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# Enhancing Food Production Monitoring and Management with a Communicating IoT-Inspired Network Framework for Data Visualization in the Agriculture Sector

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Introduction: To incorporate Internet of Things (IoT) technologies for real-time monitoring and administration of agricultural production. The purpose of this project was to highlight the improvement of food production usefulness of data visualization in facilitating informed decision-making for more environmentally responsible farming practices.
Method: The production of food uses sensors to measure time, temperature and quality. Control and monitoring systems (CMS) analyzed sensor data and send it to the cloud for analysis. IoT technology connects and shares data from devices and sensors, revolutionizing data acquisition. This network structure simplifies production, increases quality and encourages sustainable farming. Data visualization aids stakeholders in understanding intricate agricultural data, seeing trends and making well-informed decisions. As a result of improvements in technology and the widespread use of sensors, agriculture is becoming sustainable and data-driven. Water levels and leaks are tracked in real-time by a small network of sensors included in the AGRI2L system and Integrated Pest Management (IPM) was implemented to educate the agriculture crops.
Result: The research findings offered sustainable practices and responsible land management by

evaluating important crops and yield differences. It also classified individuals as insecure, food secure, moderately insecure, and severely insecure based on their food access.
Conclusion: This paper concluded by discussing the relevance of technological and data-driven ways to monitor and manage agricultural food production, with suggestions for increasing productivity and longevity.

**Keywords:** Food Production, IoT, Data Visualization, Agriculture, Monitoring, Control and Monitoring System (CMS).

## 1. Introduction

Agriculture is the phrase that is used to convey the many procedures and they are used to provide plants and domestic animals with food along with the methods that are used to manufacture other goods for the human population of the planet [(1)]. The agriculture system is accompanied by a broad range of activities that are essential to agriculture-related nouns and verbs, such as cultivating, cropping, farming, as well as cultivating vegetation [(2, 3)]. Within this context, the idea of food production monitoring and management has arisen as a vital factor, allowing the optimization of agricultural processes via the deployment of novel technology [(4)]. The agricultural sector has seen a considerable transition as a result of the widespread adoption of cutting-edge technology and the growing focus placed on data-driven methods as a means to improve production, efficiency and long-term sustainability [(5)]. Every object that can receive or transfer digital data is able to connect through the IoT which means that IoT has the potential to become an enormous source of information[(6)]. The incorporation of a communicating IoT network has cleared the path for a comprehensive and networked system that facilitates real-time monitoring, decision-making and streamlined management [(7)]. Data visualization plays an important part in this environment because it enables farmers and other stakeholders to comprehend complicated statistics, recognize trends and obtain useful insight that guides vital agricultural practices and initiatives [(8, 9)]. Visual representations of these data give a comprehensive image of the agricultural environment, which enables stakeholders to make informed decisions about managing crops, allocation of resources and minimizing risk [(10)]. The study [(11)] summarized the ways that anticipated increases in agricultural productivity would impact infectious illnesses in humans, and the ways that infectious diseases can impact food production and distribution. The article [(12)] examined some IoT topologies, connectivity, middleware, information processing technologies and looked at the unique problems along with the difficulties related to IoT.

The study [(13)] proposed a smart framework based on the IoT for assessing the quality of food at eating establishments. In a setting where food is served, the IoT is used to collect data that can directly influence the food quality. The research [(14)] proposed a paradigm for evaluating restaurants and food hubs from the point of view of the quality of the food as they provide. The outcomes of the study indicated that the strategy under consideration is better in terms of temporal efficiency, statistical performance improvement and dependability. The paper [(15)] examined Industry 4,0's safe IoT-block chain data from the food industry as a study subject. They use advanced deep learning (ADL) to create a hybrid recurrent neural networks (RNN) model. To improve the parameters of the hybrid model, they combined the use of genetic

algorithm (GA) optimization with gated recurrent units and long short-term memory as prediction models. The research [16] investigated the IoT and artificial intelligence (AI) technologies that are in use for smart sustainable agriculture (SSA), the IoT and AI technical architecture that is capable of supporting the establishment of SSA platforms was defined.

The main goal of the study [17] Industrial IoT (IIoT) aims to improve operational efficiency, productivity, asset and process management. This can be achieved via the customization of consumer products, the implementation of sophisticated monitoring software for producing floor shops, machine health, as well as the provision of predictive and preventative maintenance for industrial machinery. The primary goal of the research [18] was to determine whether or not a greenhouse monitoring system that was reasonably priced, could cover a large geographical area and it was adapted to the needs of contemporary agriculture could be of use in an era that was becoming increasingly characterized by data-driven decision-making and the need to adhere to sustainability imperatives. The article [19] provided a comprehensive investigation of the IoT and the part it plays in enabling digital transformations and IoT across a wide range of business sectors, and the development of the idea of IIoT. The study [20] presented scalable wireless sensor network architecture for remote agricultural and farming monitoring and control using IoT. The findings of the experiments have shown that the suggested technique offers superior performance to that of standard IoT-based agriculture and farming. The main goal of data visualization is to aid in the creation of a framework for efficient decision-making that might serve as a map for the production of food in agriculture.

## 2. Monitoring and Managing Food Production Using a Communicating IoT-Inspired Network Analysis

Monitoring of Food Production

The food production step follows the gathering of raw ingredients and accomplished at this juncture is the setting up of the different sensors to work with the control and monitoring system (CMS). Chemical sensors, pH sensors, microbial detection sensors and gas sensors are some of the methods used to keep an eye on how far the process food has progressed. Sensors allow for the gathering of crucial data, including time and temperature, during the many steps of food production. Measurements of moisture, micronutrients, lipids and other essential ingredients inside the food, as well as pH levels during cleaning operations and the identification of foreign bodies, supplement this data collection. The data from the sensors are sent to the CMS, where they are processed before sent to a cloud computing model. This strategy makes it easier to monitor and evaluate the freshness of food and the findings are reported back to the appropriate stakeholders using a mobile application that is designed for that purpose. Following the conclusion of the food's processing and subsequent evaluation of the product's quality, the food is prepared for packing as shown in Figure 1.

Figure 1. Monitoring of Food Production (Source: https://encrypted-tbn0.gstatic.com/images?q=tbn:ANd9GcQEeKFTaPzhDdJn6y8z4AiySTOOW6Dncw0m-HORAeE4ok_eaARpuilH0ckKUGbH5KDNjMo&usqp=CAU )

In addition, sensors are built into the packing unit to assure the continuous tracking and monitoring of freshness during the whole process of packaging as well as transportation. The use of IoT technology in food packaging has resulted in improved capabilities for maintaining food quality, increasing shelf life and proactively monitoring product status. IoT-enabled smart barcodes and RFID tags transmit full sensory data to a CMS, which is forwarded to cloud computing to enable smooth tracking and tracing of freshness throughout the packaging and transportation stages.

Communicating IoT-inspired network structure

The IoT-based food monitoring system is shown in Figure 2. Agricultural land is blanketed with a wide variety of IoT sensors to collect real-time data information on the ground and the atmosphere. The most common types of sensors used in agriculture are the optical sensor, which can sense the intensity of the light, The dielectric soil moisture sensor examines the amount of soil compaction, the electrochemical sensor gauges pH and nutrient solution levels, the mechanical sensor determines the degree to which the soil is compacted, the airflow sensor determines the degree to which the soil is permeable and the weather monitoring unit collects data pertaining to the weather.

Figure 2. Monitoring Food with IoT (Source:https://iotdesignpro.com/projects/iot-based-food-monitoring-system)

A network that is based on the IoT might make the monitoring and management of food production simpler. This makes it possible to integrate devices and sensors that are networked can monitor and control various aspects of the manufacturing process. This system operates via a network of intelligent gadgets, which collect data and send it out to other devices. A feature of the system is that it allows effective monitoring and control of critical parameters made possible by this. By harnessing the potential of the IoT, this network streamlines the manufacturing process, enhances quality control and promotes agricultural techniques that are environmentally responsible and labor-saving.

Data visualization in the agriculture sector

Data visualization is the process of converting images for data through the utilization of computer graphics and graphics processing technology. An interactive theory, methodology and technology are provided throughout this process. In contrast to the traditional approach of seeing several complicated data tables, data can be portrayed in a way that is simpler to grasp to space field visualization technology, which provides the foundation for data visualization. When it comes to the depiction of data information, an emphasis is placed not so much on more specific facts as it is on higher-level and high-dimensional data. There are several areas into which data visualization can be divided, such as text and cross-media visualization, variable data visualization, stacked as well as system structure of information visualization, time-based visualization and space-based visualization. The ability of farmers to have a better understanding of the link between the functioning of their farms and their businesses is one advantage that can be gained from the use of data visualization. The visualization of data provides very understandable information for farmers working in the agricultural sector, which aids them in the decision-making process for the management of their businesses. Farmers in the agricultural sector can integrate and manage their fields using cutting-edge technology like sensors, big data analysis, cloud computing and IoT. The AGRI2L system uses a few sensors to monitor water levels and leaks in real time. The AGRI2L solution incorporates the use of favorite as a platform for the creation of data visualization. The technology of large amounts of

data gives the potential to utilize the data in a manner consistent with scientific protocol and to make the appropriate choice at the appropriate moment.

## 3. Comprehensive Evaluation

Major crops and yield disparity

The agricultural industry is facing a variety of problems on many fronts and the disparities in major crops and yields reflect this. Variations in agricultural yields are a consequence of several factors, including but not imperfect to the effects of climate change, restricted access to resources and technical gaps. The major cause of crop decline is land degradation. Yields in farmers' fields and research sites differ greatly (Figure 3 and table 1). Lack of plant nutrients and low seed quality can affect food output.

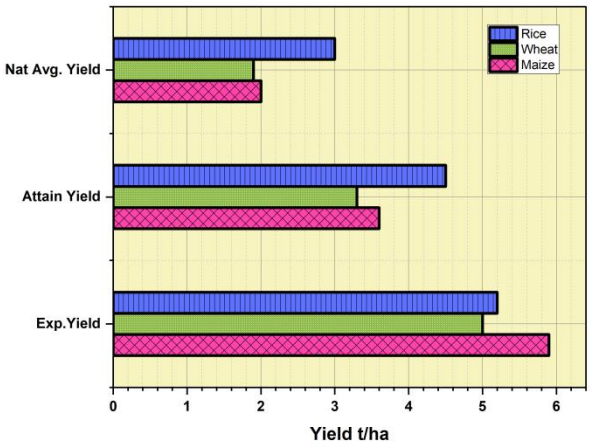


Figure 3. Major crop productivity and yield disparity (Source: author)

Table 1. Outcomes of crop productivity and yield disparity (Source: Author)

| Yield t/ha | | | |
|---|---|---|---|
| | Maize | Wheat | Rice |
| Exp.Yield | 5,9 | 5 | 5,2 |
| Attain Yield | 3,6 | 3,3 | 4,5 |
| Nat Avg. Yield | 2 | 1,9 | 3 |

Agriculture Fields

The agricultural fields demonstrate a dedication to sustainable practices, demonstrating a readiness to implement IPM and to make educated crop management choices. The fields emphasize environmentally responsible practices, from the painstaking conveyance of harvested goods to the careful consideration of the use of pesticides. The farmers ensure healthy production and the effective exploitation of available resources by placing a strong focus on permanent farm upkeep, weeding and seedling care. Figure 4 and Table 2 show the outcomes of agriculture fields.

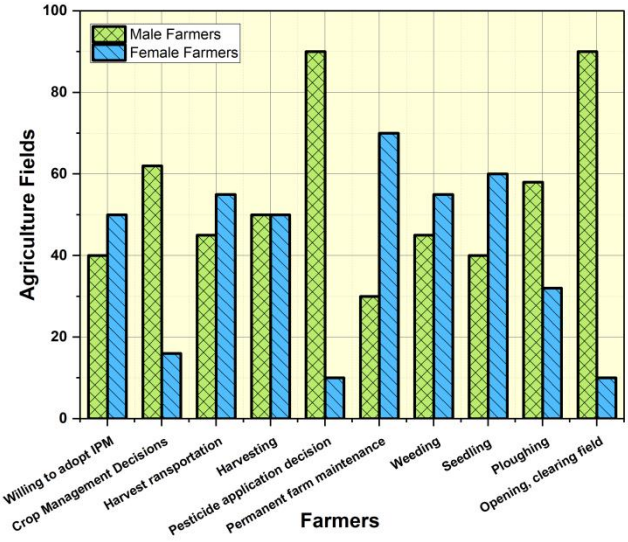


Figure 4. Food-producing agriculture (Source: author)

Table 2. Outcomes of Food-producing agriculture (Source: Author)

| Farmers | Agriculture Fields | |
|---|---|---|
| | Male Farmers | Female Farmers |
| Willing to adopt IPM | 40 | 50 |
| Crop Management Decisions | 62 | 16 |
| Harvest transportation | 45 | 55 |
| Harvesting | 50 | 50 |
| Pesticide application decision | 90 | 10 |
| Permanent farm maintenance | 30 | 70 |
| Weeding | 45 | 55 |
| Seedling | 40 | 60 |
| Ploughing | 58 | 32 |
| Opening, clearing field | 90 | 10 |

Security of food production

The degree to which people or groups have access to food that is adequate, safe and satisfies their nutritional needs are referred to as the food security level. The term food secure refers to constant availability of sufficient food, whereas the term mildly food insecure refers to a slight compromise in food quality or quantity. The phrase moderately food insecure refers to a considerable decrease in food consumption, while the phrase severely food insecure means that there is a serious shortage of food leading to hunger, malnutrition and associated health hazards. Figure 5 and Table 3 show the outcomes of food security levels.

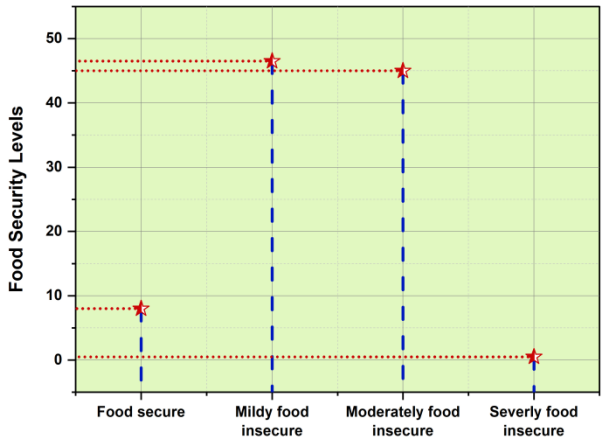


Figure 5. Food Security Levels (Source author)

Table 3.Security Levels of Food (Source: Author)

| Food Security | |
|---|---|
| Severely food insecure | 0,5 |
| Moderately food insecure | 45 |
| Food secure | 8 |
| Mildy food insecure | 46,5 |

## 4. Conclusion

The agricultural sector benefits from IoT-inspired network analysis for monitoring and managing food production. Connected sensors and devices improve data collection at every stage of food manufacturing, guaranteeing product integrity and safety. Data visualization equips farmers with insightful knowledge that facilitates decision-making and resource management. Farmers can benefit from better agricultural practices and better resource management to data visualization technology that helps them make educated choices. A dedication to ecologically responsible farming is shown by the use of sustainable methods like Integrated Pest Management notwithstanding inequalities in crop yields and difficulties in the agricultural industry. Despite progress, ensuring that everyone has access to sufficient and healthy food remains a top priority that must be addressed immediately. To help farmers and other stakeholders better understand agricultural data and make educated decisions, it is important to create and integrate cutting-edge data visualization technologies.

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