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The Development of a Smart Farming System: An Internet of Things Approach

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Abstract:- The integration of internet of things in agriculture has paved way for smart farming solutions thereby enhancing productivity and efficiency. This paper aimed at developing a smart system consisting of two (2) modules namely: The Agro-AI module, a Chabot that allows the farmers to inquire, and the Get–Started module, which is a registration portal for training farmers. In addition, the inclusion of a soil detector that can assess the soil PH, moisture and fertility, all of which play a significant role in giving real-time information about the soil conditions to boost farmers' productivity. The system was built using the following techniques: Javascript, HTML, PHP, and CSS for the front end and MySQL for the back end. The implementation of the Sf-IoT system will help improve farmers' productivity and assist farmers in making decisions regarding soil management leading to improved crop quality, yield, and harvest.

***Keywords**:- Smart Farming; Internet of Things; Agro-AI Chatbot; Soil Detector.*

I. INTRODUCTION

Agriculture is critical to the economic development of a country; it is the science and practice of cultivating soil, growing of crops and raising animals for food, and other products. Agriculture encompasses wide range of activities including crop production, animal husbandry, and agro-forestry that play a crucial role in providing food and supporting rural livelihoods. Methods and technologies used in agriculture have evolved significantly over time, driven by advances in science, engineering, and environmental perspectives [6].

Farming refers to the deliberate cultivation of crops and the raising of livestock for human use. It involves a variety of activities, from planting crops to managing animal husbandry and ensuring the overall productivity and sustainability of the land.

Reference [1] reported that farming practices generates nearly 58% of a country's primary income. In the past, farmers use traditional methods of farming that are imprecise leading to difficulties being faced due to lack of education (training) on various crops or grains, and soil fertility status. All these issues lead to low productivity and insufficient food in the nation. The integration of technologies such as sensors and artificial intelligence to collect real-time data on the crop and the soil status is termed Smart Farming which is usually employed to reduce manual labor and increase productivity. However, artificial intelligence (AI) is a subfield of Computer Science that focuses on the development of system that can carry out activities that require human intellect. Application of artificial intelligence to agriculture can optimize the crop production and monitor the soil condition. Smart Farming (precision agriculture) is an approach that utilizes technology for optimizing agricultural operations for sustainability and efficiency through data driven decision making. This research work aimed at developing a smart system with an internet of things (IoT) enabled device to assist farmers with information, tools to enhance agricultural practices for farmers' registration, interaction, and training with the integration of a smart device (soil detector) to check for soil PH, moisture level and fertility status in Oyo State.

II. EMPIRICAL REVIEW

The development of agriculture enabled humans to cultivate their food, leading to increased food security and the establishment of permanent settlements [17]. The modern era of farming has been characterized by rapid technological advancements and mechanization, sustainable farming practices, organic farming methods, precision agriculture and the integration of data analytics to optimize production and resource utilization to make data-driven decisions [9]. Precision farming (smart farming) is a practice that allows the farming process to raise live stocks and grow crops using IOTs to enhance agricultural practices [19].

Fig. 1 represents the use of IoT in Precision (Smart) farming.

Fig 1: Use of IoT in Precision (Smart) Farming (Ayaz et al., 2019)

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Convergence of the artificial intelligence and the internet of things led to development of increasingly sophisticated and autonomous systems [18] it will enhance smart farming by addressing food insecurity challenges, reducing negative effects on the environment and enhance agricultural sustainability [10]. The introduction of the internet of things revolutionized smart farming by enabling real-time monitoring of farm operations and automated decision-making processes [8] and also helped improve crop yield and optimize resource utilization by monitoring the soil moisture, soil temperature, and crop growth. The use of Global Positioning System (GPS) in smart farming allows farmer to precisely track their equipment and optimize planting, irrigation, and harvesting processes.

With advancement in technology, sensors, drones, and satellite imagery were integrated into farming practices to collate data of crops, monitor soil moisture level and weather patterns [2]. Smart agriculture system supports various agricultural applications and services that facilitate wireless communication for end-to end information sharing made possible by ICT and wireless sensor networks.

An IoT smart farming conceptual framework is illustrated in Fig. 2

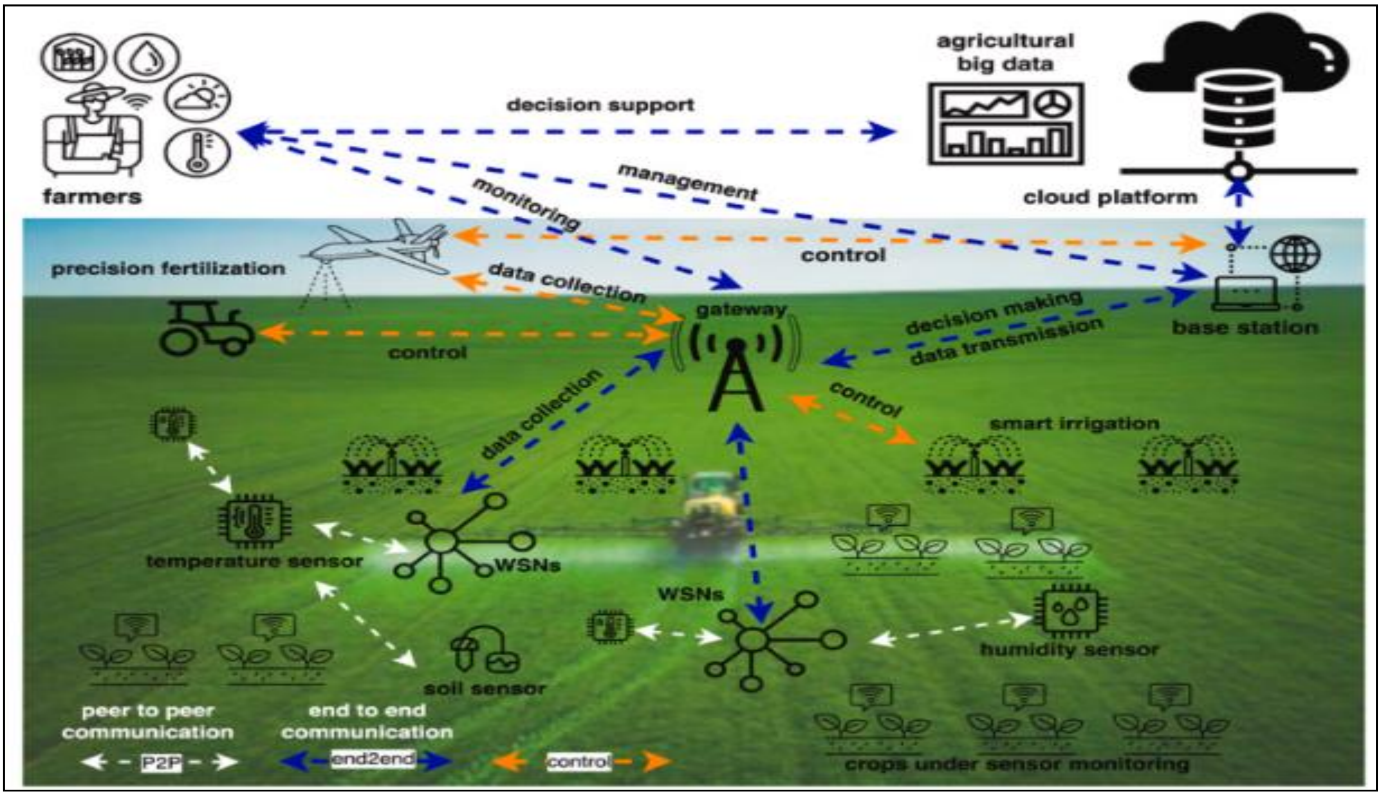

Fig 2: An IoT Smart Farming System Conceptual Framework (Dongyang, et al., 2024)

A. *Related Works*

Smart farming is a better approach to farm management in modern agriculture to improve crop production, reducing the cost of agricultural inputs and sustaining product quality of farm produce. Reference [13] presented a framework that monitors crop production using the smart devices and big data analytics to reduce agricultural wastage.

Reference [16] presented an internet-based solution for smart farming with the use of machine learning algorithm to accurately predict adequate water, optimize irrigation practices, and precisely predicts plant diseases. [15] applied a smart Agro-IoT tool that monitors the climate change, water management and soil management, to promote economic growth and boost productivity. Reference [3] developed an internet of things based farming monitoring system to collect relevant data on crop inspection, climate observation, water management, and land management.

Reference [11] reported an internet of things based advanced solution for monitoring the soil and atmospheric condition for efficient crop growth. The integration of internet of things into farming practices has provided solutions to increase the demand for food production. Reference [12] developed an internet of things based smart farming system using sensor to enhance crop production. Reference [4] explored the impacts of internet of things, artificial intelligence and data analytics on precision agriculture to ensure resource efficiency, sustainability, and cost reduction. Reference [14] integrated the use of IoT and cloud technology to monitor the soil temperature and humidity with a smart device via sensor readings which were later processed in the cloud.

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III. DESIGN METHODOLOGY

The design process involved the creation of several models, including the Use Case Diagram and Data Flow Diagram, using HTML (Hypertext Markup Language) tools for web development. For the design phase of the Smart Farming website, the input design focused on defining the data required for farmers' registration, and soil sensor inputs. A user-friendly interface was developed to allow input of data and commands. Also, HTML forms were utilized to create intuitive input fields for farmers to submit their queries, registration details, and sensor readings. The choice of HTML forms was based on their versatility and compatibility with web-based applications for easy integration with the Smart Farming website. Java Script was employed as a programming tool of the input design phase which provides real-time validation and feedback to users. The output reported the responses of farmer queries, registration confirmation, and visual representations of soil sensor data. HTML and Cascading Styling Sheet (CSS) were employed to structure and style the output elements of the website. HTML was to construct the content and layout of the output pages, ensuring the proper organization and display of information, while CSS was used to enhance the visual look and user experience by applying styles to the web page.

The integration of responsive design principles allowed for the optimization of the output across various devices, ensuring that farmers can access the information and visualizations seamlessly on different screen sizes. This system integrates Agro-AI Chabot to automate farmer interactions, a Get-Started section for farmer registration, and a cutting-edge soil detector device to generate soil properties. The Agro-AI module is an innovative feature that allows farmers to seek expert advice and guidance regarding various aspects of agriculture. Through this platform, farmers can ask questions related to crop management, pest control, irrigation techniques, and other relevant topics. The Get-Started section serves as a gateway for farmers to access the resources and courses available on the smart farming website. Here, farmers are required to register and create a profile before gaining access to the farmer class. Registration allows the system to personalize the user experience and tailor the content based on the farmer's preferences, agricultural practices, and geographical location. By capturing essential data during the registration process, the system can provide relevant learning materials, updates, and notifications to the farmers, thereby fostering a more engaging and targeted educational experience.

The farmer class is an essential component of the Sf-IoT System, offering a structured platform for agricultural learning and skill development. Through this virtual classroom environment, farmers can access educational resources, video tutorials, live webinars, and interactive modules covering diverse agricultural topics. The soil detector represents an integral part of the Sf-IoT System, providing farmers with actionable insights into soil quality and composition. This advanced sensor-based technology is capable of measuring critical parameters such as pH levels, moisture content, and soil fertility. By integrating the soil detector with the smart farming website, farmers can easily monitor their soil conditions. The data collected were processed to enable farmers make informed decisions regarding crop selection. This real-time feedback mechanism empowers farmers to adopt precision farming practices and optimize their resource utilization.

Combining the Agro-AI, Get-Started, Farmer Class, and Soil Detector device, the developed Sf-IoT System as depicted in Fig. 3, represents a holistic approach to modernizing and enhancing agricultural practices by leveraging IoT and smart web-based solutions.

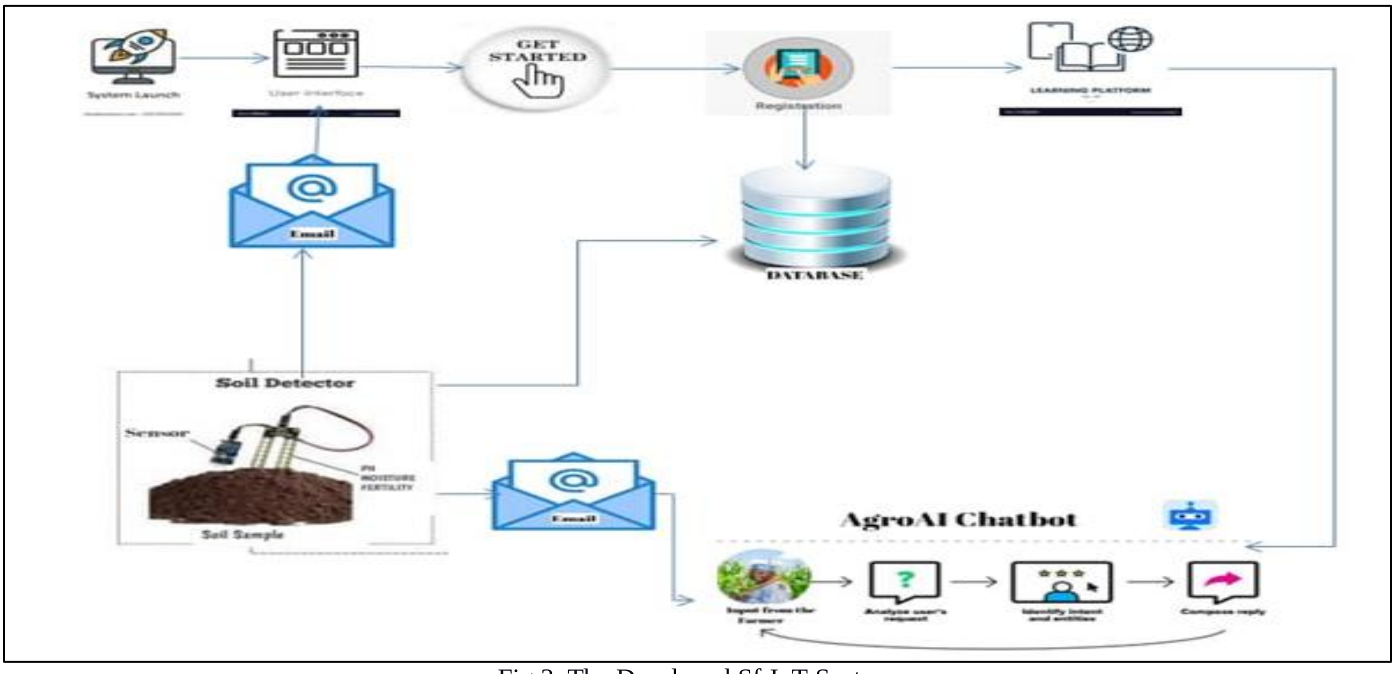

Fig 3: The Developed Sf-IoT System

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IV. IMPLEMENTATION

Implementation approach to this system entails program interfaces. Fig. 4 depicts the homepage where farmers can access all the features of the webpage. Also, Fig. 5 and Fig. 6 show the Agro-AI Chatbot section and the registration page. These interfaces designed for farmers to learn about agriculture and register for classes that will train them about farming practices.

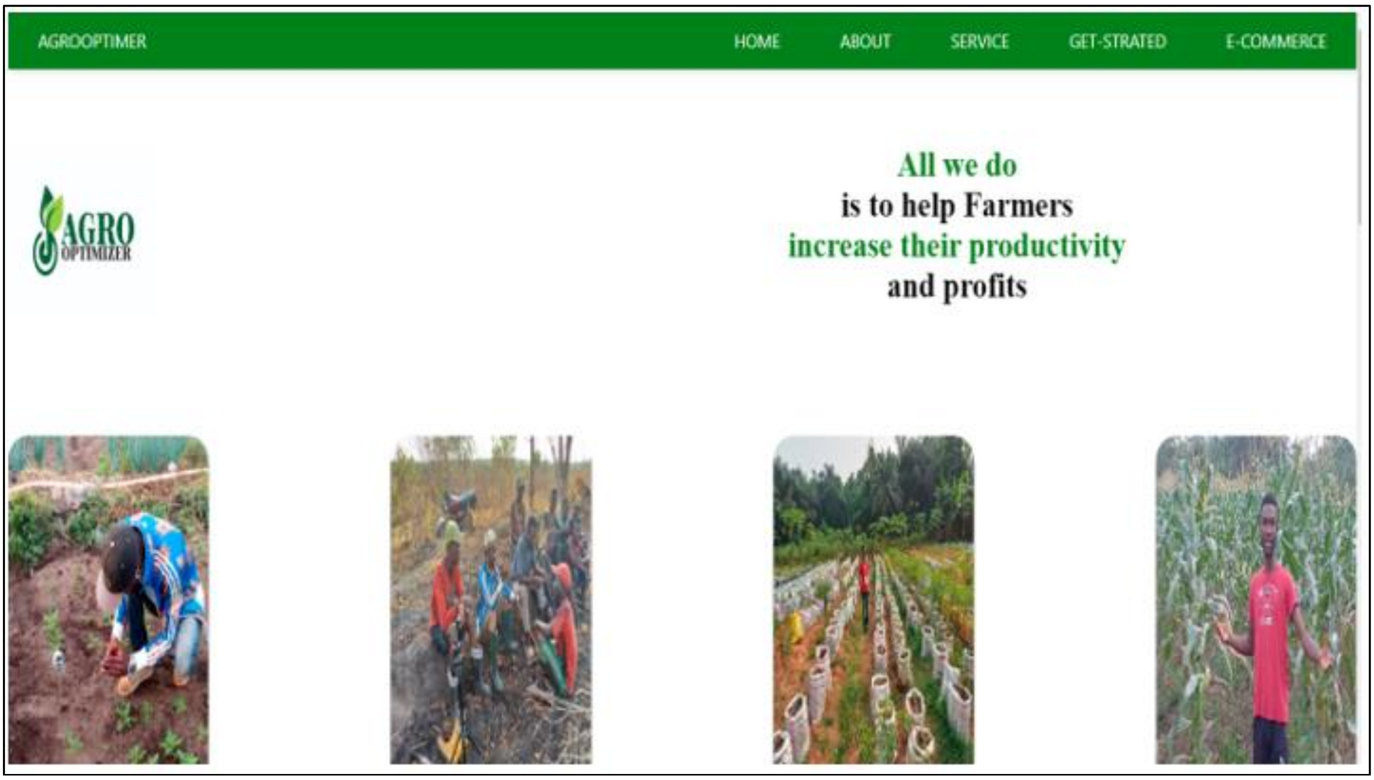

Fig 4: Farmers' Homepage

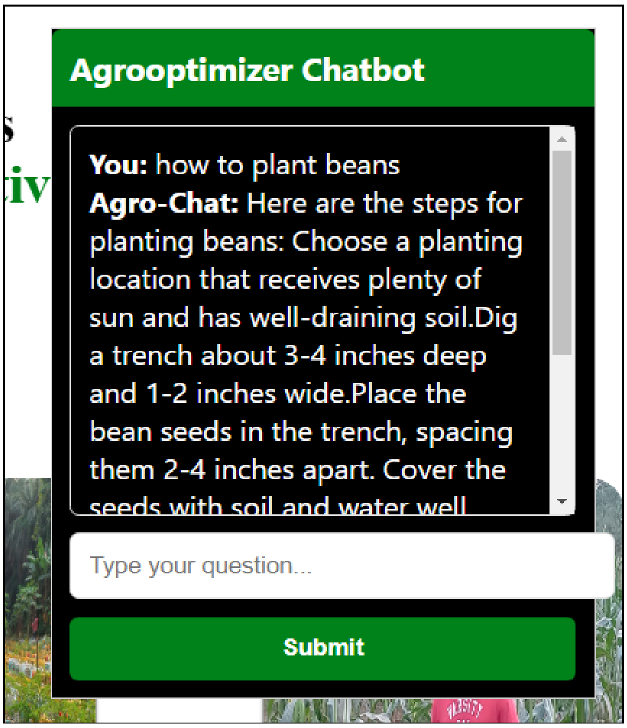

Fig. 5: Agro-AI Chatbot Section

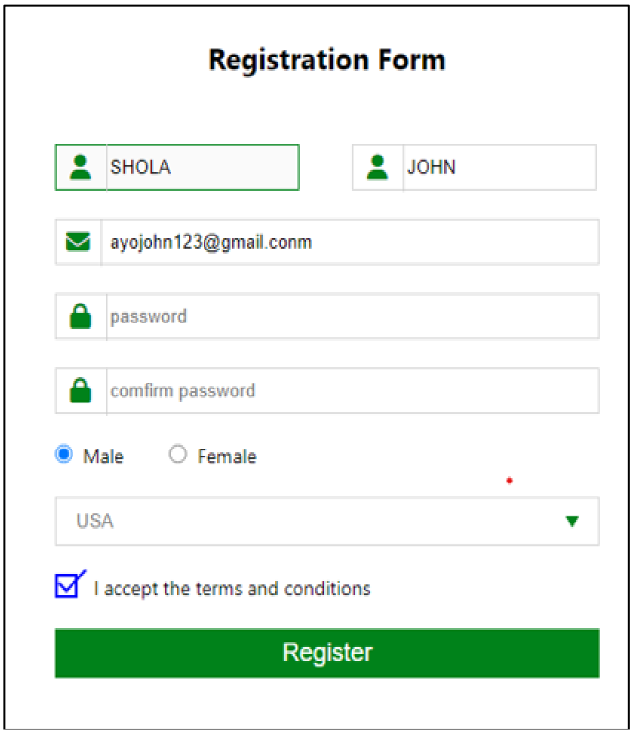

Fig 6: Farmer Registration Page

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Finally, output page in Table 1 display the soil preparation guide. The interface provides information such as soil pH, Moisture levels, and Fertility. The Good Soil pH level falls within the range of 6 to 7.5, while the bad soil pH levels are between 3 to 5.5 or 7.6 to 10. In terms of Fertility levels, Good Soil should display Normal levels between (3-6), and Poor Soil Fertility ranges between (7-10). However, these levels are typically categorized as either Normal or Low Fertility Reading. The output dataset of the soil parameters based on PH, Moisture, and fertility was indicated using Table 2 and also depicted using a chart view in Fig. 7

Table 1: Soil Preparation Guide for all Farmers

	GOOD SOIL	BAD SOIL
PH	6-7.5	3-5.5 or 7.6-10
MOISTURE	4.5	1-3 or 7-10
FETILITY	IDEAL	LITTLE OR MUCH

Table 2: Soil Preparation Guide of Farmers at Oyo State

1	S/N	Farmer's Names	Moisture	pH	Fertility
2	1	Stephen Popoola	5	7	Normal
3	2	Badmus Babatunde	6	7.5	Normal
4	3	Arinze Oramah	6	6	Low
5	4	Ndukwe Kenneth	7	6.5	Low
6	5	Akponnwovwon Victor	6	7	Low
7	6	Nzekwe David	8	6	Normal
8	7	Ukpe John Kufre	7	7.8	Low
9	8	Ani solomon Ike	6	6.5	Normal
10	9	Ishwu Ogechukwu Samson	5	6.8	Normal
11	10	Dauda baba Ibrahim	6	7.8	Normal
12	11	Pam Joseph	5	7.5	Normal
13	12	Amadi Prisca	4	7	Low
14	13	A. Adetunji Williams	6	6	Low
15	14	E. Chris miles	7	6.8	Normal
16	15	Mustapha Kanagie	8	6.5	Normal
17	16	Isyaku Sani Yankatsari	5	6.5	Normal
18	17	Oladimeji Bolanle	6	6.5	Low
19	18	Warda Roman	7	7.8	Low
20	19	Olawale Ajayi	8	7.5	Low
21	20	Aminu Usman Umar	9	7	Low
22	21	Lilian Njoku	4	7	Low
23	22	Chibuike Enebeli	5	7.5	Low
24	23	Ayomide Olanrewaju	5	6.8	Normal
25	24	Adeleke Gbenga Ajani	5	7	Low
26	25	Thomas Simon Attah	6	6.5	Low
27	26	Okolie Ebere	6	7	Normal
28	27	Joshua Adekunle	5	7.8	Normal

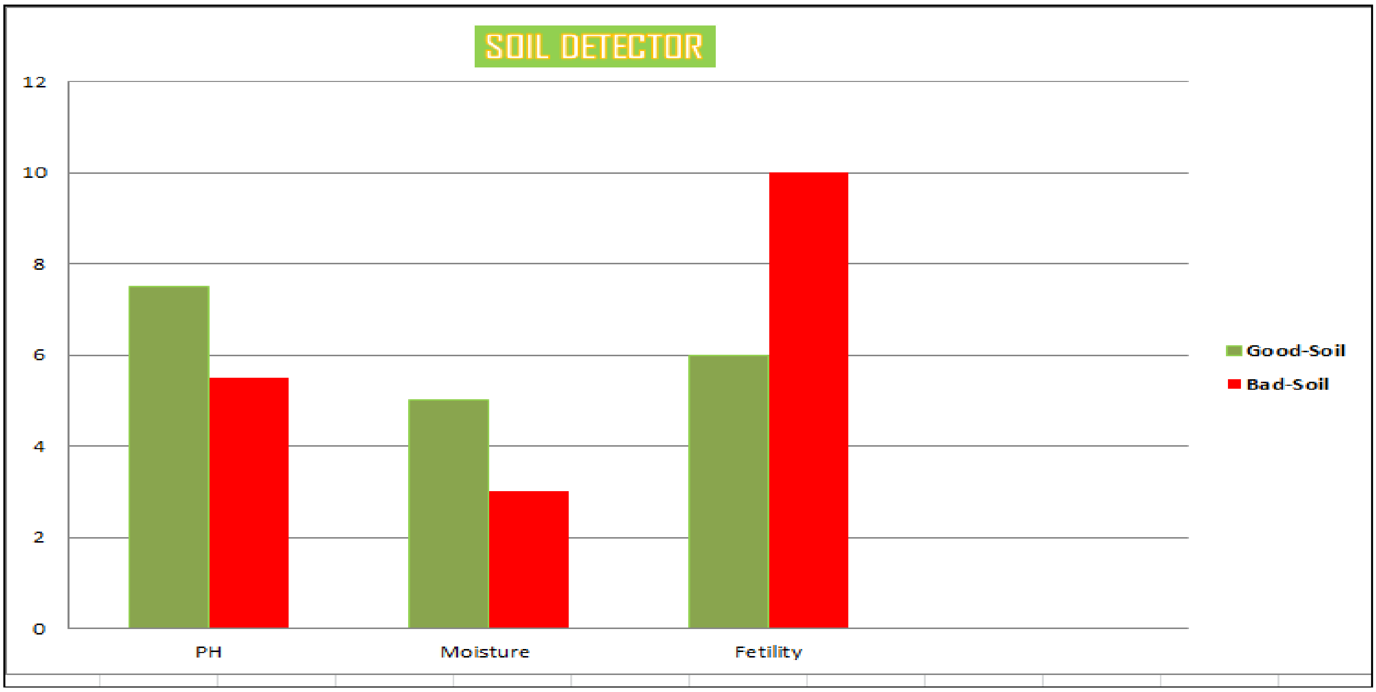

Fig 7: The Chart View of the Soil Conditions

V. CONCLUSION

Due to the growing population of the country, the demand for food production increases, making it essential to embrace innovative technologies such as IoT in agriculture. Smart farming not only benefits individual farmers by providing them with valuable insights and tools for decision-making but also contributes to the larger goal of ensuring food security for the global population. The adoption of IoT technology in smart farming, as demonstrated through the development of the smart website and the Sf-IoT soil detector, represents a critical step towards modernizing and enhancing agricultural practices. This approach has revolutionized the way farming practices is conducted thereby, increases efficiency, sustainability, and overall productivity in the agricultural sector.

REFERENCES

[1]. R. Thirumurthi, A. S Arunachalam and R. Gobinath, “Machine learning in smart agriculture”. Book: Advanced technologies for smart agriculture. pp. 23. eBook: ISBN9781032628745. Published: February 26, 2024. Publisher: Imprint River Publishers. https://doi.org/10.1201/9781032628745

[2]. D. Gómez-Candón and F. López-Granados, “Smart farming technologies for improving crop management. Precision agriculture, vol .20. no.4, pp. 963-997. 2019.

[3]. D. D. Anantha, B. Prasad, K. Sujatha, S. S. Susila and K. Subramanyam, “An efficient mechanism using IoT and wireless communication for smart farming”. Materials Today: Proceedings, vol 80, part 3, 2023, pp. 3691-3696, https://www.sciencedirect.com/science/article/abs/pii/S2214785321052226

[4]. E. Micheni , J. Machii and J. Murumba, "Internet of things, big data analytics, and deep learning for sustainable precision agriculture," in Proceeding IST-Africa Conf. (IST-Africa), pp. 1-12, Aug. 2022. htps://doi.org/10.23919/ISTAFRICA56635.2022.9845510

[5]. H. Dongyang, W. M. Asad, D. R. Sri, U. R. Anis , and A. Ismail. “Mapping smart farming: Addressing agricultural challenges in data-driven era. Renewable and Sustainable Energy Reviews. Vol. 189. Part A, January 2024, 113858. Https://doi.org/10.1016/j.rser.2023.113858

[6]. K. Nawab, L. R. Ram , R. Ghulam, I. Sargani, I. Muhammad, K. Muhammad and I. Sohaib, “Current progress and future prospects of agriculture technology: Gateway to sustainable agriculture. Sustainability, vol 13 (9), Pp4883; https://doi.org/10.3390/su13094883. Published: 27 April 2021M.

[7]. M. Ayaz, M. Ammad-Uddin , Z. Sharif , A. Mansour . and E. Aggoune, "Internet-of-Things (IoT)-based smart agriculture: toward making the Fields talk," ieeexplore.ieee.org IEEE Access, vol. 7, pp. 129551-129583, 2019 https://doi.org/10.1109/ACCESS.2019.2932609

[8]. M. Dhanaraju, P. Chenniappan, K. Ramalingam, S. Pazhanivelan, and R. “Kaliaperumal, Smart farming: Internet of Things (IoT)-based sustainable agriculture”, *Agriculture* 2022, *12*(10), 1745; https://doi.org/10.3390/agriculture12101745. Published: 21 October 2022.

[9]. M. Javaid , H. A. Abid, S. R. Pratap and R. Suman . “Enhancing smart farming through the applications of agriculture 4.0 technologies. International Journal of Intelligent Networks. vol. 3, pp 150-164. 2022 https://doi.org/10.1016/j.ijin.2022.09.004

[10]. M. K. Songol, F. M. Awuor and B. Maake, "Adoption of artificial intelligence in agriculture in the developing nations": A Review. Journal of Language, Technology & Entrepreneurship in Africa (JOLTE) vol. 12 No. 2. 2021
[11]. M. S. D. Abhiram, K. Jyothsnavi and M. N. Alivelu. "Smart farming system using IoT for efficient crop growth", IEEE International Students' Conference on Electrical,Electronics and Computer Science (SCEECS). 2020 https://doi.org/10.1109/SCEECS48394.2020.147
[12]. N. Jadhav, B. Rajnivas, V. Subapriya, S. Sivaramakrishnan , S. Sremalatha and P. Poongodi. "Enhancing crop growth efficiency through IoT-enabled smart farming system. Article: EAI Endorsed Transactions on Internet of Things. vol 10, 2024.
[13]. P. Khongdet, K. Thanwamas and S. Mohammad. "Applicability of Internet of Things in Smart Farming. Article ID 7692922. Artificial Intelligence in food quality improvement 2022. https://doi.org/10.1155/2022/7692922
[14]. P. Neha and D. K. Vaishali, "Iot-based smart farming system. International Journal of Advanced Research, Ideas and Innovations in Technology (IJARIIT). vol 7, Issue 1. 2021 Pp. 353-358.
[15]. S. Alo, R. Rahul and R. D. Satya ." Smart Farming Using Machine Learning and IoT", Agricultural Informatics: Automation Using the IoT and Machine Learning. vol iv March 8, 2021 pp. 13-34. https://doi.org/10.1002/9781119769231.ch2
[16]. S. Mathi , R. Akshaya, and K. Sreejith, "An internet of things-based efficient solution for smart farming. Procedia Computer Science volume 218, P. 2806-2819. 2023 Https://doi.org/10.1016/j.procs.2023.01.252
[17]. S. Tahira, S. Sana and H. Sarfraz, "Agricultural revolutions and food security. Institute of agricultural and resource economics, University of Agriculture, Pakistan. Chapter 5: Food Security in the Developing World. Publisher: John Wiley & Sons Ltd. 2024.
[18]. T. H. Davenport, and R. Ronanki, ." Artificial intelligence for the real world", in Harvard Business Review, vol 96 (1), pp. 108-116. European Commission. (2021). Farm to Fork Strategy. Retrieved from https://ec.europa.eu/food/farm2fork_en
[19]. Dankan , M. Sandeep, M. Ramesha, M. Jayashree and S. Ansuman., "Smart agriculture and smart farming using Iot technology". Journal of Physics: Conference Series 2089 2021 012038 IOP Publishing. https://doi.org/10.1088/1742-6596/2089/1/012038