Journal of Information Systems Engineering and Management
2025, 10(23s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Comparative Study of Organic Farming using IoT and Machine Learning Techniques

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ARTICLE INFO

Received: 18 Dec 2024

Revised: 08 Feb 2025

Accepted: 21 Feb 2025

ABSTRACT

Agriculture is a fundamental industry that supports economic growth and sustains human life. However, the excessive use of chemical pesticides and fertilizers has led to severe health and environmental concerns, necessitating a shift toward organic farming. The integration of the Internet of Things (IoT) in agriculture has emerged as a transformative approach to enhance productivity, quality, and sustainability. IoT-based smart farming allows farmers to monitor real-time environmental parameters such as soil moisture and temperature at a minimal cost, enabling efficient decision-making and resource optimization. This research focuses on developing an IoT-based organic farming system that automates irrigation, recommends optimal vermicompost application, and ensures better crop growth through real-time data analysis. IoT comprises interconnected devices with sensors, cloud computing, and analytics that assist farmers in reducing manual labour while improving efficiency. The study highlights how IoT enhances agricultural practices by providing insights into soil fertility, water management, and environmental conditions, fostering a sustainable and eco-friendly farming ecosystem. By leveraging IoT, modern farming can mitigate the adverse effects of chemical usage while ensuring long-term agricultural sustainability.

Keywords: Generalized Intuitionistic Trapezoidal Fuzzy Numbers, Transportation Problems, Optimization, Linear Programming, fuzzy ranking

1. INTRODUCTION

Agriculture is the base for all the other industries and plays an important role in the economy of any country. Biocides are used in the form of pesticides to kill insects and other pests that destroy crops. However, they can also have harmful effects on humans and animals who eat food that has been treated with them. This may result in health problems such as cancer or polluted environment because they can be washed into rivers or lakes by rainwater. Organic farming is a type of agriculture in which no chemical and pesticide is used to grow the crops. Recently IoT helps in productivity, quality, cleanliness, efficiency and mongering the environmental conditions.

The objectives of this research are to proposed IoT device primarily based organic Farming on the way to allow farmers to have live facts of soil moisture and environment temperature at very low fee so that live tracking can be carried out. IoT Smart Farming is a farming management concept using modern technology to increase the quantity and quality of agriculture. It also helps to create sustainable and eco-friendly environment so that the natural cycle will continue in progress.

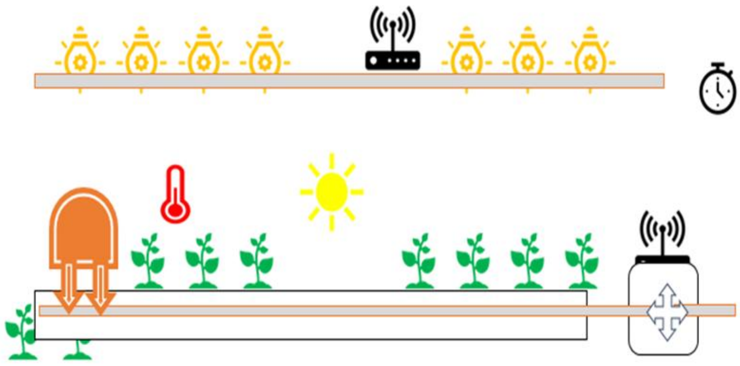

Fig-1: - IoT based smart farming

By using the Internet of Things, we can find out how fertile our land is and for which crop it is suitable. IOT helps us in irrigating the fields as per water requirement. It tells us when to apply vermicompost in the fields and in what quantity. IoT automate the irrigation system for plants as per requirement

IoT is a collection of physical objects having sensors, software and technology enabled connected to the internet. Former can monitor and control their former activities at any location and any time. IoT has a wide range of applications. It is used in smart watches, automatic production in industry, smart vehicles, home security etc.

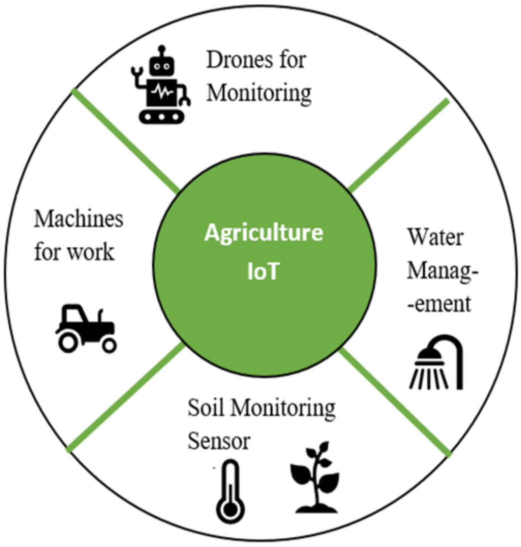

Fig-2 :- Smart farming

The main components of IoT are – physical devices, gateway, cloud, analytics and user interface are interacting with each other to perform specified objectives.

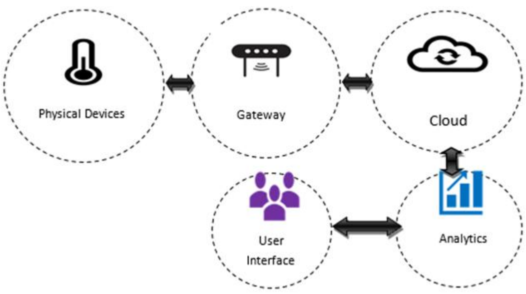

Fig-3 :- IoT components

Various experiments were carried out from time to time to supply food to the increasing population, one of which was the Green Revolution. As a result of the Green Revolution, production increased, but at the same time, the use of chemical pesticides and fertilizers is also increased in the fields. Human health and environment have been adversely affected by use of such water and foods. In the early days, when man practiced organic farming, his average age has to be around 100 years, but in the present times the average age of man has decreased. The main reason for this is the use of excessive amounts of chemical pesticides and fertilizers in farming. Therefore, it is necessary to use organic components in the agriculture with the help of current available technology.

The Internet of Things is used in different fields to improve productivity, performance and efficiency. IoT assists the farmer for reducing manual work. IoT automates the irrigation according to the moisture level of soil. IoT collects various parameters regarding environment conditions. It monitors and controls the crops for better growth in organic way.

2. LITERATURE OVERVIEW

[1] This paper explores the integration of Artificial Intelligence (AI) in organic farming to enhance sustainability and productivity. AI-powered solutions such as predictive analytics, precision farming, and automated pest control help address key challenges like low yields, pest management, and resource intensity. AI-driven technologies, including sensors, drones, and machine learning, optimize resource use, monitor crop health, and improve soil fertility. These advancements lead to higher efficiency, increased productivity, and reduced environmental impact. AI also supports climate resilience by analysing weather patterns and aiding adaptive farming strategies. Additionally, AI enhances economic viability by reducing costs, improving market competitiveness, and minimizing labour efforts. The study concludes that AI integration in organic farming can create a more sustainable, efficient, and food-secure future.

[2] This paper reviews the role of Artificial Intelligence (AI) and the Internet of Things (IoT) in transforming agriculture through automation and smart technologies. It highlights how AI and IoT improve farming processes, from land preparation to harvesting and market distribution. Key applications include smart irrigation, crop monitoring, pest control, and precision farming using sensors, robots, and drones. These technologies help reduce water, pesticide, and fertilizer usage while maintaining soil fertility and increasing productivity. The study also discusses the use of AI in decision-making, yield prediction, and greenhouse farming. Additionally, it introduces a Remote Sensing Assisted Control System (RSCS) to optimize greenhouse agriculture using AI and machine learning. Overall, the paper emphasizes the economic and environmental benefits of AI-driven agriculture, ensuring sustainable food production and resource efficiency.

[3] This paper discusses the use of Artificial Intelligence (AI) and the Internet of Things (IoT) to detect pesticides in organic fruits and vegetables. With the increasing use of chemicals in food production, a low-cost, portable, and efficient biosensing platform is essential to ensure food safety. The study highlights various sensors, including nano-sensors, pH sensors, and gas sensors, to detect pesticide residues. The collected data is processed using a microcontroller and analyzed to determine contamination levels. The system calculates the Normalized Difference Vegetation Index (NDVI) using infrared sensors and provides real-time monitoring via a mobile application. The paper emphasizes the importance of AI and IoT in ensuring food safety, reducing health risks, and enhancing agricultural sustainability.

[4] This paper explores the role of the Internet of Things (IoT) in modernizing agriculture and improving efficiency. IoT enables real-time monitoring of agricultural conditions through sensors that track temperature, soil moisture, water levels, and crop health. The study discusses various IoT-based technologies, including Arduino-controlled automation, smart irrigation systems, and precision farming tools. These advancements help optimize resource use, reduce waste, and enhance crop yields. IoT also supports remote monitoring, enabling farmers to make data-driven decisions. The paper highlights the challenges of IoT adoption, including cost and technical complexities, but emphasizes its potential in sustainable and smart farming practices.

[5] This paper explores the integration of the Internet of Things (IoT) and data analysis in smart farming to optimize agricultural processes. It presents a system using wireless sensor networks (WSN) to monitor soil moisture, temperature, and humidity for efficient crop management. The system consists of three components: hardware with sensors, a web-based application for data analysis, and a mobile application for remote monitoring and control. Data mining techniques, including association rules and regression analysis, are used to predict optimal environmental conditions for crop growth. The study highlights how IoT enhances productivity, reduces water waste, and improves

decision-making in agriculture. The implementation, tested in Thailand, demonstrated improved crop yields and resource efficiency, emphasizing the potential of digital innovations in sustainable farming.

[6] This paper explores the implementation of IoT-based smart agriculture systems to enhance crop yield and resource efficiency. Traditional farming methods rely on manual labor and unpredictable weather conditions, whereas smart farming integrates sensors, automation, and wireless networks to optimize agricultural processes. The study highlights the use of soil moisture sensors, humidity sensors, and temperature sensors connected to an Arduino-based system for real-time monitoring and decision-making. IoT enables remote farm management, automated irrigation, and pest control, reducing water waste and increasing productivity. The paper emphasizes the benefits of smart agriculture in ensuring sustainable farming, minimizing human intervention, and improving overall crop quality.

[7] This paper presents a framework called AgriTech, which integrates the Internet of Things (IoT) and Wireless Sensor Networks (WSN) to automate and optimize agricultural resource management. The system enables real-time monitoring and control of water usage, fertilizers, and insecticides to improve crop productivity. Sensors deployed in fields collect data on soil moisture, temperature, and humidity, which are then analyzed using cloud computing. Farmers can remotely manage their fields through mobile applications, reducing labor and resource waste. The paper highlights the potential of IoT in transforming traditional farming into a more efficient and sustainable practice, addressing key challenges such as water scarcity, pest control, and weather unpredictability.

[8] This paper explores the application of the Internet of Things (IoT) in smart farming to enhance agricultural efficiency and resource management. The proposed system integrates sensors to monitor temperature, humidity, soil moisture, UV index, and infrared radiation. Using an ESP32 microcontroller, real-time data is collected and displayed on a mobile application for farmers to make informed decisions. The system aims to optimize water and fertilizer use, reduce crop wastage, and improve yields. Key benefits include remote monitoring, automated alerts, and resource conservation. The study highlights the affordability and practicality of IoT-based smart farming, making it a viable solution for improving agricultural productivity.

[9] This paper explores the implementation of IoT-based smart farming systems to enhance agricultural productivity and efficiency. It focuses on live monitoring of environmental factors such as temperature, humidity, and soil moisture using sensors and cloud computing. The system, designed for mushroom farming, uses ESP32 microcontrollers and DHT-11 sensors to collect real-time data, which is accessible through a mobile application. The IoT-based setup enables remote monitoring and automation, reducing human effort and optimizing resource usage. The study highlights the benefits of smart farming, including improved crop yield, reduced costs, and efficient water and fertilizer management. Future improvements may include pest control monitoring and GPS integration for precision agriculture.

[10] This paper explores the role of the Internet of Things (IoT) in transforming agriculture by enabling automation, real-time monitoring, and data-driven decision-making. IoT technologies such as sensors, actuators, and cloud computing facilitate crop monitoring, irrigation management, and greenhouse automation. Smart agriculture enhances productivity, reduces resource wastage, and ensures better crop quality through precision farming techniques. The study highlights applications like weather monitoring, pest control, and aerial drones for farm analysis. IoT also aids in reducing pesticide use, improving efficiency, and increasing adaptability to climate changes. The paper concludes that IoT-driven agriculture can revolutionize farming by making it more efficient, sustainable, and data-centric.

[11] This paper explores the application of the Internet of Things (IoT) in modernizing agriculture by integrating smart sensors and automation. The proposed system enhances farming efficiency by using sensors for soil moisture, pH levels, temperature, and nutrient content to provide real-time data for better decision-making. IoT technology is also applied in livestock management and perimeter security. The system utilizes Long Range (LoRa) communication for data transmission, enabling remote farm monitoring. Automated irrigation and fertilizer application optimize resource use, reducing waste and improving crop yields. The study highlights the benefits of IoT in making farming more efficient, data-driven, and sustainable while reducing labor intensity and improving profitability.

[12] This paper discusses the integration of the Internet of Things (IoT) in agriculture to improve efficiency, reduce resource wastage, and enhance productivity. It highlights the role of IoT-based sensors in monitoring soil moisture, temperature, humidity, and fertilizer levels for better decision-making. The system enables remote farm management

using wireless sensor networks (WSN) and cloud computing, allowing real-time data collection and analysis. Automated irrigation and smart warehouse management are also emphasized to optimize water usage and reduce manual labor. The study concludes that IoT can revolutionize agriculture by enabling precision farming, improving crop yields, and addressing environmental challenges such as soil degradation and water scarcity.

[13] This paper explores the role of the Internet of Things (IoT) in transforming traditional farming into smart agriculture by integrating wireless sensors, automation, and data analytics. It highlights how IoT technologies enable real-time monitoring of soil conditions, crop health, irrigation, and pest control. The study discusses the use of drones, robots, and advanced sensing techniques for precision farming, optimizing resource use, and reducing environmental impact. Challenges such as connectivity issues, data security, and high implementation costs are also addressed. The paper emphasizes the potential of IoT in increasing agricultural productivity, improving food quality, and ensuring sustainable farming practices in the face of rising global food demand.

[14] This paper explores the integration of the Internet of Things (IoT) in sustainable organic fertilizer production to promote eco-friendly farming. It highlights the harmful effects of chemical fertilizers on soil health, water pollution, and human health, advocating for organic alternatives. The study presents an IoT-based system that automates the production and distribution of organic fertilizers using cattle waste, wastewater, and green leaves. The system employs sensors and mobile applications for monitoring nutrient levels and automating fertilizer application. Government initiatives supporting organic farming, such as subsidies and policy frameworks, are also discussed. The paper concludes that IoT-driven organic fertilizer production can enhance soil fertility, reduce environmental impact, and contribute to sustainable agriculture.

[15] This paper discusses the role of the Internet of Things (IoT) in modernizing agriculture by integrating sensors, automation, and data analytics. The proposed system consists of hardware and software that analyze soil conditions using sensors like DHT11 for temperature and humidity and soil moisture sensors for irrigation management. The system provides real-time data to farmers via a mobile application, suggesting suitable crops, organic farming methods, and irrigation techniques. It also includes a PIR sensor for detecting animal intrusions to protect crops. The study emphasizes the importance of IoT in improving farming efficiency, reducing resource wastage, and enabling precision agriculture, ultimately leading to higher yields and sustainable farming practices.

[16] This paper reviews the role of the Internet of Things (IoT) in modernizing agriculture by integrating smart sensors, automation, and data analytics. It explores various IoT-based applications, including precision irrigation, soil monitoring, and crop management, to improve efficiency and sustainability. The study highlights the use of MQTT protocols for secure data transmission and cloud-based analytics for real-time decision-making. IoT devices help in reducing resource wastage, optimizing water usage, and enhancing productivity. Challenges such as connectivity issues, high implementation costs, and cybersecurity concerns are also discussed. The paper concludes that IoT has the potential to revolutionize farming by making it more efficient, sustainable, and data-driven.

[17] This paper explores the role of the Internet of Things (IoT) in transforming agriculture through automation, real-time monitoring, and data-driven decision-making. It highlights the use of smart sensors, drones, and GPS tracking to improve irrigation, soil monitoring, and crop management. IoT applications help farmers optimize resources, reduce manual labor, and enhance productivity by integrating cloud computing and machine learning for data analysis. The study also examines challenges such as security risks, high implementation costs, and connectivity issues. The paper concludes that IoT-driven smart farming offers sustainable solutions to improve agricultural efficiency, reduce environmental impact, and meet the growing global food demand.

[18] This paper explores the role of the Internet of Things (IoT) in revolutionizing agriculture through smart farming techniques. It highlights IoT applications such as automated irrigation, soil and weather monitoring, and crop health management using sensors and data analytics. The study also discusses the integration of IoT with cloud computing, big data, and artificial intelligence to optimize farm operations. Security challenges, network architectures, and communication protocols for IoT in agriculture are analyzed, along with smartphone-based applications for farm management. The paper concludes by addressing existing challenges, such as connectivity issues and implementation costs, while emphasizing the potential of IoT in improving agricultural efficiency, sustainability, and productivity.

[19] This paper discusses the application of the Internet of Things (IoT) in agriculture to enhance productivity and efficiency. The proposed system utilizes sensors to monitor soil moisture, pH levels, and water volume, providing real-time updates to farmers. These sensors are connected to an Arduino-UNO module, which processes data and

enables automated irrigation, preventing water overflow and optimizing resource usage. The system also supports remote monitoring, allowing farmers to control irrigation and farm conditions via a mobile interface. The study highlights the benefits of IoT in improving crop yield, reducing manual labor, and making farming more data-driven and sustainable.

[20] This paper explores the integration of the Internet of Things (IoT) and Artificial Intelligence (AI) in modernizing agriculture and improving sustainability. It highlights the use of wireless IoT sensors to monitor key farm parameters such as soil moisture, temperature, and humidity, enabling real-time decision-making. AI-driven analytics assist in optimizing irrigation, climate control, and early disease detection. Experimental results show a 25% reduction in water usage and a 30% increase in crop yields, with a 15% decrease in crop losses due to early disease detection. The study emphasizes the potential of IoT and AI in enhancing resource efficiency, precision farming, and eco-friendly agricultural practices. Future research aims to refine AI models and expand sensor capabilities for broader agricultural applications.

3. COMPARATIVE STUDY BASED ON THE IMPORTANT PARAMETER USED IN THE PAPERS.

Table-1 Comparison for research papers [1],[2],[3],[4] and [5]

Parameter	[1]	[2]	[3]	[4]	[5]
Technology Used	AI, Machine Learning, Sensors	AI, IoT, Drones, Robots	AI, IoT, Sensors (Nano, pH, Gas)	IoT, Sensors, Smart Irrigation	IoT, Wireless Sensor Networks (WSN), Data Mining
Main Focus	Enhancing sustainability and productivity in organic farming	Automating and optimizing farming from land preparation to harvesting	Detecting pesticide residues in organic produce	Modernizing agriculture with real-time monitoring	Optimizing agricultural processes through data analysis
Applications	Precision farming, predictive analytics, pest control	Smart irrigation, yield prediction, greenhouse farming	Pesticide detection, NDVI calculation, food safety monitoring	Soil moisture tracking, crop health, remote monitoring	Soil monitoring, automated irrigation, decision-making
Resource Efficiency	Reduces water, fertilizer, and pesticide use	Optimizes water, pesticide, and fertilizer use	Ensures safer food by reducing chemical exposure	Optimizes water and fertilizer use	Reduces water waste, improves resource efficiency
Impact on Productivity	Increases crop yield and efficiency	Enhances yield prediction and farm automation	Reduces health risks from pesticide contamination	Improves crop yield and reduces waste	Improves decision-making and crop yield
Decision-Making Support	AI-driven data analytics	AI-powered yield prediction and resource management	AI processes pesticide detection data	IoT enables real-time data-based farming decisions	Uses data mining for environmental condition prediction
Challenges Addressed	Climate resilience, economic	Resource management, automation	Chemical contamination in food, food	High IoT implementation costs,	Implementation challenges,

	viability, labor reduction	costs, greenhouse optimization	safety concerns	connectivity issues	cost-effectiveness
Conclusion	AI can make organic farming more efficient and sustainable	AI & IoT improve decision-making, automation, and sustainability	AI & IoT enhance food safety through smart detection	IoT transforms traditional farming into smart farming	IoT and data analysis improve productivity and sustainability

Table-2 Comparison for research papers [6],[7],[8],[9] and [10]

Parameter	[6]	[7]	[8]	[9]	[10]
Technology Used	IoT, Sensors, Arduino, Automation	IoT, Wireless Sensor Networks (WSN), Cloud Computing	IoT, Sensors, ESP32 Microcontroller	IoT, Cloud Computing, Sensors (ESP32, DHT-11)	IoT, Sensors, Actuators, Cloud Computing
Main Focus	Optimizing crop yield and resource efficiency	Real-time monitoring and automation of farm resources	Enhancing agricultural efficiency and resource management	Improving productivity and automation in mushroom farming	Enabling automation and data-driven decision-making in farming
Applications	Smart irrigation, remote monitoring, pest control	Water, fertilizer, and insecticide optimization using mobile applications	UV and infrared monitoring, smart alerts, resource conservation	Live monitoring, real-time automation, precision agriculture	Greenhouse automation, precision farming, aerial drones
Resource Efficiency	Reduces water waste, optimizes soil moisture use	Minimizes fertilizer and insecticide waste, enhances sustainability	Optimizes water and fertilizer usage, reduces wastage	Enhances productivity, reduces human effort	Reduces pesticide use, improves crop quality
Impact on Productivity	Improves crop quality, minimizes human intervention	Increases crop yield, optimizes farming practices	Increases yield, ensures better resource utilization	Boosts crop yield, reduces costs, enhances farm efficiency	Revolutionizes farming with automation and sustainability
Decision-Making Support	Provides real-time data for better decisions	Cloud-based analytics for data-driven insights	Real-time monitoring via mobile application	Uses cloud computing for farm data analysis	IoT-enabled data analysis for smart farming
Challenges Addressed	Reduces reliance on manual	Addresses water scarcity, pest control,	Affordable and practical smart	Enhances farm automation,	Enhances adaptability to climate

	labor, optimizes irrigation	and weather unpredictability	farming solutions	introduces GPS-based farming	changes, improves efficiency
Conclusion	IoT can make agriculture more efficient and sustainable	IoT and WSN improve farm productivity and sustainability	IoT-based farming is a cost-effective and scalable solution	IoT automation enhances farm efficiency and productivity	IoT-driven agriculture ensures sustainability, automation, and data optimization

Table-3 Comparison for research papers [11],[12],[13],[14] and [15]

Parameter	[11]	[12]	[13]	[14]	[15]
Technology Used	IoT, sensors (PH, NPK, temperature, soil moisture), Arduino, LoRa communication	IoT, Wireless Sensor Networks (WSN), ANN-based smart irrigation	IoT, AI, UAVs, robotics, cloud computing, big data	IoT for organic fertilizer manufacturing, Industry 4.0	IoT, mobile apps, cloud-based monitoring, PIR sensors for intrusion detection
Main Focus	Smart farming with real-time data for informed decision-making	Digital transformation in agriculture to improve productivity	Advanced IoT-based agriculture to enhance productivity and sustainability	Sustainable agriculture through organic farming and IoT	IoT-based smart farming for real-time monitoring and control
Applications	Precision farming, smart irrigation, livestock tracking, crop monitoring	Smart irrigation, soil and weather monitoring, fertilizer optimization	Crop monitoring, pest detection, automated harvesting, resource optimization	Organic fertilizer production, sustainable farming practices	Smart irrigation, soil analysis, pest monitoring, automated fencing
Resource Efficiency	Reduced water and fertilizer waste, optimized land use	Controlled irrigation, reduced resource wastage	Efficient use of water, fertilizers, and land through automation	Reduces synthetic fertilizer use, promotes sustainable farming	Prevents overwatering, optimizes farm inputs
Impact on Productivity	Higher yield, reduced dependency on labor	Increased efficiency, improved crop quality	Enhanced yield, reduced costs, better crop health	Higher-quality organic produce, long-term soil fertility	Improved crop yield, better farm management
Decision-Making Support	Real-time farm data, AI-driven insights, market price forecasting	Data-driven irrigation and fertilizer application	AI-based recommendations, predictive analytics, automation	IoT-based monitoring for sustainable farming decisions	Cloud-based analytics for soil and crop health
Challenges Addressed	Water scarcity, overuse of fertilizers,	Climate change, soil	Labor shortages, inefficiencies in farming,	Excessive chemical fertilizer use,	Unreliable traditional farming, lack

	remote farm monitoring	degradation, food demand	environmental impact	declining soil health	of automation
Conclusion	IoT enhances farm productivity and sustainability	Smart agriculture leads to efficient and sustainable farming	IoT is crucial for future agriculture and smart farming	Organic farming with IoT ensures long-term sustainability	IoT-powered smart farming improves efficiency and crop quality

Table-4 Comparison for research papers [16],[17],[18],[19] and [20]

Parameter	[16]	[17]	[18]	[19]	[20]
Technology Used	IoT, MQTT, Node MCU, smart sensors	IoT, Wireless Sensor Networks (WSN), AI, Raspberry Pi	IoT, Cloud computing, Big Data, RFID, AI	IoT, Arduino-UNO, smart sensors	IoT, AI, Wireless IoT sensors, Cloud
Main Focus	IoT-based smart agriculture for monitoring and automation	Precision farming with IoT and AI	Integration of IoT with smart farming and security concerns	IoT-driven smart irrigation and monitoring	AI and IoT for real-time control and smart farming
Applications	Smart irrigation, soil monitoring, weather analysis	Automated irrigation, livestock tracking, crop disease detection	Greenhouse monitoring, livestock health monitoring, crop monitoring	Soil moisture sensing, water level management, remote control	Resource-efficient farming, early disease detection, climate control
Resource Efficiency	Automated irrigation saves water, optimized soil nutrition	Reduced manual work, optimized resource allocation	Efficient use of fertilizers, reduced labor costs	Smart irrigation prevents overwatering, optimized water use	25% less water usage, 30% yield increase
Impact on Productivity	Increased crop yield through real-time data	Improved yield and soil fertility	Higher productivity with IoT-enabled monitoring	Increased agricultural output and sustainability	30% higher crop yields, 15% reduced losses
Decision-Making Support	AI-based predictions for farming decisions	Cloud-based analytics for decision-making	Predictive analytics for farm conditions	IoT-enabled automation for irrigation and monitoring	AI-driven smart farming insights
Challenges Addressed	Climate change, water scarcity,	Labor shortages, overuse of fertilizers	Security risks in IoT-based agriculture	Unreliable water management, excessive resource use	Crop diseases, resource depletion, environmental impact

	inefficient farming				
Conclusion	IoT helps modernize farming and improve efficiency	IoT enables precision farming with better decision-making	IoT and AI integration is crucial for the future of farming	Smart farming optimizes water and energy use	AI and IoT together ensure sustainable agriculture

4.1 A comparative value based on the provided soil parameters (Soil Moisture, Temperature, pH Level, and NPK Content) for different conditions.

Table-5 comparative value based on the provided soil parameters

Parameter	[11]	[12]	[13]	[19]	[20]
Soil Moisture (%)	30 - 50%	30 - 50%	25 - 55%	30 - 55%	35 - 50%
Temperature (°C)	15 - 32°C	15 - 45°C	10 - 40°C	15 - 45°C	18 - 40°C
pH Level	5.5 - 7.5	5.5 - 7.5	5.0 - 8.0	5.5 - 7.5	5.8 - 7.2
NPK Content (mg/kg)	600 - 900	600 – 900	500 - 950	600 - 950	650 - 920

4.2 A comparative graph based on the provided soil parameters (Soil Moisture, Temperature, pH Level, and NPK Content) for different conditions.

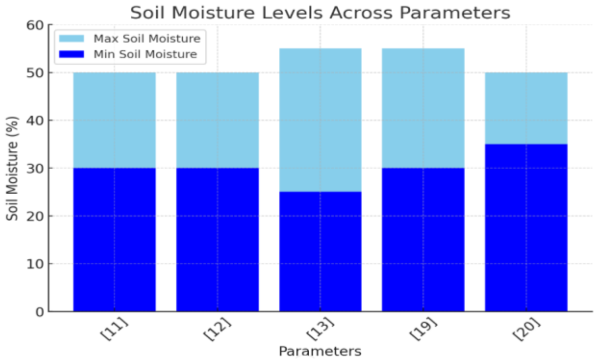

Fig-4: - Soil moisture level

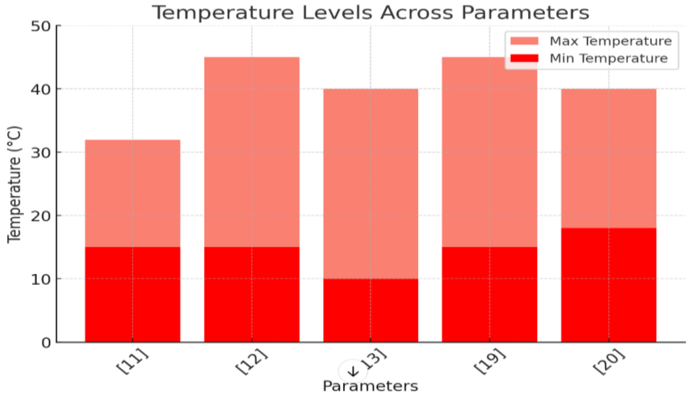

Fig-5: - Temperature level

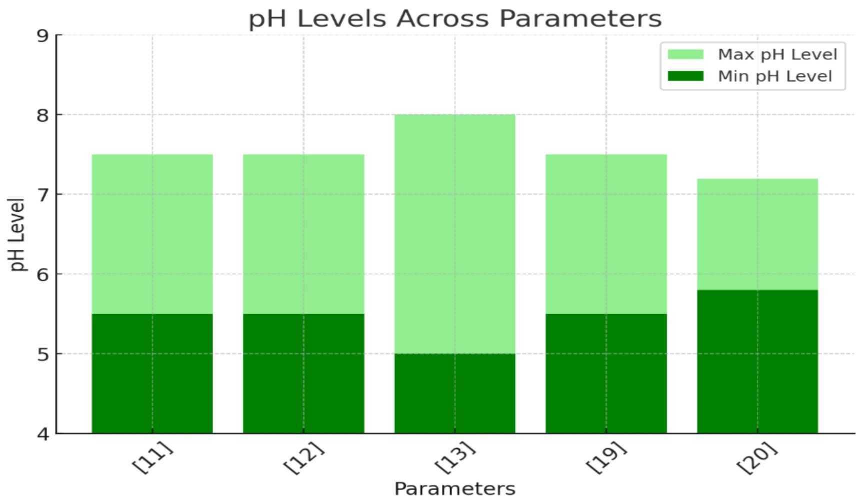

Fig-6: - pH level

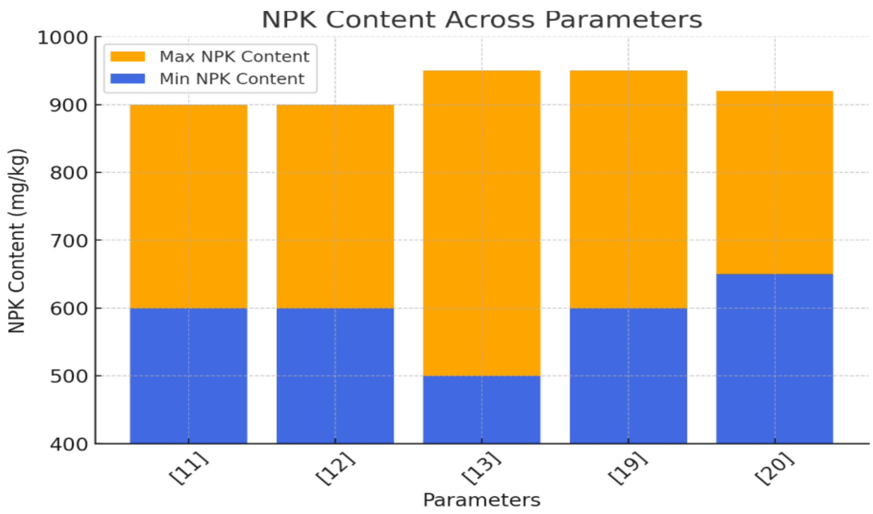

Fig-7: - NPK Content

5.1 **Dataset for healthy soil in organic farming, covering key parameters such as organic matter content, pH, nutrient levels, microbial activity, and moisture content.** Sample Dataset: Healthy Soil for Organic Farming

Table 6: - Healthy Soil Parameters

Soil Sample ID	pH Level	Organic Matter (%)	Nitrogen (N) ppm	Phosphorus (P) ppm	Potassium (K) ppm	Microbial Activity (CFU/g)	Moisture Content (%)	Soil Texture
S1	6.5	4.2	30	25	200	1.2×10^6	25	Loamy
S2	6.8	5.0	40	28	220	1.5×10^6	30	Silty Loam
S3	7.0	3.8	35	22	210	1.3×10^6	27	Clay Loam
S4	6.3	4.5	32	24	195	1.1×10^6	26	Sandy Loam
S5	6.7	5.5	45	30	230	1.6×10^6	32	Loamy
S6	6.2	4.0	28	20	180	1.0×10^6	24	Silty Clay

S7	7.1	4.8	38	27	215	1.4×10^6	28	Loamy Sand
S8	6.9	5.2	42	29	225	1.7×10^6	31	Loamy
S9	6.6	3.9	31	23	190	1.2×10^6	25	Sandy Loam
S10	6.4	4.7	36	26	205	1.3×10^6	29	Clay Loam

5.2 Ideal parameters for organic forming

Table 7: - Ideal parameters for organic forming

S. no.	Parameter	Range
1.	pH Level	6.0–7.5
2.	Organic Matter (%):	3–6%
3.	Nitrogen (N):	30–45 ppm
4.	Phosphorus (P):	20–30 ppm.
5.	Potassium (K):	180–230 ppm.
6.	Microbial Activity (CFU/g):	above 1.0×10^6 CFU/g
7.	Moisture Content (%):	25–35%
8.	Soil Texture	Loamy is ideal

5.3 Ideal Soil Temperature for Organic Farming by Soil Type

Table 8: - Ideal Soil Temperature

S. No	Soil Type	Ideal Temperature (°C)
1.	Sandy Soil	18 – 35
2.	Clay Soil	15 – 25
3.	Silt Soil	16 – 28
4.	Loamy Soil	15 – 30
5.	Peaty Soil	10 – 25
6.	Chalky Soil	12 – 27
7.	Saline Soil	18 – 32

5.4 Natural Pest & Disease Control for Organic Farming

Table 9: - Natural Pest & Disease Control Parameters

S. No	Pest/Disease	Affected Crops	Organic Treatment Applied (L/ha)
1.	Aphids	Vegetables, Fruits, Herbs	8 L/ha

2.	Whiteflies	Tomatoes, Cucumbers, Beans	6 L/ha
3.	Caterpillars	Cabbage, Broccoli, Lettuce	10 L/ha
4.	Spider Mites	Peppers, Tomatoes, Eggplants	5 L/ha
5.	Slugs & Snails	Leafy greens, Strawberries	12 L/ha
6.	Cutworms	Corn, Lettuce, Carrots	7 L/ha
7.	Powdery Mildew	Cucurbits (Pumpkins, Squash)	10 L/ha
8.	Downy Mildew	Grapes, Spinach, Basil	8 L/ha
9.	Blight (Late Blight)	Tomatoes, Potatoes	14 L/ha
10.	Root Rot	Beans, Peas, Cucumbers	7 L/ha
11.	Nematodes	Carrots, Tomatoes, Potatoes	6 L/ha
12.	Fungal Wilts	Peppers, Melons, Eggplants	9 L/ha

5.5 Water Irrigation Methods in Organic Farming

Table 10: - Water Irrigation Methods

S. No	**Irrigation Method**	**Water Usage (L/ha per day)**	**Efficiency (%)**	**Suitable Crops**
1.	Drip Irrigation	2,000 - 4,500	85 – 95	Vegetables, Fruits, Herbs
2.	Sprinkler Irrigation	4,000 - 7,000	70 – 85	Grains, Legumes, Root Crops
3.	Furrow Irrigation	6,000 - 12,000	50 – 70	Row Crops (Corn, Cotton)
4.	Flood Irrigation	8,000 - 15,000	40 – 60	Rice, Sugarcane, Pastures
5.	Subsurface Irrigation	1,500 - 4,000	80 – 90	Orchards, Vineyards
6.	Basin Irrigation	7,000 - 14,000	45 – 65	Rice, Wheat, Barley
7.	Spray Irrigation	3,500 - 6,500	75 – 85	Leafy Greens, Fruits
8.	Alternate Wetting & Drying	2,000 - 3,500	75 – 90	Paddy Fields

5.6 Crop Rotation & Diversity for Improved Production

Table 11: - Crop Rotation & Diversity

S. No.	**Rotation Strategy**	**Crop Groups Involved**	**Key Benefits**	**Yield Improvement (%)**
1.	Legume-Grain Rotation	Beans, Peas → Wheat, Corn	Improves soil nitrogen, enhances grain yield	15 - 25%

2.	Leafy Root Rotation	Lettuce, Spinach → Carrots, Beets	Reduces soil nutrient depletion	10 - 20%
3.	Three-Year Rotation	Corn → Legumes → Vegetables	Balances soil nutrients, pest control	20 - 30%
4.	Cover Crop Integration	Clover, Rye → Main Crops	Improves soil organic matter, retains moisture	10 - 20%
5.	Brassica Rotation	Cabbage, Mustard → Potatoes, Tomatoes	Controls soil-borne diseases, enhances soil health	12 - 22%
6.	Diversified Crop Rotation	Mixed Vegetables, Herbs → Grains	Enhances biodiversity, improves pest resistance	15 - 30%
7.	Intercropping	Maize + Beans, Carrots + Onions	Maximizes space, reduces weed competition	10 - 25%
8.	Rice-Pulse Rotation	Rice → Lentils, Chickpeas	Reduces soil salinity, improves nitrogen content	18 - 28%
9..	Legume-Grain Rotation	Beans, Peas → Wheat, Corn	Improves soil nitrogen, enhances grain yield	15 - 25%

6. EXISTING RESEARCH:

- Some papers discuss general **precision farming** (Papers [1], [2], [4], [5], [7], [10]), but they do not explicitly differentiate **organic farming** from conventional farming.
- A few papers mention **organic fertilizers** (Paper [14]) but do not explore comprehensive IoT and AI applications for **organic agriculture**.
- Papers primarily focus on **yield optimization and pest control** without considering **organic alternatives** to synthetic chemicals (fertilizers, pesticides).

7. GAP IDENTIFIED:

- **Lack of dedicated research on IoT & AI for Organic Farming**. Most studies emphasize IoT and AI in conventional farming rather than exploring how **AI-driven monitoring and IoT-based automation can specifically support organic practices**.
- The impact of **organic pest management using AI-based image recognition** or **IoT-driven biopesticide application** is missing.
- **Absence of AI models that assess soil quality for organic farming** and provide sustainable recommendations (e.g., vermicomposting timing, crop rotation).

8. CONCLUSION

The study emphasizes the significant role of IoT and AI in enhancing organic farming by enabling real-time monitoring, automated decision-making, and resource optimization. Through various comparative analyses, the research highlights that IoT-based smart farming systems can improve soil fertility, water management, and pest control while reducing dependency on chemical fertilizers and pesticides. Despite the promising advancements, gaps remain in integrating AI-driven models specifically for organic farming practices, such as automated organic pest management and soil quality assessment. Addressing these challenges through further research and technological innovation can pave the way for a more sustainable, eco-friendly, and efficient agricultural ecosystem. By leveraging IoT and AI, organic farming can not only increase productivity but also ensure environmental sustainability and long-term food security.

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