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A Study on the Role of Technology in Improving Agricultural Productivity

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ABSTRACT

Optimization of agricultural practices for enhanced crop yield is considered to be essential phenomena for the countries like India. In order to strengthen the economy and also to meet the food demand for the exponentially growing population, optimizing the agricultural practices has become necessity. In India, weather and geographical conditions are highly variable and were thought to be the major bottleneck of agricultural practices to achieve improved crop yield.

Agricultural practices in India are facing many challenges such as change in climatic conditions, different geographical environment, conventional agricultural practices; economic and political scenario. Economic loss due to the lack of information on crop yield productivity is another major concern in the country. These hurdles can be overcome by the implementation of advanced technology in agriculture.

Some of the trends observed are smart farming, digital agriculture and Big Data Analytics which provide useful information regarding various crop yields influencing factors and predicting the accurate amounts of crop yield.

The exact prediction of crop yield helps formers to develop a suitable cultivation plan, crop health monitoring system, management of crop yield efficiently and also to establish the business strategy in order to decrease economic losses. This also makes the agricultural practices as one of the highly profitable ventures. This paper presents insights on the various applications of technology and usage of agricultural technology in India.

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INTRODUCTION

Agriculture is the basis for food security and survival. Mankind living on the globe depends majorly on the agriculture-based crops for their survival. India is an agricultural dependent country and the fact that the majority of the populations are vegetarians and solely depends on the agricultural products for their survival. Being an agriculturally based nation, country's economy is principally influenced by annual crop yields of agricultural practices. Recent survey indicates that more than 60 % of the population is in to agriculture and the majority among the rest is connected to the other aspects of agricultural practices.

Recent survey indicates that more than 60 % of the population is in to agriculture and the majority among the rest is connected to the other aspects of agricultural practices. The other facets of agricultural practices include agricultural machinery companies, fertilizer companies, crop yield marketing and sales companies etc. Agriculture activities help humans to raise the most principal food crops with ideal animal population to achieve environmental balance. In the country like India, farmers cultivate major food crops such as rice, wheat, cereals, pulses, different vegetables known as onions, potatoes, sugarcane, oil seeds, mango, orange, red chilli and also various commercial crops such as coconut, coffee, tea, cotton, rubber and jute. The majority of the rural population close to 70% depends on the agriculture for their household. Agriculture contributes approximately 18% to the total GDP of the country and provides employment to over 60 to 70 % of the population in India. At present India stands second globally in terms of agriculturally based products.

Cultivation of various agricultural crops influences the economy of the country at broadest range and plays a pivotal role in the overall in socio-economic structure of the country. The success rates of Agri practices majorly influenced by certain factors namely soil fertility, climatic conditions, weather forecast, temperature, water level with the rainfall measures, irrigation condition, fertilizers availability, pesticide used, controlling of weed population, process of cultivation, harvesting methods employed and economic and political scenarios.

Majority of the former communities in India predict crop yield based on the conventional practice with the knowledge of previous experiences, but this approaches alone may not be efficient as the climatic conditions keep changing drastically due to the overall change in the weather forecast at global level.

The agriculture sector forms only about 18 percent of India's GDP despite employing almost 65 percent of the total workforce. Despite significant improvement in food grain production, there are several challenges to tackle as the government aims to increase agricultural production as a share of GDP. Agriculture in India is largely dependent on nature, but climate and global warming issues make farming unpredictable. The need of the hour is to educate farmers in the use of modern technology and innovative approaches to increase productivity and raise profitability. Agricultural development practices over a while have been perceived to exploit natural resources faster than they could be renewed. Exponential growth in the human population has resulted in demand for food and shelter, which the "natural" carrying capacity of the land is under pressure to provide.

Natural imbalance is visible in pollution, soil degradation, wildlife population decline, and human created alterations of flora and fauna. It is reasonable to assume that human population growth will continue and place greater demands on the Agri-ecosystem. Thus, technology has and will continue to play a major role in agriculture and sustainable development going forward. Technology has a major role in farming and agriculture practices; and with the advent of digital technology, the scope has widened. Innovation in agriculture is leading an evolution in agricultural practices, thereby reducing losses and increasing efficiency.

This is positively impacting farmers. The use of digital and analytic tools is driving continuous improvement in agriculture, and the trend is here to stay, resulting in improving crop yields and helping to increase the income of the farming community.

EXECUTIVE SUMMARY

Global agriculture is currently undergoing a multi-dimensional transformation driven by the convergence of historical lessons from the Green Revolution and modern technological innovations in Artificial Intelligence (AI), the Internet of Things (IoT), and autonomous robotics. While the initial Green Revolution of the mid-20th century saved billions from starvation through high-yielding varieties (HYV) and chemical inputs, it introduced long-term environmental and health challenges.

The current "Second Green Revolution" or "Evergreen Revolution" seeks to solve these legacy issues while addressing modern pressures: a global population projected to reach 9.6 billion by 2050, acute labor shortages (the average farmer age in the U.S. now exceeds 58), and climate change. Key takeaways include:

Automation as a Necessity: Autonomous tractors and sprayers are moving from concept to field, offering up to 50% reductions in operational costs and providing a solution to the global shortage of skilled rural labor.

IoT and Connectivity: Smart farming ecosystems utilizing sensor networks (soil, weather, and livestock wearables) enable real-time, remote management and data-driven decision-making.

Precision and Predictive Analytics: Advanced deep learning models (CNNs, LSTMs) and remote sensing (LIDAR, hyperspectral imaging) allow for unprecedented accuracy in yield prediction and resource allocation.

Sustainability through Efficiency: Smart irrigation and variable-rate application technologies are significantly reducing water and chemical waste, aiming for "productivity in perpetuity without ecological harm."

CRITICAL DRAWBACKS

Factor	Negative Environmental / Health Impact
Chemical Inputs	Contamination of waterways, greenhouse gas emissions (nitrous oxide), and pesticide-related health issues (est. 1 million poisonings annually).
Biodiversity	Shift toward monocultures and abandonment of traditional, nutritious indigenous crops.
Resource Use	Soil degradation, depletion of aquifers through intensive irrigation, and heavy reliance on fossil fuels for fertilizer and machinery.

CORE TECHNOLOGIES

Autonomous machines operate on three technological pillars:

Sensors and Actuators: LIDAR (Light Detection and Range) for 3D environment mapping, highresolution cameras for plant identification, and GPS with RTK (Real-Time Kinematic) correction for centimeter-level route precision.

Connectivity: Management platforms for remote monitoring and real-time operational adjustments.

Artificial Intelligence: AI modules that process sensor data to prevent collisions and adjust application rates (e.g., spraying) autonomously.

MARKET MODELS AND ECONOMICS

Farmers can invest in factory-ready autonomous units or "retrofit" existing equipment. **Factory-Ready:** Models like the John Deere 8R cost between USD 500,000 and 600,000.

Retrofit Kits: Solutions from companies like Blue White or PTx Trimble range from USD 50,000 to 70,000, allowing conventional tractors to be automated in under a day.

ROI: Farms adopting automation have reported operational cost reductions of up to 50%, with a return on investment typically achieved within 2 to 4 years.

LIVESTOCK MONITORING

Wearable Sensors: Smart collars monitor vital signs (heart rate, body temperature) and rumination activity in real-time.

Early Intervention: AI algorithms establish baseline behavior for individual animals; deviations trigger alerts for potential illness, reducing veterinary costs and disease outbreaks.

GPS Tracking: Ensures safety and prevents theft or loss of livestock.

DATA-DRIVEN DECISION MAKING

The wealth of data generated allows for:

Machine Learning Insights: Optimization of planting schedules and predictive yield modeling. **Traceability:** Improved food safety by recording storage conditions (temp/humidity) throughout the supply chain.

PRECISION AGRICULTURE AND YIELD PREDICTION

Precision Agriculture (PA) uses data-driven strategies to manage inter- and intra-field variability. Recent advancements in deep learning (DL) and remote sensing have significantly enhanced the accuracy of crop yield forecasting.

PREDICTIVE MODELING TECHNIQUES

Advanced neural networks are used to uncover complex, non-linear relationships in agricultural data:

CNN (Convolutional Neural Networks): Highly effective for spatial data analysis and image processing from drones and satellites.

LSTM (Long Short-Term Memory): Used for time-series analysis to account for temporal changes throughout the growing season.

Hybrid Systems: Combining deep learning with traditional crop simulation models (e.g., WOFOST, APSIM) to improve reliability.

REMOTE SENSING TOOLS

Multispectral/Hyperspectral Imaging: Detects physiological stress, nitrogen levels, and earlystage diseases before they are visible to the human eye.

Vegetative Indices (VIs): Tools like NDVI (Normalized Difference Vegetation Index) and GNDVI are used for field mapping and yield estimation.

SMART IRRIGATION AND WATER EFFICIENCY

With global water scarcity increasing, smart irrigation systems represent a vital technological shift from fixed-schedule watering to real-time response.

Key System Components

Soil Moisture Sensors: Capacitive sensors and tensiometers provide direct data on water content and plant-available moisture.

Weather Stations: Integrate real-time rainfall, wind speed, and evapotranspiration (ET) data to adjust schedules automatically.

Automated Controllers: Process sensor/weather data to manage smart valves, ensuring water is delivered precisely to the roots.

BENEFITS OF AUTOMATION

Water Conservation: Elimination of runoff and evaporation waste.

Improved Crop Health: Prevention of crop stress, salinization, and nutrient leaching through consistent hydration.

Operational Efficiency: Remote monitoring via mobile apps allows farmers to manage irrigation for vast areas from any location.

IMPLEMENTATION BARRIERS

Initial Costs: High capital requirements remain a barrier for small-scale farmers, despite longterm ROI.

The Human Factor: Automation does not eliminate the need for humans; it shifts the requirement toward highly trained technicians capable of configuring and supervising complex systems.

Scalability and Reliability: Sensors require regular calibration, and models developed for one geographic region (e.g., U.S. Midwest) may not be accurate in another (e.g., African sub-tropics).

OBJECTIVES

To study various modern technology used in improving agriculture productivity in India. To analyse the importance and impact of modern technology in India.

METHODOLOGY

The study is based on Secondary data. The data was collected from Books, Magazines, Journals, Internet and so on.

REVIEW OF LITERATURE

Bruinsma (2017): examined that the adoption of technology in agriculture has significantly increased agricultural productivity These technologies, including digital tools and their innovation, such as aerial imagery, drones, and satellites, sensors, the internet of things, mobile applications among others have automated farming and transformed it into a data-driven industry as farmers can now manage their farms and cropping activities on real-time and with much ease.

Technological advancements in the agricultural sector have empowered agriculturalists, businessmen, and investors to extend their potential in delivering agricultural activities during a time when food security is being threatened by climate change and population growth. Evidently, increased mechanical automation, the extensive utilization of pesticides and fertilizers, stressing the importance of industrial farming and soil management have made agricultural production possible at a time when farms and the number of farmers are steadily diminishing.

FAO; Evenson & McKinsey; Anyan & Frempong (2019): Their study is based on information and communication technology (ICT) is fundamental in the dissemination of agricultural information. ICT enables the collection and sharing of accurate and timely information in relation to farmers' needs, and in a format that is easily accessible and consumable by the farmers, for instance on weathercast, market and pricing, financial access and support, etc.

Essentially, ICT enables the dissemination of knowledge to farmers and connects various stakeholders and members of the value-chain in agriculture such as the farmers and consumers, agricultural financial and credit facilities, agricultural research institutions, policymakers, agricultural input manufacturers, agricultural training, support, and extension service providers among others. The applications of ICT in agriculture have ranged from supporting land preparations, planting and the pre-harvest activities, harvest operations, and post-harvest activities including market access and yield preservation.

IMPORTANCE OF MODERN TECHNOLOGY IN AGRICULTURE IN INDIA

Technology in agriculture affects many areas of agriculture, such as fertilizers, pesticides, seed technology, etc. Biotechnology and genetic engineering have resulted in pest resistance and increased crop yields. Mechanization has led to efficient tilling, harvesting, and a reduction in manual labour. Irrigation methods and transportation systems have improved, processing machinery has reduced wastage, etc., and the effect is visible in all areas.

New-age technologies focus on robotics, precision agriculture, artificial intelligence, blockchain technology, and more. In 1960, during the Green Revolution, India managed to achieve selfsufficiency in foodgrain production by leveraging modern methods of agriculture like chemical fertilizers and pesticides, higher quality seeds, and proper irrigation. Technological advances appeared eventually, in agricultural development in India.

The introduction of tractors was followed by new tillage and harvesting equipment, irrigation methods, and air seeding technology, all leading to improved quality of the food and fibre. Farmers can leverage scientific data and technology to enhance crop yields and keep themselves abreast with cutting-edge methods of farming.

TECHNOLOGY USED IN AGRICULTURE

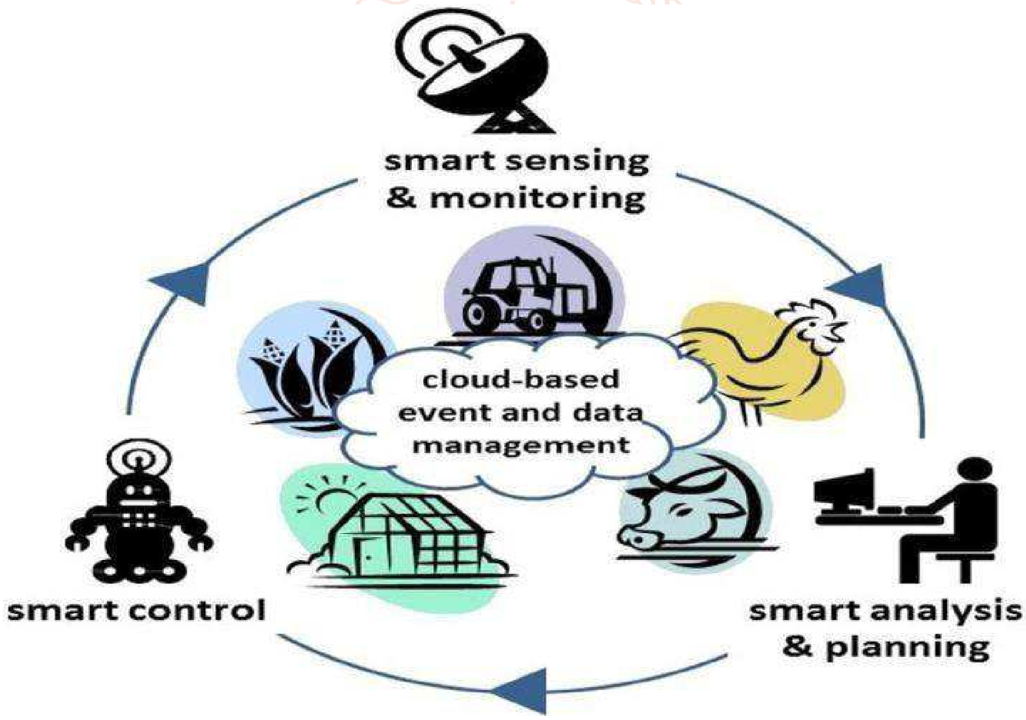
Digital Agriculture: Digital Agriculture is the use of new and advanced technologies, integrated into one system, to enable farmers and other stakeholders within the agriculture value chain to improve food production. In comparison with conventional and sensor-based approaches, an advanced approach termed as digital agriculture can help the farmers to understand their agricultural practices in a much better and effective way in a real time manner. Thus, digital agriculture holds profound impact on the crop yield enhancements, by empowering the formers with required scientific knowledge to implement good agricultural practices.

The user interface system used in digital agriculture provides opportunity to the formers to share their ideas. This also helps them to get knowledge about different kind of cultivation procedures implemented in the different parts of the globe for the particular crop and equip them with technological advances and business skills to make their agricultural practices as successful venture.

Digital agriculture helps formers in maintaining their inherent agricultural practices and at the same time provides useful information to update their knowledge and the skills. It also provides an opportunity to review the historical information in understanding the various situations and difficulties to gain an essential knowledge in taking the right decisions. The composite agricultural practices combined with rigorous and enhanced crop yield require an implementation of robust automated systems with less development time at low cost. Agricultural safety is a big concern in current scenario which can be implemented by controlling the various contaminants that promote crop damage. Agricultural automation systems including field machinery, irrigation systems, greenhouse automation, animal automation systems, and automation of fruit production systems help in achieving enhanced crop yields.

SMART FARMING

Smart Farming is a development that emphasizes the use of information and communication technology in the cyber-physical farm management cycle. Smart Farming represents the application of modern Information and Communication Technologies (ICT) into agriculture, leading to what can be called Third Green Revolution. Agriculturally based practices in India needs indefinite transition from the conventional methods to the smart farming approaches in order to achieve sustainable and profitable agricultural practices. Smart forming also termed as Internet of Agriculture Technology (IoAT), employs Information and Communication Technologies (ICT) in understanding the various aspects.



The concept of smart farming representing the cyber-physical system-based management cycle. As per the recent survey, the world population is going to reach close to 10 billion by the year 2050. Providing the food for these mammoth populations is considered to be a big challenge for the governments, and it is highly impossible with less cultivable land available and conventional agricultural approaches. The only way to deal this ample task is the implantation of smart agricultural practices and the application of IoT technology in agriculture to overcome the crop limiting hurdles such as biotic and abiotic stress, crop failure, crop damage, loss of productivity and wastage to achieve progression in the agricultural practices.

IoAT refer to the application of various sensors to monitor the different conditions such as light intensity, humidity percent, temperature measures, soil moisture content etc. in real-time situation and also helps in the automation of irrigation system to reduce water wastage. The benefits provided by the IoAT is ample and some of the most important benefits are listed to be sensorbased field monitoring, effective resource mapping, remote crop monitoring, climate monitoring & forecasting, controlled usage of fertilizers and pesticides and finally the accurate prediction of crop yield.

SUPPLY CHAIN STRATEGIES

Food security is one of the most important, critical and major concerns globally today and world is going to face an immense food crisis in coming years. To accommodate future needs of the growing population with the limited availability of cultivable land, it is imperative to decrease product and food losses by strengthening the food security measures through automated food security supply chain approaches. Automation is very much essential in all the stages of cultivation i.e., selection of quality seed, process of planting seeds, growing the young plantlets, establishing protection from pets to avoid crop damage, supplying the nutrients and water at optimal level to decrease crop failure and increase crop productivity. Other applications of automation include controlled and effective harvesting method to decrease crop wastage, post-harvest collection of crops, processing of collected crop and transportation for marketing. Food safety measure brings confidence and increases acceptability of the consumers on products or food items. This can be achieved by denoting the safety measures implemented in all the stages i.e. process of cultivation, harvest and post-harvest operations, of crop management. Safety measures implanted through automated food chain approaches give more business to the industry and also furnish reputation to the formers which increase their confidence and attract more people towards agricultural practices.

Models practiced in supply chain strategies of agriculture practices, (a) B2B model, (b) B2C model, (c) C2C model.

Application of big data analytics certainly helps in overcoming the hurdles in food supply chain by integrating with Application Programming Interface (API) system. Big data analytics can certainly add value to the agricultural practice in many regards such as bringing the returns from scientific investments, establishing the good agricultural practice, implementation of precision agriculturally based techniques at field level, efficient food supply chain mechanism and automation of the total process for the profitable agriculture.

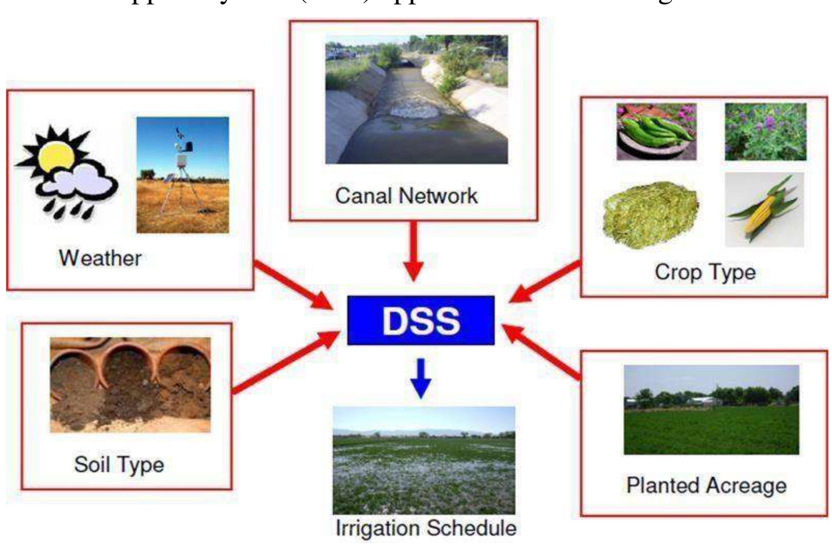
DATA MINING AND ANALYTICS

Decision support system (DSS) in the field of agriculture is ably supported by data mining tools. The main aim of the processes involved in data mining is to extract the information from the currently available data sets and then transform the same using specific tools to a unique format that is easily understandable and can be used for advanced purposes. Data mining helps in soil fertility studies and empowers the farmers in making a decision to sow specific variety of the crop that resultsin a better yield.

The main aim of soil classification is to predict the engineering properties and fertilizer of soil there by order the choices for use. The currently available statistical techniques and the laboratory test consume lot of time, energy and money. It is possible to develop more efficient techniques for solving complex and large data sets of soil with improved accuracy and effectiveness. Data mining techniques based on GPS, k-means approach, SVMs, K-nearest fertilize method are useful to study the soil characteristics, pollution in atmosphere, the factors that influence the crop yield. Soil tests are normally conducted to study the fertility of the soil, impurity and other deficiencies if any in soil that to be removed.

Most of the Soil testing laboratories that are owned by either government or private sector offer different protocols for analysis of the soil and the literature pertaining to the soil characteristics.

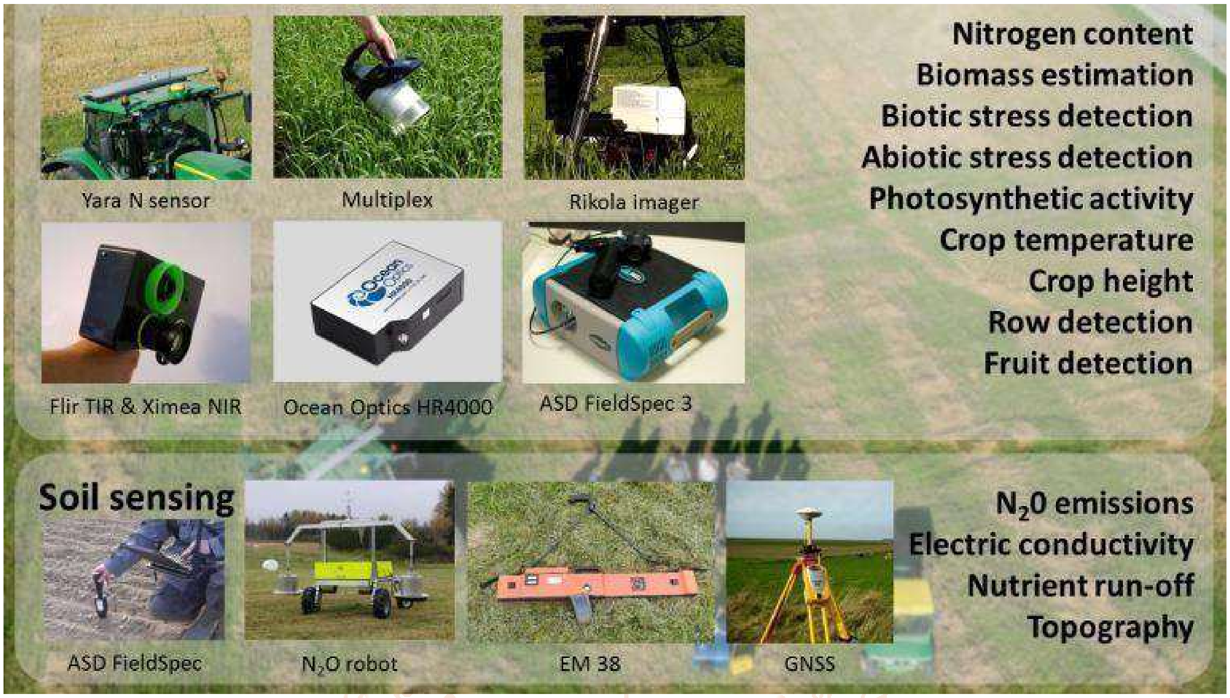
An architecture of Decision Support System (DSS) applied in the field of agriculture.



WEATHER FORECASTING TECHNIQUES

One of the greatest challenges for agriculture is climate change and its impact on human life. In contrary to other fields like e-commerce and advertising where Big Data has played big role in their success, there is little impact on advanced understanding of the environment.

This inconsistency curtails the climate data with complex nature. Big data analytics has been in use to mine large datasets of climate with more focus of differences between the traditional big data and mining climate data approaches. In India the impact of climate change effects plant growth development and subsequently crop yield. Due to the increase in the temperatures, there is a drastic reduction in the duration of the crop. Increase in crop respiration rate had resulted in pattern change of pest attack.



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Most of the crops have adjusted to the growing season, day lengths of the middle and lower latitudes and with poor response to the much longer days of the summer. Increased temperature accelerates the rate of release of CO2 during warmer seasons resulting in reduced crop yield. By collecting the data of rainfall and temperature of last 5 years one can analyse the data by using different big data analytics tools to get the exact change in the Indian agricultural climate. Sensors play a vital role in predicting the effectiveness of the certain seeds, fertilizer in different section of the farm. To achieve an optimum crop yield, software guides the farmers to sow the hybrid varieties seeds at one corner and different variety at another corner.

AGRICULTURE/ CROP MANAGEMENT

Various seasonal, economic and biological factors influence the crop production but unpredictable changes in these factors lead to a great loss to farmers. Crop protection & weed control solutions need to be developed to reduce the crop damage and in turn increase the overall yield of the crop. The existing models consist of three major elements:

- Data Capture & Storing.
- Data Analysis
- Recommendations based on analytics.

Application of Integrated Crop Management (ICMs) in agriculture

This unified solution needs concurrent advances in the domains of agricultural science, collaboration between supply chain partners and in ICT. New techniques are required to use the historical data for prediction of the occurrence of pests, weeds and other diseases. Integrated Crop Management System (ICMs) is a technique of agricultural practices that balances the necessities of organizing a profitable agriculture-based business with environmental accountability. ICMs includes practices that helps to reduce waste, boost energy efficiency and diminish pollution. Technology used for agriculture has positive impact.

CONCLUSION

Technology usage in agriculture, it can be observed that there are numerous approaches that can be used for improving the quality and quantity of crops. In contrast to other developed countries, in India it is a big challenge to achieve the anticipated growth due to non-maintenance of resources on which the production systems depend. Various elements influence the successful use of quality farming.

The usage of technology in agriculture domain has resulted in digital agriculture, precision agriculture, analytics for crop yield etc. In India, large numbers of people are engaged in agriculture and there is a gap between the farmers and technology. Governments have introduced various methods into agriculture to help the farmers to take the advantage of technology. In spite of this, there is a scope for user friendly easily understandable ago advisory systems to help farmers to take decision on crops to be sown.

Also, at different levels of crops growth, these technological inventions should help farmers to extract best yield with reduced expense.

REFERENCE

[1] Bruinsma, J. (2017). World Agriculture: Towards 2015/2030: An FAO Study. Routledge, https://doi.org/10.4324/9781315083858.

[2] Fao; Evenson, R. E., & McKinsey, J. W. (2019). Research, Extension, Infrastructure, and Productivity Change in Indian Agriculture. In Research and Productivity in Asian Agriculture (Page No:158-184). Cornell University Press, https://doi.org/10.7591/9781501734328-007.

[3] K. M. Arjun, "Indian Agriculture- Status, Importance and Role in Indian Economy," International Journal of Agriculture and Food Science Technology, vol. 4, no. 4, pp. 343-346, 2013.

[4] J. W. Jones, et al., "Toward a new generation of agricultural system data, models, and knowledge products: State ofagricultural systems science," Agricultural Systems, pp. 269-288, 2017.

[5] L. Mariani and A. Ferrante, “Agronomic Management for Enhancing Plant Tolerance to Abiotic Stresses— Drought, Salinity, Hypoxia, and Lodging,” Horticulture, vol. 3, no. 4, pp. 52-69, 2017.

[6] B. M. Sagar and Cauvery N. K., “Agriculture Data Analytics in Crop Yield Estimation: A Critical Review,” Indonesian Journal of Electrical Engineering and Computer Science, vol. 12, no. 3, pp. 1087-1093, 2018.

[7] C. C. Sekhar, et al., “Effective use of Big Data Analytics in Crop planning to increase Agriculture Production in India,” International Journal of Advanced Science and Technology, vol. 113, pp. 3140, 2018