and making farming more relevant than ever.

The major effective and convenient technological interventions utilized in smart agriculture includes

1. **Sensing Technologies:** In conventional practice of agriculture, farmers visit their fields regularly to understand the changing field conditions but due to the use of various sensors which are installed at critical positions of the field offer a precise view from which the farmers can observe ongoing field activities without being physically present. Different sensors such as temperature, humidity, soil pattern monitoring, light and moisture are used to detect many parameters affecting plant growth and development. The crops in the field are regulated by maintaining different factors at certain predefined level but when it go below a certain critical level, the changes are obtained by the sensor and definite required actions are performed until the factor returns to its predefined level. Crop growth conditions are affected by several prerequisites, such as humidity of soil, level nutrients, light exposure, rainfall, leaf colour etc. Sensors are the significant constituent of smart agriculture which help the farmers to monitor the changes in the fields in real-time as they collect the data from the field quickly along with its accessibility to online platforms for easy diagnosis and decision making. It can also be combined with modern advanced tools used in agriculture such as auto-controlled harvesters, agribot weeders, and UAVs etc. for collecting wide range of data over shorter timeframe. Utilization of modern sensing technologies helped to make the farming process faster, less laborious and more precise. They constantly observe the crop lifecycle with precision while tacking various detrimental situations. Sensing technology monitors different crop growth stages with higher accuracy thereby determining the various needs of the crops for efficient management of farms. However, the agriculture demands for broad technological solutions which will have less impact on the environment promoting sustainability.

2. **Remote Positioning Technologies:** Remote positioning technologies constitutes of remote sensing by using satellite and Global Positioning. Remote sensing helps to monitor the crop growth by collecting the data from the sensors and observing the changes in light, humidity, temperature etc. along with satellite imaging to determining the nutrient value , soil drainage capacity, weather pattern etc. for suitable cultivation of crops. Remote sensing is considered as technological backbone of agriculture considering the variability within-field for precise management of farm deviating from the conventional method of uniform management. Data obtained from the remote sensing can be effectively utilized to identify crop type differences, weeds and insect's categorization, locating soil stress, determining conditions of plants and monitoring dry spells. Global Positioning helps to determine accurate information on longitude, elevation and latitude in order to compute their real-time location. The information on exact location helps farmers to determine the occurrence disease and pest, soil type, irrigation facility, weeds etc. along with accurate location based on field data for determining the amount of inputs and effective resource utilization.

3. **Drones and Robotics:** Drones create regularly updated maps to monitor the fields remotely. They work in coordination with the sensors and GPS (Global positioning systems) which are equipped with cameras and sensors that are used for multispectral imaging, thermal mapping, visual imagery and surveying fields while flying over the field to gather the data. They provide information on metrics such as health indices of plant, measurement of plant height, counting of plants and prediction of yields, canopy cover, and chlorophyll measurement, weed pressure mapping etc. Drones are widely used by Farmers for monitoring of crop growth, nutrient solutions spray, application of water and insecticides in the unreachable terrains and for different heights of crop. It helps in providing information on plant growth management practices such as fertilization, irrigation, weed management; crop disease management etc. It also provides insights on the early detection of pest and disease infestations along with their treatment with high covering of large area and precise application with respect to traditional farming methods. Not only drones, robotics in different farm activities significantly improves production of crop growth by automation in farming vehicles and agribots which are navigated and tracked in real time from the comfort of homes to perform tasks such as seeding, transplanting, weeding, spraying, harvesting etc. achieving higher yields with minimal human intervention. These technical improvements thereby constitute a technical revolution generating explorative changes in agricultural practices by achieving new level of efficiency as compared to traditional methods.

4. **Internet of Things (IoT's):** The driving force for smart agriculture is Internet of Things (IoT's). It involves inter-connection of various smart digital objects and acquisition of data remotely by the help of drones, agribots, sensors, intelligent cloud-based information, and agricultural operations automation through mobile devices and internet which is revolutionizing the agriculture industry. It helps in connecting farm machines and sensors together in an integrated way for making farming activities data-driven and automated. Internet of Things (IoT's) refers to the combined application of information and communications technologies which involves interconnection of sensors, drones and robots which are connected together through internet to gathering data through satellite and positioning systems in order to perform various field operations aimed at increasing efficiency, accuracy and predictability. It helps in the accessibility of all the modern tools and technologies by adhering into a single system for seamless exchange of data and information. IoT's technology helps in better access and control over agricultural process to reduce production risks and improves the ability to foresee production results, helping farmers to plan better. Internet of Things in smart agriculture helps to optimise farm monitoring by improving overall plant production and productivity, reducing farm waste, saving fuel, water, fertilizer use and promoting sustainability**.**

5. **Big data analytics:** Data collection is an important part of smart agriculture as the huge quantity of data is available from the field such as yields of crop, mapping of soil, doses of fertilizer application, data on weather conditions, activities of farm machines etc. Thanks to the ability of data analytics acting as data pipeline to downstream solutions which plays a crucial role to analyse massive amounts of data and information which are derived by the sensors from the field and drones, satellite communications, Internet of Things and calibrated with the past information of the different farming activities in order

to enhance the crop growth process and efficient farm management. Big data analytics can be implemented in a variety of actionable ways such as by creating dashboards, monitoring infrastructures and providing farmers with intelligence to develop more resilient digital technologies. It is impossible without them to imagine the possibility of accurate forecasts, prediction, cloud-based intelligent analysis, activity planning, designing efficient farm models and decision making. The implementation of big data analytics in agriculture sector had profound effects globally and is assured to be more insightful in the coming years.

6. **Artificial intelligence and Machine learning:** Artificial Intelligence has lot of direct applications in smart agriculture. Introduction of artificial intelligence in agriculture solves many challenges of conventional farming methods. AI-enabled solutions will help farmers to do more with less. Artificial intelligence by the help of predictive analytics can analyse market demand, forecast prices of the commodities as well as determine optimal times for different farming activities. AI-solutions promote farmers not only to reduce farm wastage, but also to improve the quality of produce ensuring faster market access. The implementation of AI in agriculture and allied sectors may look like a logical step which opens up a lot of opportunities for the farmers. Whereas machine learning can be described as the Self-learning technology which gives power to predict climate change, soil conditions, water parameters, carbon content, pest and disease spread and more. Machine learning algorithms helps in the identification of premium value products and recent unavailable items. It helps to analyse, differentiate and categorize the farm produce before its processing and its delivery to consumers. It also helps to analyse the real-time data for performance analysis.

IV. ODISHA: STATUS AND SCOPE

Odisha is one of the rural based agrarian states of India, where about 83% of its people lives in remote areas and 61.8%of its workforce are involved in the agriculture and allied sectors. The workforce of the state contributes to about 18 per cent to the state's GDP and 3% towards India's agricultural GDP producing about Rs.75,800cr worth of outputs from agricultural and allied activities. Odisha have tropical climatic conditions with high temperature and humidity, rainfall conditions medium to high and mild winters. It has a cultivated region of 6.4 million ha out of total geographical area of 15.5 million ha. More than 50 % of the cultivated area is rain fed and Irrigated land is covered by only about 54% while only 21% of total irrigated land is facilitated by lift irrigation such as tube well, water pumps run by electricity or fossil fuels. In the current agricultural scenario where mostly the marginal and small farmers constitute a larger part of about 80% in the farming community in which they either own a land or rent for performing various farming activities whereas only 20% belong to the large farmers. The average land holding size is 1.25 ha for all farmer categories but for marginal and small farmers the average land holding is only 0.6 ha which are fragmented largely. Odisha has huge diversity in nature and farming is the prime occupation where the majority of the population in the state depends on agriculture considering temporal and spatial variations in crop growth conditions and their productivity. It faces a huge problem to provide sustainable livelihoods to a large chunk of people who lives in remote areas and primarily depends on agriculture and allied sectors as the only way of living. The state faces various natural calamities in the fragile ecosystem such as cyclones, erratic rainfall, drought, dry spells and floods affecting various farming activities and crop

growth conditions. The agricultural performance of the state largely determines the nutritional and food security of the people which plays a significant role in reducing poverty, hunger and helps to attain inclusive growth. Odisha observes change in climatic conditions and natural calamities as the primary threat to its development which has resulted in unpredictable natural challenges in agriculture and allied sectors. In order to address the growing food demand of the population it is essential to make agriculture smart and sustainable. Farmers need to understand and adopt new digital interventions and modern technologies to tackle the adverse vagaries of nature. Smart agricultural technologies provide opportunities to adapt and mitigate the change in climatic conditions and natural calamities by increasing the production potential of crop growth without hampering the environment thereby ensuring food, livelihood and nutritional security in a sustainable way.

V. CONCLUSION

The new possibilities of the modern era lead to the diversification in agriculture and allied sectors. Technical innovations contributing to diversification can provide innovative ways for successful farming practices that promotes sustainability to the environment. Smart agriculture helps to lead a concrete way out of ancient and conventional farming methods and practices. It conveys a reach toward agricultural sustainability by diversifying modern digital networks across all the actors of agri-food industry. Increase in the diversity of technologies must be in line with the farmers, consumers and decision-makers who are satisfied with the advantages of these technological benefits. But this would be possible only by the development of proactive policies which supports and facilitates the necessary legal and market architecture for the sustainable use of appropriate digital technologies. Thanks to the Agro-based start-ups which are tech-driven and have been very innovative in assisting farmers and government to adopt new policy changes and revolutionising modern digital farming techniques. The India government has funds allocated of INR2422.7 cr. to the States during 2021-22 for introducing new digital technologies such as UAVs (drones), artificial intelligence; block chain, remote sensing etc. in agriculture and allied sectors. Further, it has also allocated INR 7908.18 cr. in 2021-22 to Indian Agricultural Research Institute (ICAR) toper form developmental research activities for the promotion of new transformational technologies, their demonstrations and capacity building of the farmers for their adoption. The government is also promoting the agri-tech start-ups by providing financial support and helping them to gain access to viable and cost-effective solutions. Apart from that awareness, training and skill development extension activities are widely conducted for the farmers to promote these sustainable modern technologies. Thus, smart agriculture have immense capacity to enhance nutritional security, resilience in farming and lowering emissions of greenhouse gases making world a better place to live by promoting sustainability.

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