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Data Science in Agriculture

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Abstract -*Data Analytics has already changed the world and has brought various new ideas to improve decision-making, analyze trends, and identify opportunities. Today Machine Learning, the Internet of Things(IoT), Artificial Intelligence, and Big data are revolutionizing and changing the current scenario of using traditional methods in almost all Sectors. Agriculture in India engages almost 42 percent of India's workforce yet contributes only 14 percent to India's Gross Domestic Product(GDP). A great deal of research has been going around about applying Data Analytics in Agriculture. However, there are many challenges to achieving the integration of these technologies. Firstly, the awareness of these technologies to farmers is quite uncommon, and secondly, the variation in data about the harvest and production, weather change, disease, and insect damage, etc. could not be predicted, because of which the supply and demand of agricultural products have not been controlled properly. This paper gives insight into the use of Data Science for agriculture with precision farming and remote sensing equipment.*

***Key Words*: Artificial Intelligence, Machine Learning, Data Analytics, Precision Agriculture, Remote Sensing**

1. INTRODUCTION

Agriculture is a huge sector all over the globe with food demand growing day by day. Traditional agricultural methods should be combined with Current Technology to manage the existing resources and tasks to increase productivity and output better results. Today Smart Farming using IOT and Big data analytics play a crucial role in shaping the agricultural economy. The Internet of Things (IoT) depicts the network of physical objects or things that are placed with sensors, software, and other technologies to connect and exchange data with other systems over the internet. There are Machines with different types of sensors that measure data in their environment which is used for the machines' behavior. This varies from relatively simple feedback mechanisms to deep learning algorithms. This is achieved by combining with other, external Big Data sources such as weather or market data. Because of fleeting developments in this sector, Big Data can be described as a term for large or complex Data sets on which traditional processing is insufficient. The terms Big Data and Smart Farming are not that omnipresent in various regions. Because of which we cannot expect everyone to have proficiency in research and developments in these domains. Just as smart machines and sensors appear more frequently on farms and the amount of agricultural data will lengthen, agricultural operations will be progressively data-guided. Alternatively, the rapid progress in the Internet of Things (IoT) and cloud computing are amplifying Smart Farming. While precision agriculture only refers to the site-specific application, Smart Farming considers situations generated by events in real-time. These techniques allow the farmers to react quickly to sudden changes in circumstances, such as weather event warnings or a disease. These features generally include smart assistance in the implementation, maintenance, and use of the technology. AI techniques like artificial neural networks have also been used to evaluate soil moisture and crop predictions for automated and error-free applications of water, fertilizers, pesticides, etc. The rising field of nanotechnology as well, along with the use of various types of sensors makes it possible to collect large volumes of data, amount, and precision from the fields and farms. Modern solutions are now integrating non-traditional data sets like weather data and satellite imagery to track cultivation progress and weather patterns. Rapid improvement in sensing methods, smart information and communication technologies, as well as social media, have contributed to the expansion of Big Data and ML in many environmental fields.

Although big data and data analytics has brought significant advances to the world today, there are still several challenges left to explore. It is expected from Data Science and Analytics Technology to gain statistical patterns of the crop. The effect of big data in agriculture is massive and we have only started exploring its applications. This paper focuses on the solutions obtained for real-life problems experienced by farmers. Brief description of using Precision Agriculture and Remote Sensing Technology that uses Big Data Technology to establish a high-quality Agricultural Production is given in the paper.

2. Literature Survey

The first paper I went through was “Precision Agriculture using IoT data analytics and Machine Learning” by Ravesa Akter and Shabir Ahmad Sofi which was published in the journal named Journal of King Saud University in the year 2021. In this paper, the authors discussed the Adoption of IoT(Sensors) and data analytics for the prediction of apple scab. Apple scab is a common apple disease which is caused by the fungus Venturia inaequalis. This fungus infects both leaves and fruit. Because of this, a large number of Apples are wasted. The authors studied and analyzed the data to understand the factors affecting the growth of Apples. Studying in R-Squared values, factors like pH, Potassium, and phosphorous played an important role in the production of Crops. Based on this data, they designed some prediction models which can be used to discover whether or not conditions were adequate for infection to spread. They used real-time data as the input for Linear Regression Model. Required sensors were properly programmed and placed surrounding the crop. After the collection of Accurate data for data pre-processing, analysis was done. By the combination of temperature and hours of leaf wetness, we can recognize whether that region is safe or not.

"Machine Learning in Wireless Sensor Network Based Precision Agriculture" is a paper published by the Journal of The Electrochemical Society in the year 2020. The authors are Yemeserach Mekonnen, Srikanth Namuduri, Lamar Burton, Arif Sarwat and Shekhar Bhansali. In this paper, the authors discussed Wireless Sensor Networks developed using open-source hardware platforms, Arduino-based micro-controller, and ZigBee55 module to detect and manage specifications critical to crop growth such as soil conditions, environmental and weather conditions. The main intent of this exploratory project wasto investigate more about the network of food, water, and energy by designing an IoT based farm system that will give the potential to produce more food with less energy and water using a simple self-operating system powered by solar panel in order to supervise current and future resource insufficiency. The farm operates on distributed wireless sensor technology and is able to observe and estimate various environmental criteria, such as soil temperature and moisture, in real-time to program precise irrigation events. The system further collects real-time weather statistics in order to minimize environmental influence and make better arrangements for managing resources like water and energy. This information collected is accessible in the local and external databases, and the users have the ability to fetch the information using a built-in mobile application. "Big Data in precision dairy farming" article published in the Animal Journal in the year 2019 was written by the authors C. Lokhorst, R. M. de Mol, and C. Kamphuis. In this paper, the authors discussed the present scientific utilization of Big Data within the precision dairy farming sector. They discussed how the extent of Big Data is very huge but not yet reached. The maximal potential is expected to occur when data with different features are used, that originate from animals, groups, farms, and chain parts in adding utility to functional and deliberate decisions.

"Applications of Remote Sensing in Precision Agriculture" article was published in the year 2020 by Rajendra P. Sishodia , Ram L. Ray, and Sudhir K. Singh. This paper was published in the Remote Sensing Journal. In this paper, the authors talk about Advancing technologies, such as remote sensing, global positioning systems (GPS), geographic information systems (GIS), Internet of Things (IoT), Big Data analysis, and artificial intelligence (AI). These are the encouraging tools being imposed to enhance agricultural performance and inputs directed to strengthen production and reduce inputs and yield losses. Remote sensing systems, using computerized information technologies, usually bring about a large capacity of data due to the high structural resolutions needed for various applications.

Growing data processing procedures such as Big Data analysis, artificial intelligence, and machine learning have been operated to obtain convenient information from a big data volume. Cloud computing systems have also been used to store, process, and distribute such a huge amount of data. All these modern data additions and processing techniques have been practiced globally, to assist the managing process for field crops, horticulture, viticulture, pasture, and livestock. The authors also talk about using satellite images to monitor high-resolution images for disease and crop water stress detection.

3. Precision Agriculture and Satellite Imagery

One definition of Precision Agriculture (PA) described the term as ‘an industrial technique to farming management that perceives, measures, and analyzes the needs of discrete fields and crops’. In simple words farming that collects and uses data of maps for managing and enhancing the production of crops is called Predictive farming. Predictive farming is comparable to taking a pill to target a disease. The production is highly monitored from the type of crop appropriate for a plot to the use of pesticides in intended regions only. The adoption of Precision farming lessens the cost of production and wastage. Precision farming is carried out by adopting systematic software and the usage of technical gadgets.

Huge amount of data is collected on testing of soil, measurement of plot, pattern of weather as well as crop analysis through sensor equipment placed within the fields. The data is measured to formulate decisions and based upon those results, very detailed and practices can be utilized. The European Space Agency's Sentinel-2 satellite has a lot of potential applications in precision agriculture due to its specific spatial, temporal, and spectral capacities. One very notable use of Sentinel-2 which aims at field monitoring is the ESA Sen2-Agri system which generates constituents of time along thegrowing season.

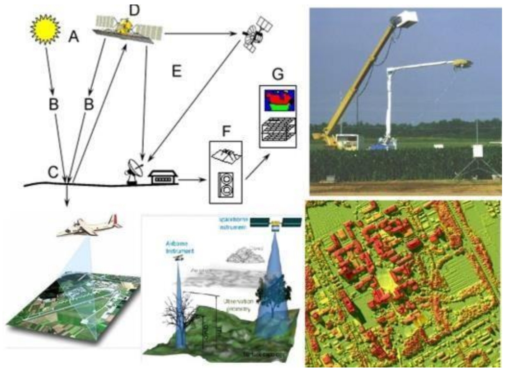

Fig -1: Precision Agriculture

The profitability of Sentinel-2 multi-temporal data for crop-type monitoring is very crucial as it reaches up to 91%–95% overall accuracies in various crop classifications while single-date images show insubstantial results. Besides the reanalyzed time, the higher geographical and spectral resolution also upgrades area detection and evaluations. Regarding classification techniques, object-based and pixel-based have shown to be accurate classification approaches using Sentinel-2 imagery. The object-based dynamic time distortion was demonstrated to be more systematic in classifying crops than the pixel-based approach when using multitemporal Sentinel-2 imagery, nonetheless, the random forest algorithm seems to be more coherent for crop type classification when crop spectral irregularity is high. In common terms, the consolidation of Sentinel-2 imagery and various algorithmic methodologies, like the random forest algorithm, k-nearest neighbor, and support vector machines have also shown suitable classification accuracy, resulting in over 90% of overall accuracy for several approaches. Understanding the conditions of the crop, namely crop type attributes and surface expansions, is central to accurately making classification method conclusions when using Sentinel-2 imagery.

4. Use of Remote Sensing Techniques

Researchers have long identified the requirement to survey soil and land databases for efficient management ofnatural resources at local, regional, and national levels.

The consciousness of the physical, biological, and chemical properties of soil is necessary to draft and perform irrigation, drainage, nutrient, and other crop management procedures, which are essential constituents of Precision Agriculture. A conventional approach to implementing remote sensing methodologies in agriculture has been around even before 1958. This is when the name "remote sensing" was first suggested. For instance, aerial photography has been used to observe soils, land, andcrop patterns in the US during the 1930 and 1940s.

However, these traditional techniques of soil and land mapping use classification which typically involve substantial fieldwork and laboratory investigation, which are high-priced and time-consuming. The emergence of satellite remote sensing during the following years promoted more effective mapping of land use at global levels. Remote sensing is the technology by which the characteristics of required objects, areas, or phenomena can be recognized, estimated, and analyzed without direct contact with them for the purpose of making useful decisions. Remotely sensed images can be utilized to identify recognize insufficiencies, diseases, water deficiency or surplus, weed infections, insect damage, wind damage, herbicide damage, and plant populations. Data obtained from remote sensing can be convenient to rate applications of fertilizers and pesticides. Information from remotely sensed depictions allows farmers to treat only damaged areas of the farm. Complications within a field may be recognized remotely before they can be visually recognized. Herdsmen use remote sensing to associate prime grazing areas, overgrazed areas, and the areas of weed infections. Lending organizations use remote sensing data to estimate the comparative values of land by correlating archived images with those of adjoining fields. There are various types of Remote Sensing systems which include spatial resolution, spectral resolution, radiometric resolution, and temporal resolution.

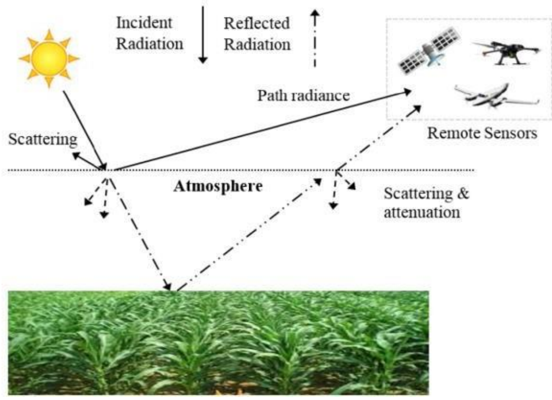

Fig -2: Remote Sensing Technology

Even though the concept and design of remote sensing technology are quite serviceable, even so, it has a lot of drawbacks. First is the expensive machinery and implementation cost. It is very costly to operate especially on small fields. Secondly, the measure of uncertainty can be huge. It is not always trustable to gain accurate output values. The Data evaluation can be difficult to understand theoretically how the device is analyzing the computations. It might be tough to understand measurement unpredictability. Sometimes the active systems close to the field such as radar and laser interfere with the remote sensing system. This affects the analyzing process and accurate data cannot be obtained. Considering the intricacy of image processing procedures and the amount of technical knowledge and competence it requires for implementation, there is a need to inspect and create an easy and reliable system for image pre-processing, inspection, and application in real-time. Big drawbacks and gaps remain in the creation of tools and foundations that can simplify the use of satellite data for real-time applications for people. The development of precise, convenient systems is likely to result in wider usage of remote sensing data in commercial and non-commercial methodologies.

5. CONCLUSION

So, from this paper, we first understood the importance of bringing Data Science in the Agriculture Domain. It is necessary to recognize independent problems properly, in order to find optimal solutions for them. Agriculture is a crucial sector that will shape the future of the world. To acquire better quality, better quantity, and more attested outcomes we need to utilize present cutting-edge technology. Today technologies like Data Science, Analytics,Artificial Intelligence, Remote Sensing, etc., have already been used in a lot of applications, yet we are still at the initial stages of a technology-driven world. Getting accurate insights from data and monitoring the patterns through various models is crucial for the appropriate management of existing resources. Moreover, it is also essential to empower small farmers and expand these methodologies to them as well. Our creativity and imagination will give us more power to obtain greater solutions. It will surely take some time, but will eventually happen and benefit humankind.

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