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The Internet of Things for Smart Farming: Measuring Productivity and Effectiveness †

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Abstract: The Internet of Things (IoT) has been developed using the current Internet architecture. The IoT concept aims to increase productivity, accuracy, and financial gains. The purpose of this study is to evaluate how well the agricultural sector is using the Internet of Things (IoT). In this study, descriptive analysis approaches are used with qualitative methods. Reviews of the literature from numerous credible national and international periodicals are used in the data collection process. This study found that it is now possible to remotely monitor agricultural development, soil moisture, and crop risk thanks to the growth of the Internet of Things and the digital transformation of rural areas. The efficiency of agriculture and farming processes can be increased by automating human intervention, especially when using the Internet of Things.

Keywords: Internet of Things; effectiveness; agricultural sector

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1. Introduction

The system of interconnected computers, people with unique IDs, and other objects with the ability to interact over an Internet lacking human touch is called the Internet of Things (IoT). The Internet of Things (IoT) aims to integrate the physical and digital worlds through communication and data exchange over the Internet, which includes linked sectors, smart towns, smart houses, and smart energy. Therefore, energy-linked autos, smart farming, linked architecture and buildings, hospitals, and transport are a few instances of places where IoT can be used [1]. In the current world, technological breakthroughs have altered nearly every industry, but especially agriculture. Similar to this, sensors, Internet of Things (IoT) advancements, and smart agriculture [2] are used by the more risk-averse agriculture industry [3]. It is profitable, improves the ecology of the land, protects water supplies, slows down the decomposition of the soil, and ensures a healthy and diverse habitat [4]. Also, all fields of agriculture have distinct critical characteristics to be individually assessed with respect to quantity and quality with regard to a certain crop, such as the type of soil, drainage flow, accessibility of nutrients, and insect susceptibility. Farming optimization in the same location requires geographic variations, rotating crops, and a yearly growth development period [5]. In accordance with estimators made by the United Nations, the global population will exceed 9.8 billion people by 2050 and 11.2 billion people after 70 to 80 years [6]. The projected 2-billion-person increase in the global population is also anticipated to have experienced most of the consequences of population expansion [7]. Among the more significant industries in the economy is agriculture, which also contributes significantly to a nation's financial development. In order to meet demand, the Food and Agriculture Organization (FAO) of the United Nations thinks that world food output must increase by 70% by 2050 [8].

Smart farming, sometimes referred to as smart agriculture, is a farming technique that employs sustainable techniques to fulfill the rising food demands of the population while avoiding adverse impacts. The whole world has accepted it and is behind it. This strategy's primary concept is to reduce costs across the board for all operations related to the agriculture sector while efficiently utilizing the resources available for sustainable production [9]. For the rise in production to occur, cultivation techniques must be improved, and various technologies must be adaptable to deliver vital information about the agricultural fields so that necessary measures may be taken. Smart farming or precision farming is the use of cutting-edge technologies in the fields to achieve an optimum irrigation operation [10,11]. Sowing through crop harvest, storage, and transportation all involve the use of sophisticated machinery and tools in modern agriculture. The system is intelligent and cost-effective due to its accurate tracking capacity and timely analysis utilizing a range of sensors. There are now automated drones, cultivators, tractors, satellites, and robots besides conventional agricultural technology. Sensors may begin collecting data right away after installation, which is then available for online analysis right away. Accurate data gathering at each place is made possible by electronic sensors, allowing site- and crop-specific farming [12]. The agricultural crop production industry has access to effective solutions to support farmers and researchers thanks to the Internet of Things. Additionally, it facilitates decision-making by providing numerous easily accessible data sources on soil [13], water [14], pesticides [15], fertilizers [16], and manures [17]. Precision farming has the potential to further mitigate the consequences of global warming by addressing runoff problems, pollutants, and the use of fewer pesticides and fertilizers on agricultural products [18,19].

The Internet of Things may be utilized to control agricultural sensors and connect them to cloud infrastructure, for example, to enable the deployment of precision agriculture [20]. Some of the farming uses for IoT include managing farms, animal monitoring, water control, greenhouse control, drones, and automated farm machinery. All of these contribute to agrarian automation. They will also need more assistance to ensure the longevity of the farmed food sector. To meet these demands, agricultural output forecasts, crop protection, and land assessment are crucial for global food production [21].

2. Materials and Method

The architecture of our suggested IoT-based smart farming monitoring system (SFMS) for crop farming is covered in this section. The Internet of Things, cloud computing power, and the advancement of mobile and communication technologies may lead to the creation of low-cost smart agricultural applications and solutions. The design of our suggested SFMS system comprises sensors that collect data regarding air humidity, light intensity, and temperature. Through a gateway, the unprocessed data are sent to a cloud platform so they may be analyzed. After that, the farmer receives notification via email, short messaging service (SMS), or mobile app to take any necessary precautions. The three levels of generic architecture of the Internet of Things are the layers of perception, network, and application, as illustrated in Figure 1 [22]. At the perception layer, often referred to as the "sensing layer", events in the actual world are acquired via a variety of sensors, etc. The network layer uses gateways, routing and switching functions, Wi-Fi and Bluetooth, and other technologies to route data across the Internet. The application layer communicates with the user directly. Using the services that they have identified, each of these tiers carries out certain duties and activities [23].

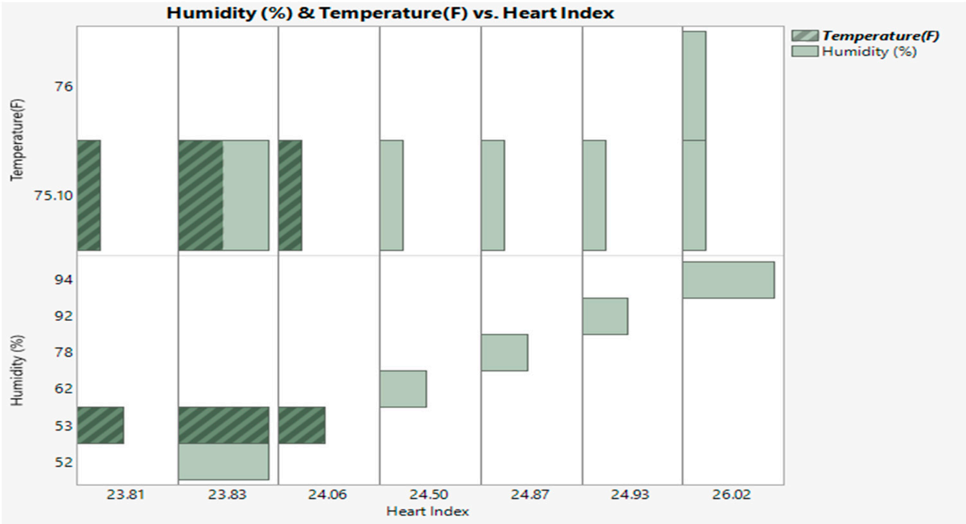

Figure 1. Temperature and humidity by Heart Index.

Traditional farming uses very little, if any, technology and is solely dependent on the expertise of the farmers. Information on environmental factors and their influence on crop growth, health, and productivity is lacking, as are data analysis and prediction systems. Our goal is to close the technology gap and use contemporary technical solutions for improved crop production and cultivation, as well as for the mitigation of crop-related issues. IoT-based farming has the potential to overcome the drawbacks of traditional farming. IoT-based solutions have the potential to improve crop quantity and quality, increase productivity, and manage diseases.

Figure 2 describes the three layers of internet of things for improvement in agriculture production.The whole process is interlinked with each other factors affecting the production. The application layer in which report of things, application and monitoring of things have been done. Then these things go through the process of internet of things [22].

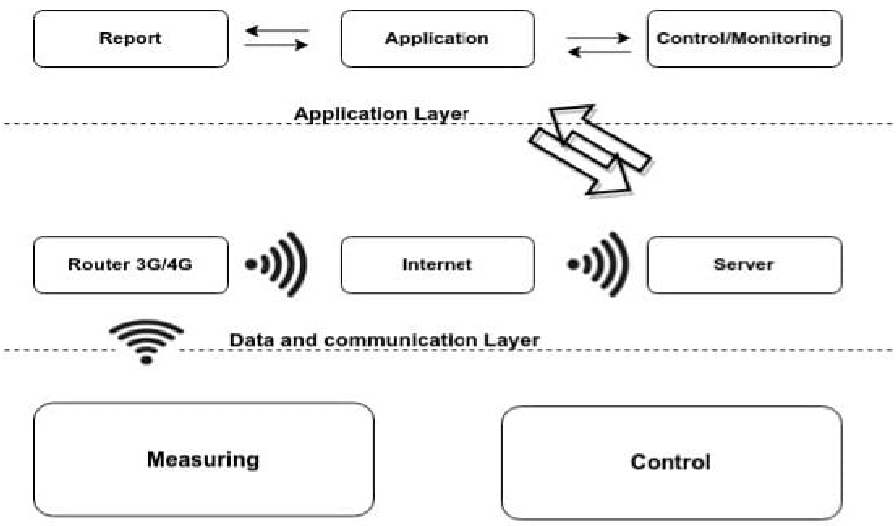

Figure 2. Three layers of Internet of Things [22].

3. Results

Adopting innovative techniques based on sensor and IoT technology increased crop output more than using traditional agricultural practices. The improvement of produce quality and output is greatly helped by the regulated use of novel, cutting-edge sensor-based technologies. One of the first smart farming techniques, the cultivation of plants in a regulated setting, became popular in the nineteenth century. In nations that experienced extreme weather, these practices intensified over the 20th century. Indoor agriculture produces crops that are less impacted by the environment. As a consequence, crops that were previously produced under ideal conditions are now cultivated anytime, anyplace, thanks to the usage of sensors and communication tools. Crop production under regulated conditions depends on a number of variables, including shed constructions and wind-effect-controlling materials, aeration systems, the precision of monitoring parameters, decision-support systems, etc. The exact monitoring of environmental factors is one of the biggest obstacles in greenhouses; as a result, it takes a number of measuring units to forecast the many parameters needed to regulate and maintain the regional weather. Sensors are utilized in a greenhouse powered by IoT to detect and keep track of interior characteristics, including humidity, temperature, light, and pressure. In addition to shielding plants from hail, winds, UV radiation, and bug and pest assaults, the smart greenhouse has assisted farmers in automating field labor without manual inspection. Utilizing lighting, temperature, and air humidity sensors, hibiscus plants are cultivated with the necessary wavelength at night. Research has found that the need for water was reduced by 70–79%, and the IoT makes it feasible for farmers to communicate directly with consumers to increase farming efficiency and profitability. For researchers and designers, creating viable precision farming systems for smallholder farmers still poses testing and design challenges. The use of GPS and position information to direct machinery to specified locations within the farm, increasing agricultural production in comparison to human-driven equipment, is another advantage of data analytics in smart agriculture. Time, gasoline, and operating costs will all be saved as a result of this.

Table 1 shows the diiferent tools, their role in agricultural application and the advantages these tools and their application for improvement of smart farming. The functions and monitoring of these tools with specific output is also described in the table.

Table 1. IoT use in agricultural improvement.

Using IoT	Agriculture Applications	Advantages of Agriculture
Wireless Sensor Network (WSNs)	Combining sensors to track a range of physical characteristics.	Sensor's data can be easily managed and collected.
Cloud Computing	Availability of an on-demand computer resource pool as well as personal computers and other devices.	Making the maps of agriculture field.
Massive Data Analysis	Various type of data is accessible.	Get about market behavior and customer desires.
Embedded system	The system works efficiently on various processes and controlled over them.	Production cost can be reduced and profit can be increased.
Communication protocols	Data sharing made possible through these network.	Simple management of massive data.

Table 2 below displays digital values associated with the graphical outputs of all sensors. The Internet server hosted by Ubidots is utilized to facilitate the execution and oversight of several experimental data grabs. As previously stated, sensor data are saved on a cloud server and updated every five seconds. The table below displays only 11 random experimental values. To demonstrate the operation of the suggested system in various environmental settings, these values are included as an example.

Table 2. Sensor-based assessment and tracking benefits of intelligent agriculture.

Sr. No	Temperature (F)	Humidity (%)	Heart Index	Flame Detection	Soil (%)	Pres (Hg)
1	75.10	52	23.83	Peace	85	35.81
2	75.10	53	23.81	Peace	85	32
3	75.10	53	23.83	Peace	85	35.81
4	75.10	52	23.83	Peace	85	34.6
5	75.10	53	23.83	Peace	85	39.8
6	75.10	53	24.06	Peace	85	31
7	75.10	62	24.50	Peace	76	35.81
8	75.10	78	24.87	Fire-367	72	33
9	75.10	92	24.93	Fire-382	72	35.81
10	75.10	94	26.02	Fire-377	82	35.40
11	76	94	26.02	Fire-372	76	35.81

Industrial agricultural farming techniques degrade soil quality more quickly than nature can rebuild it. Arable land has decreased due to the alarming pace of erosion and agricultural use of fresh water, adding to the strain on existing water troughs. With vertical farming (VF), it is possible to maintain the plants in a highly controlled environment, considerably lessening the use of resources while simultaneously boosting output at various periods; based on the number of stacks, just a percentage of the ground surface is required. When compared to conventional farming, VF is also quite good at raising yields and decreasing the usage of water. The goal of IoT-based phenotyping is to assess the crop and associated traits and provide resources for crop breeding and digital agriculture. The links between genotypes, phenotypes, and their growth conditions are determined by the trait analysis methods and modeling tools.

4. Discussion

Lately, the IoT has had a significant impact on the agriculture business, with a wide variety of sensors being used for various smart agricultural aims. IoT applications are linking a growing number of networked devices, including various sensors, drivers, and intelligent objects, to mobile devices over the Internet on an annual basis. As a consequence of the extensive use of wireless remote data collecting, IoT services include information exchange and smart controlling and solutions for making decisions. These skills may support the smart agriculture sector by facilitating productive output. Developing modernized farming while researching an IoT area of interest in the agricultural sector is the conventional approach to agriculture. IoT growth has greatly benefited all industries over the past 10 years [24]. IoT has a tendency to be a vital technology in integrating different approaches to offer clever remedies for all of the recognized issues. It facilitates easy communication between people and things. IoT has helped to solve issues in many other industries, but it is especially important in the agriculture sector [25]. By installing connected sensors across the farm, which provide immediate data, farmers can make decisions and execute actions to boost crop yields. Information on cultivation and wireless sensor networks (WSNs) with GPS capabilities are constantly updating topographic information. Recent advancements in computerized visuals and data processing have expanded WSN capabilities and made it possible to evaluate crop quality and health precisely.

5. Conclusions

The development of IoT technology in recent years has largely helped the farming sector, especially because of its connecting infrastructure. This includes the cloud-based advanced analysis and decision-making process, the network of remote data collection, smart objects, the use of vehicles and sensors accessible through mobile devices and the Internet, and the automation of agricultural processes. Farmers will obtain insight into how to conduct precise and useful agriculture to resolve field concerns through the use of remote sensors, such as those for temperature, humidity, soil moisture, water level sensors, and pH values. By developing efficient tactics, this development can enable agricultural management systems to manage farm data in an organized manner and expand the agribusiness.

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