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# Integration of Iot and Data Analytics for crop Yield Prediction and Resource Management

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***Abstract*— In a world marked by escalating population growth and the essentiality of food, achieving optimal crop yields with limited resources has emerged as a critical imperative. Traditionally, farmers relied on their experiential wisdom to forecast crop yield, a practice constrained by subjectivity and inefficiencies. However, the advent of technology, specifically the combination of the Internet of Things (IoT) and data analytics, has inaugurated a transformative era in agriculture. This paper explains the fusion of IoT and data analytics as a powerful paradigm for crop yield prediction and resource management, poised to revolutionize agricultural practices. Integrating the IoT and data analytics techniques in crop yield prediction can pave better operational efficiency and productivity. IoT enabled sensors, encompassing climatic data and soil nutrient status, furnishes real-time insights into the dynamic variables impacting crop growth. Coupled with pre-existing knowledge encompassing farming conditions and crop varieties, these real-time data are processed using diverse analytics techniques, including machine learning algorithms and predictive modelling. The resulting crop yield predictions furnish stakeholders with actionable intelligence, facilitating informed decision-making and resource allocation. Farmers can gain advantages from enhanced effectiveness in operations, increased output, and the best possible distribution of resources. Moreover, the synthesis of IoT and data analytics produces a continuous loop of monitoring and adjustment, adopting a practical approach to crop management. Such advancements ripple across the agricultural ecosystem, empowering stakeholders ranging from policymakers and agribusinesses to researchers and consumers.**

***Keywords*— Internet of Things, IoT, Agriculture, Crop yield, Data Analytics, Prediction, Sensors, Cloud**

## I. INTRODUCTION

The Internet of Things is considered a model move in the advancement of the smart agriculture field [1]. IoT is contributing significantly to the area of modern agriculture. The IoT is the network of physical objects embedded with hardware units, software, and other technologies to connect and exchange data with other devices and systems over the internet. IoT connects any objects to the internet using specified protocols through sensors to exchange data for achieving particular objectives [2].

The IoT can integrate with Wireless Sensor Networks (WSN), data analytics, cloud computing, Artificial Intelligence, and end-user applications to provide high operational efficiency and crop yield [1]. The IoT nodes (sensors) collect precise data regarding the physical and environmental conditions of soil and plant. Data can be stored locally or be transferred to the cloud platform for computing. By applying data analytics techniques, we can know, what happened, why it happens, what will happen and how can we make it happen. This knowledge can be communicated to the end users for taking immediate action [3].

Data analytics is the scientific process of converting data into insights for enhanced decision making. It is commonly classified as descriptive, diagnostic, predictive, and prescriptive. Descriptive analytics is commonly applied to historical data to answer the question “What has happened”. Diagnostic analytics is usually performed when analyzing the historical data and the data pattern to answer the question “Why something happened”. Predictive analytics is the process of transforming raw data into useful information that can be used to create future forecasts, gather knowledge about upcoming occurrences, and provide "What will happen" answers. Prescriptive analytics is applied when developing a system to provide the end-users with predictions and then suggest advice options to take advantage of them [4].

Data analytics require methods that can transform a large amount of structured, unstructured, and semi-structured data into a more understandable data and metadata format for analytical processes. They are classification, clustering, association rule mining, and prediction categories, which involve many methods and algorithms to do information extraction and analysis requirements [6].

The increase in world population, unstable climatic conditions, reducing natural resources, and agricultural land result in a shortage of food for everyone. Presently, agriculture production contributes to over 70% of freshwater consumption and unsustainable levels of chemical consumption for crop production [10]. These problems are drivers that lead agriculture into smart/precision agriculture with the application of IoT and data analytics to improve productivity and sustainability [1]. The application of IoT and data analytics can begin with crop selection, irrigation, soil and nutrient management, crop monitoring, pest and disease management, fertilizer application, yield monitoring, and harvesting. Such IoT based system can be developed and implemented, that will collect, secure, and store datasets either at the local level or at cloud platforms, analysis using data analytics techniques on a large amount of data, producing conclusions and decision making for end users (farmers and other stakeholders) that should improve agriculture productivity.

Crop yield prediction is one of the important elements in agriculture practices. It helps farmers in calculating crop yield before sowing seeds in their fields, using optimal agriculture inputs, reducing losses and getting the most favourable price for their harvest [5].

## II. LITERATURE REVIEW

M. Wicaksono *et al*. [11], developed a dynamic system model that enhances the productivity of rice farming in East Java, by maximizing the application of IoT in planning rice planting schedules and management. The result showed a causal loop diagram of internet-based system thinking that can be used as a recommendation for increasing land productivity. Raw data from the humidity sensor, soil pH sensor, temperature sensor obstacle sensor goes to the Raspberry Pi device where the data is processed and stored in the database and is used as material for validation and comparison of real system models. Primary data is used for system modelling purposes, and secondary data used in studies include data on pests, weather and climate, data on rice prices at the producer level, data on demand for rice for industry and feed, data on consumption per capita, and other data related to food commodities (rice) and scientific research

N. Kumar *et al.* [12], proposed an Internet of Things based architecture of smart agriculture techniques. The proposed architecture has a number of layers to carry out smart agriculture tasks. The architecture is composed of a core network layer, an edge network layer, an end-user layer, a device and storage layer, and a management layer. The IoT sensors like drones, and relays, whether sensors are connected to gateways through Node MCU or Arduino with Wi-Fi module. Data is loaded on the cloud through gateways for monitoring and controlling farming remotely using mobile phones and computers. In the IoT architecture all the sensors placed on the remote area of form and weather station are used to gather the information received by the multiple sensors and information is transmitted to an analytical tool for analysis. Sensors square measure devices that are sensitive to anomalies. The monitoring of crops would be done by the farmer with the help of an analytical dashboard.

O. Elijah *et al*. [1], gave an outline of IoT and data analytics technologies and practices in agriculture. The authors divided their study into four sections communication technology, internet, data storage, and technology. The authors also provided an analysis and data on how the aforementioned sections can be employed for dealing with diminishing agricultural resources. The benefits and drawbacks of various technologies such as cloud computing, WSN, radio frequency identification, middleware systems, etc. to their implementation in the agriculture area are also discussed. Studies on how these technologies be applied and develop an IoT ecosystem, with technical and business scenarios were also presented.

M. Ammad Uddin *et al*. [13], proposed a system for crop monitoring from the phase of seed germination to harvest. The advantages of such a framework incorporate enhancement of yield quality and amount, effective utilization of assets, and protection from the bad climate. The application of the IoT for the trackability of seeds is conducive to more effective agricultural practices, appropriate land use, and high quality produce. The authors focused on developing a system for monitoring crops from the stage of seed germination to harvest. And proposed a resource-optimized fast health crop monitoring system. Saudi Arabian agriculture was examined as a case study. IoT and drones were harnessed to make an efficient agricultural monitoring system. Data collection methods were employed to gather data from diverse devices arranged in localized clusters. The system was designed to withstand a harsh environment with agility and feasibility.

Vandana B *et al*. [14], proposed a model that will help rural farmers to use Information and Communication Technologies (ICTs) in agriculture fields using big data analytics to improve crop yield. The proposed design is categorized into a collection of data and processing modules. The real-time environmental data like temperature, humidity and soil moisture are collected using IoT sensors and historical data like temperature and rainfall is collected from standard data sets. Farmers' feedback is also taken as data; the Hadoop platform is employed for data processing and MapReduce for programming. Classification technique is used to categorize the various field parameters and prediction technique is used for pest management. All collected data is stored in a local cloud platform. A web application is used to give the solution when it is essential for the small-scale farmer.

## III. PROPOSED METHODOLOGY

### A. Data Collection

Soil nutrient status, farming situation, crop variety, and climate (sunshine hours, wind speed, rainfall, humidity, and temperature) are the main factors affecting crop yield. Wheat crops from the Patan block of Jabalpur can be taken for study. It is irrigated in farming situations and fertilizers are applied based on the soil health card provided by the soil testing lab of Krishi Vigyan Kendra Jabalpur on selected crop varieties. The climatic and soil data, the real-time data can be collected using sensors in the loT domain.

A typical structure of an IoT device includes actuators linked by either wired or wireless connections, sensors for acquiring data on the physical and environmental state of soil and plants, and an embedded system housing a processor, memory, communication modules, input-output interfaces, and battery power. Various sensors are commonly employed in the field of smart agriculture, catering to different tasks. These sensors are utilized for the collection of data such as air temperature, soil temperature, air humidity, soil moisture, leaf moisture, precipitation, wind speed, wind direction, solar radiation, and barometric pressure. In the realm of smart agriculture, low-power communication protocols are categorized into short-range and long-range based on their communication coverage. Networks such as Wi-Fi, LoRa, Cellular, Zigbee, and Bluetooth serve as representations of wireless communication technology. The specific deployment of IoT devices for smart agriculture applications determines the selection of communication spectrum bands and operational protocols [8].

B. Data Storage

The regular database system needs more capacity for the data gathered from the IoT sensors. Cloud-based data storage and an end-to-end IoT platform have a crucial role in the smart agriculture system. Cloud computing assists in the storage and analysis of this data to maximize the advantages of an IoT infrastructure [15]. Major cloud platforms are ThingSpeak, Microsoft Azure, Ubidots, Google-based Firebase, Amazon Web Services, Cloud Sense, Generic Cloud, Sensor DB, SEnviro, Huawei, etc. Based on privacy policy, cloud platforms can be divided into Public, private, and hybrid clouds. Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS), Software-as-a-Service (SaaS), and Network-as-a-Service (NaaS) are cloud-based services provided to the users. Cloud computing has come out as an important standard for managing and delivering the new emerging applications in the area of agriculture efficiently over the internet [9].

C. Data Pre-processing & Preparation

Data can be surveyed so that a better understanding can be gained of the dataset. The data cleansing practices include the elimination of duplicate records, quarantining outlier records that exceed the bounds, standardization of attribute values, substitution of missing values, etc. [7].

D. Data Processing

Crop yield prediction can be done using various data analytics techniques. Huge amounts of organized, semi-structured, and unstructured data can be stored and processed using the Hadoop platform. It can support real-time for immediate decision-making and historical analysis. Hadoop network has two major pillars, Hadoop Distributed File System and MapReduce programming paradigm. Hadoop Distributed File System is the infrastructural component and MapReduce is the computational framework.

Map reduce is a data processing model which deals with very extensive data sets in a distributed environment. It allows parallel computing with supporting functions. It is necessary for the operation of the Hadoop framework and a core component. It enables the distributed processing of enormous data volumes on clusters of traditional hardware. Map and Reduce are its two main components, and they cooperate to process and analyse data. Classification and prediction techniques are applied to analyse the data.

## IV. CONCLUSION

The development of a crop yield prediction model will benefit farmers in getting insight for improved decision-making, optimal use of agricultural inputs and continuous monitoring of crop growth. Investors and insurance companies can calculate the credit risk for the crop. Farmers and other stakeholders can benefit from the model to understand the market and suggestive measures can be adopted for improving crop yield. Crop yield prediction based on historical data using statistical analysis is not accurate as the present condition (real-time data) has also an impact on prediction. Predicting crop yield is a challenging task towards precision agriculture. The main challenge is the identification of suitable algorithms and an effective model of data analytics. Through enhanced predictive accuracy, resource optimization, and sustainable practices, the fusion of IoT and data analytics paves the way for a resilient agricultural future.

## REFERENCES

[1] O. Elijah, T. A. Rahman, I. Orikumhi, C. Y. Leow and M. N. Hindia, “An Overview of Internet of Things (IoT) and Data Analytics in Agriculture: Benefits and Challenges,” IEEE Internet of Things Journal, vol. 5, no. 5, pp. 3758-3773, Oct. 2018.

[2] K. K. Patel and S. M. Patel, “Internet of Things-IOT: Definition, Characteristics, Architecture, Enabling Technologies, Application & Future Challenges,” International Journal of Engineering Science and Computing, 6 (5), pp 6122-6131, 2016.

[3] R. Akhter and Shabir Ahmad Sofi, “Precision agriculture using IoT data analytics and machine learning,” Journal of King Saud University – Computer and Information Sciences 34, pp 5602–5618, 2022.

[4] Husamaldin, L., Saeed, N., “Big data analytics correlation taxonomy,” Information 11 (17), 1–12. 2020.

[5] B. M. Sagar, 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 December 2018.

[6] Marjani, M., Nasaruddin, F., Gani, A., Karim, A., Hashem, I. A. T., Siddiqa, A., &Yaqoob, I. “Big IoT data analytics: architecture, opportunities, and open research challenges.” IEEE Access, 5, pp 5247-5261, 2017.

[7] Data Science Concepts and Practice, Second Edition, Vijay Kotuand Bala Deshpande

[8] Vu KhanhQuy, Nguyen Van Hau, Dang Van Anh, Nguyen Minh Quy, Nguyen Tien Ban, Stefania Lanza, Giovanni Randazzo and AnselmeMuzirafuti, “IoT-Enabled Smart Agriculture: Architecture, Applications, and Challenges,” Appl. Sci., 12, 3396, 2022.

[9] S. Singh, I. Chana, and R. Buyya, “Agri-Info: Cloud Based Autonomic System for Delivering Agriculture as a Service Data Analytics,” Internet of Things, vol. 9, pp. 1–16, 2020.

[10] Lucio Colizzi, et.al, Chapter 1 - Introduction to agricultural IoT, Agricultural Internet of Things and Decision Support for Precision Smart Farming, Pages 1-33, 2020.

[11] M. Wicaksono, E. Suryani, R. Hendrawan, “Increasing productivity of rice plants based on IoT (Internet of Things) to realize Smart Agriculture using System Thinking approach,” Procedia Computer Science 197 pp 607–616, 2022.

[12] N. Kumar, A. K. Dahiya, K. Kumar and S. Tanwar, “Application of IoT in Agriculture,” 9th International Conference on Reliability, Infocom Technologies and Optimization (Trends and Future Directions) (ICRITO), pp. 1-4, 2021.

[13] M. Ammad Uddin, M. Ayaz, E. H. M. Aggoune, A. Mansour and D. Le Jeune, “Affordable Broad Agile Farming System for Rural and Remote Area,” IEEE Access, vol. 7, pp. 127098-127116, 2019.

[14] Vandana B and Satish Kumar S., “A Novel Approach using Big Data Analytics to Improve the Crop Yield in Precision Agriculture,” 3rd IEEE International Conference on Recent Trends in Electronics, Information & Communication Technology (RTEICT-2018), May 18th & 19th 2018.

[15] N Verma, V Jotwani, “Viable Cloud Computing Setup Based On Service-LevelPortfolio”,Webology

 