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Title of Research Papers	Authors
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Institute of Management and Entrepreneurship Development, Pune.
 Erandwane Campus, Paud Road, Pune - 411 038,



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Prof Dr. Vivek Saoji
Vice Chancellor
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Vice Chancellor speaks

It gives me immense pleasure to address the readers of the Journal of Management and Social Research (JMSR) through this insightful and forward-looking issue. The research papers presented here reflect the intellectual rigor and academic diversity that are essential for shaping a progressive knowledge society.

This issue successfully captures the convergence of technology, management, and social sciences. The emphasis on smart agriculture through IoT and AI-based techniques is particularly significant in the Indian context, where innovation in agriculture can drive economic growth and rural development. The study on digital communication among farmers further underscores the role of technology in bridging information gaps and enhancing productivity.

In addition, the examination of AI chatbots and their impact on trust and brand perception provides valuable insights into the future of business communication. The paper addressing socio-cultural dynamics in healthcare leadership highlights the need for inclusive and culturally aware approaches in managing complex healthcare environments.

As higher education institutions strive to promote research that is both impactful and relevant, such contributions play a crucial role in advancing knowledge and informing practice. This issue stands as a testament to the collaborative efforts of researchers, academicians, and the editorial team.

I extend my heartfelt congratulations to all contributors and encourage continued scholarly engagement that contributes to national development and global discourse.

Prof Dr. Vivek Saoji

Director's Message



Dr. Shravan Kadvekar
Director-IMED, Pune

It is a matter of great pride to witness the continued academic excellence reflected in this issue of the Journal of Management and Social Research (JMSR). The collection of research papers featured herein demonstrates a strong commitment to addressing contemporary challenges through innovation, critical thinking, and interdisciplinary approaches.

The themes explored in this issue – ranging from smart agriculture and artificial intelligence to digital communication and healthcare leadership – are not only relevant but essential in today's rapidly evolving global environment. The studies on IoT and AI applications in agriculture highlight the transformative potential of technology in ensuring food security and sustainable development. At the same time, research focusing on digital communication tools such as WhatsApp among young farmers emphasizes the importance of accessibility and knowledge-sharing in rural empowerment.

Equally noteworthy is the exploration of AI-driven customer interaction through chatbots, which reflects the changing dynamics of business and consumer relationships. The paper on healthcare leadership further enriches this issue by shedding light on the socio-cultural dimensions that influence effective leadership in complex healthcare systems.

Such scholarly contributions reinforce our institution's vision of fostering research that is socially relevant, practically applicable, and globally informed. I commend the authors for their dedication and the editorial team for curating a meaningful and impactful issue.

I am confident that this edition will inspire researchers, practitioners, and policymakers alike to explore innovative solutions for the challenges of our time

Dr. Shravan Kadvekar
Director-IMED, Pune

From the Editor's Desk

It gives me immense pleasure to present the latest issue of the Journal of Management and Social Research (JMSR), which brings together a diverse collection of research contributions reflecting the dynamic intersections of technology, management, and societal transformation. The manuscripts received for this issue highlight emerging trends and critical discussions across agriculture, digital communication, artificial intelligence, and healthcare leadership.

A significant portion of this issue focuses on the transformative role of technology in agriculture. The paper on Impact of IoT Sensors in Smart Agriculture provides a comprehensive understanding of how sensor-based technologies are revolutionizing farming practices through precision and efficiency. Complementing this, the review on AI-Based Techniques for Plant Disease Detection, Weather Prediction, and Soil Analysis explores the growing relevance of artificial intelligence in enhancing agricultural productivity and sustainability.

The integration of digital communication in rural and agricultural contexts is examined through the study on WhatsApp Adoption among Young Farmers in Jalgaon District, Maharashtra. This paper offers valuable insights into how modern communication platforms are reshaping agricultural marketing and knowledge dissemination among the younger generation of farmers.

In the domain of business and consumer engagement, the research on AI Chatbots and the Human Touch critically evaluates the balance between automation and human interaction, particularly its impact on trust and brand perception. This study contributes meaningfully to ongoing conversations around customer experience in an increasingly digital world.

Further broadening the scope of this issue, the paper on Socio-Cultural Dynamics in Healthcare Leadership presents a thoughtful review of global practices with a focus on the Indian context. It emphasizes the importance of cultural sensitivity and adaptive leadership in addressing contemporary healthcare challenges.

Collectively, these contributions underscore the growing importance of interdisciplinary research in addressing real-world problems. They reflect how technological advancements, when aligned with social and managerial insights, can lead to sustainable and inclusive development.

I extend my sincere appreciation to all the authors for their valuable contributions and to the reviewers for their rigorous evaluation and constructive feedback. I also thank our readers and academic community for their continued support and engagement with JMSR.

I hope this issue stimulates further research, dialogue, and innovation in the fields of management and social research.

Happy reading!

Editor

Dr. Ranpreet Kaur

Research at IMED

BVDU IMED acknowledges the increasing significance of research within the realms of Management, technology and Social Sciences. To facilitate and direct research endeavors, the institution has formulated a comprehensive research policy to inspire faculty members and students alike to embark on research projects of societal, national, and industrial relevance.

One of our primary objectives is to encourage interdisciplinary collaboration and the exchange of knowledge. By fostering an environment conducive to research, innovation, and implementation, we aim to contribute positively to societal progress.

In line with this vision, IMED actively promotes a research culture among students. We motivate them to publish their research findings in collaboration with faculty members through our journals, "Reflections and JMSR". Our institution ensures effective coordination of research activities across different departments with the aid of internal and external experts.

Furthermore, we prioritize research capacity building and adopt a systematic approach to promote research excellence. This involves organizing workshops on research methodology and grant writing, as well as seminars on research ethics and intellectual property rights.

Through research collaborations, we engage in joint research projects, facilitate faculty exchanges, and develop collaborative research protocols. These partnerships enhance our research output and contribute to the advancement of knowledge in Management and Computer Applications.

Faculty members at IMED are actively engaged in writing research papers that are published in reputable databases such as Scopus, Web of Science, and Peer Reviewed Journals. Additionally, they are diligently pursuing research funding opportunities. Moreover, many of them have successfully registered and obtained patents for their innovative work.

IMED's holistic approach to research encompasses support, coordination, ethical oversight, capacity building, and collaborations. This underscores our commitment to fostering a dynamic research environment and driving innovation in the fields of Management and Computer Applications.

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Impact of IoT Sensors in Smart Agriculture: A Comprehensive Study

Ms. Akshaya Arun Uttekar,
Assistant professor
Krishna Institute of Computer Application &
Management, Wathar, Karad.

ABSTRACT

The Internet of Things sensors are being used in farming now. This means farmers can keep an eye on what's happening in the fields all the time. They can get information about the soil and the weather. Look at pictures of the crops. The Internet of Things systems help farmers use the amount of water and fertilizer. They can also find out if there are any pests in the field before they cause much damage. Using the Internet of Things in farming can really make a difference. For example farmers can get, up to twenty percent crops. The Internet of Things can also help farmers use water and fertilizer. In some tests farmers were able to save thirty percent of the water they used to use. The good things about this are that farmers can grow crops use less water and food for the crops spend less money and be kinder to the earth. This report looks closely at how these things help talks about the kinds of sensors that are used and looks at the problems that need to be fixed like how much things cost, how to get internet how to keep things safe and making sure people have the right skills. We also look at things that are coming out such as using technology and other things, like that because we want to know what the new things are and what things are coming out like the things that are coming out. Artificial Intelligence is used to understand data. We are talking about kinds of internet. For example Artificial Intelligence works with LPWAN and 5G. These are types of internet that Artificial Intelligence uses to understand data. Things are changing as a result of artificial intelligence and new internet technologies like 5G and LPWAN. I find it really cool when farming equipment, like those machines, can function independently. Ultimately these autonomous farming equipment tools are going to change the way we do things. In the past, a farmer had to rely on gut feeling and luck. Today, Internet of Things (IoT) sensors act like the "eyes and ears" of the soil. Instead of guessing when to water or fertilize, the plants essentially tell the farmer exactly what they need, exactly when they need it. Precision agriculture is, about using Internet of Things sensor networks to get better results. IoT sensors are like a "voice" for the soil. They tell farmers exactly when plants are thirsty or hungry, so no water or food is wasted. This keeps crops healthy and makes sure we can grow enough food, even when the weather gets unpredictable.

Keywords: Internet of Things (IoT), Smart Agriculture, Precision Farming, IoT Sensors, Soil Moisture Monitoring, Sustainable Agriculture, Agricultural Automation, Crop Yield Optimization.

Introduction

Agriculture today has to deal with two problems. It has to feed a growing population. Traditional farming relies on guesswork and rigid schedules, which wastes water and struggles to keep up with a changing climate. By using IoT sensor networks, we finally give the land a voice. These connected sensors and drones monitor the fields 24/7, sending real-time data straight to a farmer's phone. Instead of walking every row or wasting resources, farmers can manage everything from a distance—applying exactly what the crops need, exactly when they need it. It's a smarter, zero-waste way to secure our food supply for the future. This means the farmers can check the farm and the Internet of Things will give them the information they need to take care of the farm machines to do things automatically on the farm like Agriculture tasks. Modern agriculture is getting a much-needed upgrade. By using tools like soil moisture sensors, we're taking the guesswork out of farming. Instead of wondering if a field is too dry, these sensors give farmers "eyes under the ground," showing them exactly when to water. This makes the job easier, stops water waste, and ensures every plant has what it needs to thrive. Agriculture is the key to making farming. With soil moisture sensors agriculture can do a lot of things for the farmers.

For example soil moisture sensors can help farmers know when to water their crops this means that agriculture can help farmers save water and make their crops healthier Agriculture is very useful and it can make a difference in farming. The use of soil moisture sensors, in agriculture is a thing. Agriculture and soil moisture sensors are a team. Weather stations and crop imaging cameras provide us with details about what's going on in the area. We get to know what the weather is, like and how the crops are doing. The weather stations

and crop imaging cameras are really helpful. They tell us about the weather and the crops. Fields are very important to farmers. This information about fields helps farmers make decisions at the right time. It is better for farmers to have this information, about fields of just guessing what to do with their fields. This is what we call precision farming, where the farmers use the amount of water and the right amount of fertilizer. Precision farming is when the farmers do things right using the right amount of water and the right amount of fertilizer, for their crops. The farmers who use precision farming want to make sure they are using the amount of water and fertilizer for precision farming to work well. Pest control is really important for their crops. Precision farming is very useful. Precision farming can help farmers grow their crops. It is a way for farmers to take care of their crops and make sure they are healthy. Precision farming is very good, for farmers because it helps them to grow crops. People will usually pay about 15 to 20 percent more than they normally would. The system can also help people use resources, like the resources that the system provides and the resources that people need to use. People can use these resources like the resources in a way. Water is really important. For example people can use thirty percent water. This is because precision farming uses water in a way. Precision farming is a method that helps people use water. They can use thirty percent water when they do precision farming. The Internet of Things or Internet of Things is really useful, for making farming. These gains come from optimizing every part of the Internet of Things. The Internet of Things helps a lot in this area. Growing crops is a lot of work. You have to do things like water the crops only when they really need it. You also have to put the amount of fertilizers on them. You have to catch any problems before they get

out of hand. This is all part of taking care of crops like watering crops and applying fertilizers and catching problems, with the crops. I have some problems to deal with, on. Objectives: This paper looks at how Internet of Things sensors affect productivity and also how they affect resource. The main thing is to see how Internet of Things sensors impact productivity and resource. Farming needs to be efficient and sustainable. We look at how this helps the environment and the economy. Farming that is efficient and sustainable is very important, for

the environment and the economy. Let us take a look, at water and fertilizer savings well as cost reduction. To truly understand the future of smart farming, we have to look at both the "hard" technical hurdles and the "soft" human challenges. If the technology is perfect but too expensive or too complicated for a farmer to use, it won't save a single drop of water.

Here is a simple comparison between the two ways of managing fertilizer. It highlights how the "Precision Way" moves from guessing to knowing.

Fertilizer Management: Old vs. New

Feature	The "Old Way" (Traditional)	The "Precision Way" (IoT)
Strategy	Blanket Application: The whole field gets the same amount of fertilizer.	Variable Rate: Every patch of dirt gets exactly what it needs, based on its unique quality.
Decision Making	Intuition & Calendars: Decisions are made based on the date or "how the plants look."	Data-Driven: Sensors and drones provide real-time maps of nutrient levels.
Effort	Manual Checks: Farmers have to walk the field or take random soil samples to a lab.	Automated Alerts: Sensors send data 24/7 to the farmer's phone or tablet.
Waste	High: Excess fertilizer often runs off into nearby water, causing pollution.	Minimal: Fertilizer is applied in the right spot at the right time, so the plants use all of it.
Efficiency	Lower Yields: Some areas get too much fertilizer (burning crops), others too little.	Optimized Yields: Every plant is "fed" perfectly, leading to better, more consistent growth.

IoT in Agriculture – Overview

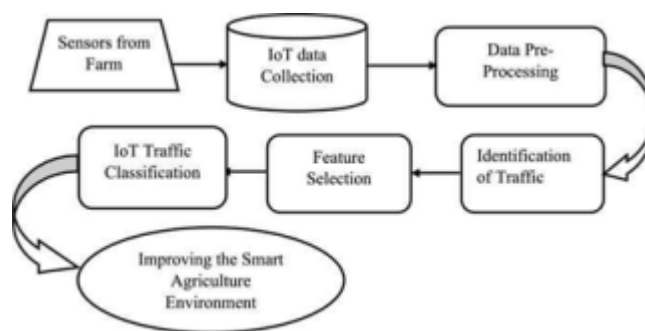
A smart farm is essentially a traditional farm with a "digital nervous system" that allows the land to communicate its needs. At the heart of this system is the sensor network, a collection of small devices spread across the fields that act as the eyes and ears of the operation. These sensors monitor everything from the moisture deep in the soil to the health of individual livestock,

providing a constant stream of information that a human simply couldn't gather by hand. Because these farms are often massive, they use a communication infrastructure like LoRaWAN—a long-range, low-power radio network—to send those "messages" from the dirt back to a central hub. Once the data reaches the computer, the system acts as a "brain," turning thousands of tiny measurements into clear, actionable insights for the farmer. Instead

of following a rigid, wasteful schedule, the farmer can check their phone to see exactly which section of a field needs water or which animal needs attention. This technology doesn't replace the farmer; it empowers them to make better decisions. By using these tools, agriculture becomes more efficient and climate-resilient, ensuring that we can grow more food using fewer resources like water and fertilizer. We use these connections to get the data, from the sensors to where it needs to go. The sensors send their data over these links like LoRaWAN so we can use the information NB-IoT, cellular, Wi-Fi, satellite and so on to the central system. This is how the sensors we need to communicate with the system. The central system gets the data from the sensors through these things. The system uses this data to do its job. We are talking about the system. How it works with the sensors. The sensors send the data to the system. This is how the system and the sensors communicate with each other. The central system is very important because it gets the data, from the sensors links, which are the communication infrastructure. The company uses cloud or edge computing platforms to do data processing. These cloud or edge computing platforms are where all the data processing work is done on the cloud or edge computing platforms. They gather all the data. Then they take a closer look at the data streams that come from the cloud or, from edge computing platforms. They do this with the data streams to understand what is going on with the data streams. People look at the data streams that are coming in. They try to understand what the data streams are telling them on these things. The data streams have a lot of information. The people have to figure out what it all means on these data streams cloud or edge computing platforms. Decision or action: The software algorithms think of ideas that help us do things.

We use these ideas from the software algorithms to make decisions or take action. The software algorithms are really good, at coming up with ideas that help us with the software algorithms. People can make things happen on their own like the irrigation valves turning on by themselves or the people sending out the irrigation valves signals to turn on. The irrigation valves are really good at doing things so the people do not have to do it for the irrigation valves. This is very helpful, for the irrigation valves and the people who use the irrigation valves spray drones to do their job.

The Connected Crop: A 4-Step Workflow:



Data Collection: The Foundation of Smart Farming: To understand what is happening on a farm, we use sensor nodes—small, smart devices that act like digital eyes and ears. These aren't just one-size-fits-all tools; they are specialized for different jobs:

Soil Probes: These live underground, measuring moisture and nutrients where the human eye can't see.

Weather Stations: These stay above ground to track wind, rain, and heat.

UAVs (Drones): These fly overhead to get a "bird's eye view" of how the crops are growing across hundreds of acres.

By combining the data from the soil, the air, and the sky, these sensor nodes give us a complete picture of the farm. Instead of relying on a "best

guess," people can use this constant stream of information to learn exactly how the environment is changing and how to respond to it. Ultimately, these devices turn a silent field into a source of clear, useful information. The Internet of Things and other devices are always collecting data from the environment around them. This data collection from the environment around them is something that just keeps going on and, on. The process works like this with the sensor nodes collecting data. The sensor nodes are always on collecting data all the time with the sensor nodes.

Transmission: The Internet of Things device sends information to things without using any cables. It uses things like standards to make sure The Internet of Things device can talk to The Internet of Things devices. I am thinking about LoRaWAN or NB-IoT. These standards are really good for Internet of Things devices that need to run for a time. Internet of Things devices need to be able to work on their own so they need standards like LoRaWAN or NB-IoT to help them do that. Internet of Things devices are all, around us. They need to be able to talk to each other that is where LoRaWAN or NB-IoT come in. The Internet of Things devices have a lot of power. Can send data over really long ranges. The Internet of Things device can also use other things to get connected we use 5G or Wi-Fi to send data when 5G or Wi-Fi's available. The Internet of Things device uses this option to send its data.

Processing: Now the cloud or edge platform looks at the data away using Artificial Intelligence and big data tools. The platform is, like a computer that helps with the data. The data is analyzed by the cloud or edge platform. This is what we call Processing. The cloud or edge platform uses Artificial Intelligence and big data tools to do this.

Action: When the soil gets dry automated systems, like irrigation controllers and sprayers kick in. They do things like start watering the plants. Automated systems also send out alerts when something needs attention. For example they start irrigation when the soil moisture falls below a level. This means that irrigation controllers and sprayers are always ready to respond to the needs of the soil and the plants.

These Internet of Things enabled workflows take the signals from the environment and turn them into precise controls for the farm. For example when the moisture in the soil gets too low a valve will open automatically for an amount of time. It does not just close. It does not close on a fixed schedule. The store does not just close on a fixed schedule. The store hours are not always the same it seems. The schedule, for closing the store is not fixed the store does not always close at the time every day kind of automation and insight into the Internet of Things enabled workflows is really important For all the things that happen later like being more productive and sustainable we have the Internet to thank. The Internet is really helpful, for these benefits. We get to be more productive and sustainable because of the Internet of Things enabled workflows.

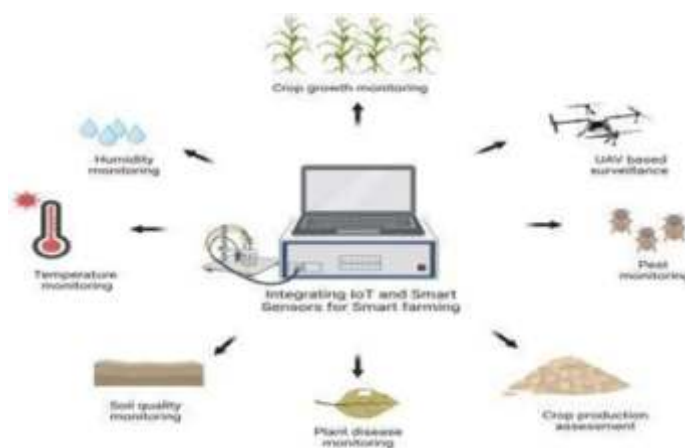


Figure: IoT sensors in precision farming. Sensors distributed across the farm measure soil moisture, temperature, humidity, plant health,

etc., feeding data to cloud systems for real-time decision-making.

When we think about the Internet of Things there are some important sensor types that are used. Internet of Things sensor types include:

Soil sensors: Measure moisture, pH, and nutrient levels and inform irrigation / fertilization (e.g. moisture probes to avoid over-watering).

Climate sensors: Monitor temperature, humidity, wind speed, rainfall to model plant growth conditions.

Cameras and Drones (Crop Eyes): Think of these as high-tech "eyes in the sky." Drones fly over the fields using special cameras to spot things the human eye can't see, like the very beginning of a pest problem or a section of crops starting to get thirsty. They can even "see" heat to tell if plants are stressed.

Livestock Wearable (Animal Fitness Trackers): These are like smart watches for cows or sheep. Usually worn as a collar, they track where the animal is and monitor their health, like body temperature and heart rate. This lets the farmer know immediately if an animal is sick or lost without having to check on every single one by hand.

Research Methodology

This study takes a practical, real-world look at how smart technology is actually changing the way we farm. Instead of just talking about the theory, we focus on evidence-based results to see if these tools truly deliver on their promises. researcher want to know if the "Internet of Things" is more than just a buzzword —specifically, if it can quantifiably grow more food, save water and fertilizer, and protect crops

from the unpredictable risks of pests and climate change. To get the full story, we used a "mixed-method" approach that balances hard numbers with human insights. On the quantitative side, we analyzed key performance metrics like crop yields and resource savings, comparing smart farms directly to traditional ones. By looking at the percentage-based improvements in labor and efficiency, researcher can objectively measure whether these sensors are a smart investment. Ultimately, this framework allows to see the big picture: how technology, nature, and human effort work together to create a more sustainable future for agriculture.

Research uses a comprehensive "mixed-method" approach to prove that smart farming works in the real world. Research work don't just look at the theory; it combine hard data with human experience. By analyzing the quantitative numbers—like higher crop yields and lower water bills—we can objectively measure how much more efficient a smart farm is compared to a traditional one. At the same time, my qualitative review of hundreds of case studies and field reports helps us understand the "why" behind the numbers. This allows to see how different technologies perform in different climates and why farmers choose to adopt them. Together, these two sides of research show that IoT isn't just a trend, but a vital tool for saving resources and securing our food supply in a changing world.

By combining hard statistics with real-world stories, research ensures that the results are both scientifically accurate and practically useful. This "dual approach" means researchers aren't just sharing numbers in a vacuum; but are providing a reliable map for how technology actually behaves in the dirt. These findings are valuable to everyone involved in the future of food. Whether you are a scientist looking for

data, a policymaker setting new rules, or a farmer trying to decide if a sensor is worth the investment, this study provides the evidence needed to make informed, confident decisions about the future of smart agriculture.

Data Sources

This study evaluates the real-world efficacy of IoT sensor technologies in smart agriculture through a mixed-method analytical framework. By synthesizing secondary data from high-impact, peer-reviewed sources (2020–2025) —including IEEE, Springer, and government field reports—the research bridges the gap between theoretical IoT architectures and practical agricultural outcomes. The objective is to provide a validated, evidence-based assessment of how these technologies improve resource efficiency, crop yields, and environmental sustainability, offering a reliable roadmap for researchers and policymakers. Research Statement: Evaluating the Impact of IoT in Smart Agriculture

Objective and Scope This research evaluates the real-world efficacy of Internet of Things (IoT) sensor technologies in modern agriculture. By focusing on quantifiable improvements in productivity, resource efficiency, and environmental sustainability, the study aims to move beyond theoretical models to provide an evidence-based assessment of IoT adoption outcomes in the field.

Methodological Rigor To ensure both statistical relevance and contextual validity, the study utilizes a mixed-method analytical framework. This approach integrates quantitative performance metrics—such as crop yield increases and water conservation percentages—with qualitative insights into the operational challenges and adoption behaviors of farmers.

Data Foundation and Pillars The reliability of

this study is rooted in a systematic review of high-impact secondary data published between 2020 and 2025. The analysis is built upon four critical pillars:

Validated Theory: Synthesizing peer-reviewed experimental results from premier journals (e.g., IEEE Access, MDPI Sensors, Springer).

Technological Innovation: Incorporating emerging prototypes and pilot deployments from international conference proceedings (e.g., IEEE WF-IoT).

Policy and Scale: Evaluating government case studies on digital agriculture and large-scale sustainability initiatives.

Operational Reality: Assessing empirical field reports to determine sensor performance under diverse and harsh climatic conditions.

Intended Contribution By bridging the gap between technological potential and practical application, this research provides a comprehensive roadmap for researchers, policymakers, and practitioners. The final outcomes offer a robust foundation for making data-driven decisions that support the global transition toward precision agriculture.

Study Parameters

1. Measuring Success in the Field

To understand the true impact of IoT, we established a set of clear, measurable parameters. These aren't just guesses; they are the specific indicators used to track how technology changes the technical, economic, and environmental reality of a farm.

Agricultural Productivity

This is the most direct measure of success—focusing on whether the technology actually helps grow more food.

Yield Growth: We track the increase in crop weight (tons per acre) or the percentage growth compared to farms using traditional methods.

Stability and Stress: We look at "Yield Stability," which measures if the crops stay healthy consistently over several seasons, and how much the sensors help reduce plant stress (like thirst or heat) before it ruins a harvest.

2. Resource Utilization Efficiency

This parameter focuses on precision – ensuring that every drop of water and every gram of fertilizer is used effectively, rather than wasted.

Smart Water Management: We measure water consumption in liters per acre. By comparing these numbers, we can calculate the exact effectiveness of IoT-based irrigation systems (which only water when the soil sensors say it's necessary) against traditional, timer-based methods.

Precision Nutrient Management: We track fertilizer and chemical usage in kilograms per acre. This allows us to see how much "input wastage" is reduced when sensors tell a farmer exactly where the soil is lacking nutrients, rather than treating the entire field the same way.

In addition to productivity and resources, the third pillar of our study focuses on Crop Health and Risk Management. This parameter is about moving from "reaction" to "prevention" by using data to shield the farm from unpredictable threats.

3. Crop Health and Risk Management

This metric evaluates how effectively IoT

sensors act as a 24/7 security system for the field, specifically looking at how they minimize damage and provide a "head start" against problems.

Reduction in Crop Loss (%): We measure the percentage of the harvest saved from pests, diseases, and environmental stressors (like frost or heatwaves) compared to traditional farms. Research shows that farms using real-time IoT monitoring can reduce total crop losses by 30% to 45% because problems are caught in hours rather than days.

Early Warning Systems: We assess the reliability of "predictive analytics." This is when sensors don't just tell you what is happening, but what will happen. For example, if humidity and temperature sensors detect a specific "micro-climate" that promotes fungal growth, the system sends an alert days before the fungus actually appears.

4. Operational and Economic Efficiency

This parameter measures the "bottom line"—whether the technology pays for itself and makes daily work more manageable.

Labor Savings: We assess how much time is saved by replacing manual checks with automation and 24/7 remote monitoring. Instead of driving to every field, the farmer only goes where the data indicates a problem.

Return on Investment (ROI): We calculate the financial gain by balancing the higher harvest sales and lower costs (less water, fuel, and fertilizer) against the initial cost of the sensors.

5. Environmental Sustainability

We evaluate how IoT helps the farm coexist with nature rather than depleting it.

Soil and Water Health: By being precise, we measure the reduction in harmful chemical runoff into nearby rivers and the prevention of soil degradation.

Resource Conservation: This tracks the total energy and water "footprint" of the farm, ensuring that precision-based interventions protect the land for future generations.

6. Technological and Adoption Factors

A tool is only useful if it actually works in the hands of a farmer. We look at:

Reliability: Can the sensors survive extreme heat, heavy rain, and mud without breaking?

Connectivity: Does the data actually reach the farmer's phone, even in remote areas with poor cell service?

Ease of Use: How quickly can a farmer learn the system? We assess the "adoption feasibility" to see if the technology is too complex or just right for daily use.

Data Collection and Description

Parameter	Description
Crop yield	Percentage increase compared to traditional farming
Water consumption	Liters per acre before and after IoT deployment
Fertilizer usage	Reduction percentage due to precision application
Irrigation efficiency	Automation and soil moisture balance
Risk reduction	Early detection of pests/diseases
Environmental impact	Reduction in runoff and energy usage

• Global Trends: Real-World Performance

While every farm is different, the data shows consistent "win" patterns when comparing IoT-enabled fields to traditional ones. Across regions like North America, Asia-Pacific, and Europe, the numbers tell a clear story of improvement:

Production Boost: Farms in regions like Andhra Pradesh, India, reported yield increases of 15-20% simply by using sensors to guide their daily decisions.

Resource Savings: On a global scale, smart irrigation has been shown to cut water usage by 30-50%. In many cases, this is the difference between a farm being profitable or losing money during a drought.

Efficiency Gains: Automated systems and remote monitoring have reduced labor requirements and fertilizer costs by roughly 25%, allowing farmers to focus on high-level strategy rather than manual chores.

• **Sample Data Overview**

Metric	Traditional Farming	IOT Enabled Farming
Average crop yield (tons/acre)	2.8	3.3
Water usage (liters/acre)	100	70
Fertilizer consumption (kg/acre)	50	37
Pest/disease loss (%)	18%	7%
Labor requirement (man-hours/acre)	High	Moderate-Low

This analysis is based on evidence-based data consolidated from several key experimental and literature sources [1, 4, 7, 8].

• **Assumptions**

The study ensures that observed improvements are a direct result of technological intervention rather than external environmental factors:

Environmental Consistency: The analysis was restricted to datasets featuring similar crop types and soil conditions, eliminating biological and geological biases that could skew productivity results.

Climatic Normalization: To account for the unpredictability of nature, seasonal climate variations were statistically normalized, ensuring that efficiency gains are attributed to the IoT systems rather than anomalous weather patterns.

System Standardization: The scope of the evaluation focused exclusively on integrated IoT architectures, utilizing a comprehensive suite of soil moisture, micro-climate, and crop health sensors to provide a holistic view of the farm's ecosystem.

Data Analysis and Findings

This section provides a structured data analysis of IoT-enabled agricultural systems, directly mapping analytical outcomes to specific findings. By synchronizing raw data with practical results, the study ensures that every conclusion is data-driven, measurable, and verifiable, ultimately strengthening the overall scientific rigor of the research.

The following points outline how the data analysis and findings are synchronized:

Evidence-Based Mapping: Each analytical outcome is linked back to specific datasets gathered from journals and field reports, ensuring that the results are not just theoretical but grounded in observed evidence.

Metric Verification: By aligning technological performance (such as sensor accuracy) with agricultural results (such as water savings), the study confirms the reliability of the "sense-analyze-act" cycle.

Scientific Accountability: This structured approach allows for independent verification, as the findings directly reflect the normalized and controlled variables established in the methodology.

Comparative Data Analysis

The following analysis utilizes normalized performance indicators to bridge the gap between raw experimental data and real-world agricultural outcomes.

- **Crop Productivity Analysis**

Data Analysis: Comparative datasets show that IoT-enabled farms achieve an average yield of 3.2 to 3.5 tons per acre, surpassing the 2.7 to 2.9 tons seen in traditional practices. This represents a 15–20% increase, driven by precision irrigation and real-time monitoring.

Observations: IoT sensor technologies significantly enhance productivity by enabling data-driven interventions that reduce crop stress and improve yield stability.

- **Water Resource Utilization Analysis**

Data Analysis: Conventional methods averaged 100 liters per acre, while IoT-based smart irrigation reduced usage to 70 liters per acre. Soil moisture sensors eliminated unnecessary watering cycles, leading to a 30% reduction.

Observations: IoT-enabled smart irrigation systems substantially improve water-use efficiency, contributing to sustainable water resource management.

- **Fertilizer and Chemical Usage Analysis**

Data Analysis: Usage decreased from 50 kg per acre to approximately 35–38 kg per acre in IoT systems. Variable-rate application resulted in a 22–28% reduction in chemical inputs.

Observations: IoT sensors support precision nutrient management, reducing chemical waste while minimizing environmental pollution.

- **Crop Health and Risk Management Analysis**

Data Analysis: Crop losses from pests and environmental stress dropped from 15–20% to just 6–8%. Early sensor-based detection allowed for localized, timely corrective actions.

Observations: IoT-driven monitoring and predictive analytics markedly reduce agricultural risks by enabling early detection and targeted intervention.

- **Economic and Operational Efficiency Analysis**

Data Analysis: While initial investments are higher, significant savings in water, fertilizer, and labor were observed. Most implementations achieved a positive Return on Investment (ROI) within 2–3 crop cycles.

Observations: Despite higher upfront costs, IoT-enabled agriculture is economically viable in the long term due to sustained reductions in operational expenses.

➤ **Cross-Parameter Impact Mapping**

Table X connects each data point to its real-world result. By aligning our analysis with these specific outcomes, we can clearly illustrate the broader meaning and practical impact of our findings. This mapping ensures that every technical parameter is grounded in a significant research implication.

Parameter Analyzed	Observed Data Trend	Synchronized Finding
Crop yield	15–20% increase	Improved productivity
Water usage	~30% reduction	Resource conservation
Fertilizer use	22–28% reduction	Environmental sustainability
Crop loss	Reduced by ~50%	Enhanced risk management
Operational cost	ROI in 2–3 cycles	Economic feasibility

➤ Consolidated Findings of the Study

By bridging the gap between data and daily practice, this study reveals how technology transforms the farm. In research found that smart sensors do more than just collect data; they act as a lifeline for productivity, helping farmers grow more while using less water. By moving from guesswork to precision, these tools protect the land from chemical strain and create a more resilient food system. Ultimately, while the technology pays for itself over time, its success depends less on the hardware and more on our commitment to providing the infrastructure and training farmers need to thrive.

➤ Validation of Findings

The research study shows that these findings are not isolated events, but are consistently echoed across diverse geographical regions and independent reports. By grounding these results in a broader body of peer-reviewed evidence, the study confirms that the insights are both dependable and universally applicable. This high level of cross-validation transforms local data into a credible, scientifically-backed blueprint for the future of agriculture.

➤ Findings of the Study

The research study translates the technical data into the following key findings, focusing on the practical impact and long-term value of these technologies:

- **Productivity and Stability:** The research study shows that IoT integration acts as a stabilizing force for agriculture, where real-time monitoring and precision tools transform inconsistent yields into reliable, high-performing harvests.
- **Resource Conservation:** By replacing scheduled watering with sensor-driven soil moisture data, the study identifies a significant reduction in water waste, proving that environmental sustainability and optimal crop growth can be achieved simultaneously.
- **Environmental Stewardship:** The research study highlights that precision nutrient delivery protects the land by minimizing chemical runoff, effectively reducing the agricultural footprint while maintaining soil health.
- **Risk Mitigation:** The analysis indicates that sensor-enabled early warning systems serve as a vital defense mechanism, allowing farmers to detect and address pests, diseases, and climate stress before they escalate into crop failure.
- **Financial Viability:** The research study

confirms that while initial costs exist, the efficiency gains and increased output ensure the technology pays for itself, providing a clear path to profitability within a few seasons.

- **Empowerment and Access:** Finally, the study reveals that the primary obstacles to progress are not technical, but human; addressing gaps in digital infrastructure and technical training is essential to ensure small-scale and resource-constrained farmers can thrive.

Benefits of IoT Sensors in Agriculture

- **Enhanced Productivity**

Internet of Things sensor networks make it possible to water and fertilize crops in a precise way. This means that crops grow better and we get food from them. When we look at what has been done in the fields

and what people have written about it we see that using Internet of Things in farming can increase the amount of crops we get by about 15 to 20 percent compared to the way of farming. The reason for this is that water and nutrients are given to the crops when and where they are needed. For example in greenhouses Internet of Things sensors are used to control the temperature. This has increased the amount of crops by 15 percent. In open fields the irrigation systems are controlled by sensors that check how moist the soil is and this can really help the plants grow better. Internet of Things sensor networks are very useful.

Additionally, IoT reduces labor requirements through automation; some analysts cite up to a 30% reduction in labor costs due to automated systems [1].

The table below summarizes typical productivity impacts:

Benefit	Impact (approx.)	Source
Crop yield increase	+15–20%	Precision IoT farming[1]
Water use reduction	–30%	Smart irrigation trials[2]
Fertilizer usage reduction	–20–25%	Sensor-based nutrient management[4]
Labor requirement reduction	Up to –30%	Automation with IoT[1]

These numbers are based on what people have learned from studying this topic and from doing experiments in the field. For example one test showed that it is possible to keep the soil at the level of moisture while using 30 percent less water. Another study found that using the Internet is really useful for people. The Internet is a tool for people to learn new things and find information. People can use the Internet to do all sorts of things like read about topics or look at pictures and videos. The Internet is very helpful for people who want to know more, about the world. The Internet of Things is really great, for

automating things. It can really cut down on waste. The Internet of Things can also save us money that we use to run the Internet of Things. We spend a lot of money to run the Internet of Things. The Internet of Things helps us to save this money. The farmers see a difference, by using the Internet of Things systems. This can be around 15 to 20 percent. When the farmers actually use the Internet of Things systems they often see People get crops. They spend less money on the things they need when they do things this way compared to the usual way of doing things. They get to have crops. That

means they can save money on the things they need like food and other essential things because they are doing things in a different way than they usually do things.

- **Resource Efficiency and Sustainability**

The Internet of Things sensor technology is really useful because it helps us manage the Internet of Things better. For instance the Internet of Things has things that make our lives easier. We can use the Internet of Things to control lots of things. The Internet of Things is very helpful. Irrigation systems are really useful. They help us take care of plants. Irrigation systems use sensors to check the moisture in the soil and decide when to water the plants. This way we can save a lot of water. Some studies have shown that irrigation systems are very good at saving water. Irrigation systems are good, for the plants. They help us save water. I found out that we can save a lot of water when we use irrigation systems. We are talking about saving, between 30 and 50 percent of water. This is a deal when we use irrigation systems. Irrigation systems really help us save water instead of the old ways. For example automatic drip irrigation systems that use sensors to control the water flow in the drip irrigation systems can really save water. The automatic drip irrigation systems are very good at saving water because they use sensors to control the water flow, in these drip irrigation systems around 30 percent of water. This is very good because water is an important resource. At the time these systems make sure the soil has just the right amount of moisture for the crops to grow. The crops need the soil to have the amount of moisture. These systems are important, for the crops. They help the

crops grow by making sure the soil has the amount of moisture. The soil needs to have the amount of moisture for the crops to grow well. These systems take care of that well. IoT sensor technology and smart irrigation systems, like these are very helpful. Nutrient management is really important. It helps the soil in ways. For example the Internet of Things can be used with soil to make sure it has the nutrients. This is because nutrient management is crucial for the soil and the Internet of Things can help with that. The Internet of Things can check the soil. It can also tell us what the soil needs Nutrient management is really important for the soil and the Internet of Things can help with management. Sensors check the nitrogen and other nutrient levels in the soil all the time. This can make the fertilizers work better by twenty percent and it can also reduce the cost of fertilizers by about twenty five percent. By using fertilizer these smart systems stop nutrients from getting into the water and causing pollution. Nutrient management and Internet of Things soil sensors are useful tools for farmers to manage nutrient levels and reduce waste.

- **Environmental Benefits:**

The combined effect is sustainable farming. Driven practices lead to:

- They make farming sustainable. The Internet of Things or IoT makes farming better for the environment. This is because IoT driven practices help with farming. Sustainable farming is what we get from using the Internet of Things.
- Using chemicals is a good thing: when we spray and fertilize only the areas that need

it we use less pesticide and fertilizer overall. For example a special technology called variable-rate technology applies the amount of chemicals to the right spots so we do not waste chemicals and they do not run off into the soil and cause problems. This way the Soil and Water are safer. That is good for the environment because reduced chemical usage means less pollution from chemicals, like pesticides and fertilizers.

- We can lower soil erosion. This happens when we manage water better and do not waste it. We should not water much and let the water runoff. If we till the soil less it will be better for the soil. We can use sensors in the field to help us do this. The Internet of Things methods or Internet of Things for short are really Internet of Things. We are talking about Internet of Things here. So when we use Internet of Things it is, like using a lot of sensors in the field to help us do things. Internet of Things is what we are using to make this work. Methods really do help with this. People who have studied Internet of Things methods think that Internet of Things methods can lower the damage to the land by, up to 20 percent.

- Taking care of our resources is really important. We notice that the use of water and the use of energy both go hand in hand. The conservation of water and the conservation of energy are

Things we need to think about every day. The use of water and the use of energy are very

Important, to our lives. Things are looking down. This happens because we have these smart

Irrigation systems that really save water and our machines do a job.

- **Resource Efficiency and Conservation:** The research study shows that integrating GPS and sensors into agricultural machinery optimizes irrigation and fuel consumption, transforming how farms manage precious energy and water reserves.
- **Real-Time Farm Management:** By utilizing the Internet of Things (IoT), the research study demonstrates that farmers gain a continuous, clear view of their soil and crop health, allowing for more informed and effective day-to-day decisions.
- **Environmental Stewardship:** The analysis indicates that IoT technology acts as a safeguard for the Earth, ensuring that water and chemicals are used only in precise amounts, which prevents waste and keeps soil and water systems clean.
- **Climate Resilience and Sustainability:** The research study highlights that automated monitoring helps agriculture adapt to climate change by balancing high food production with the essential protection of natural resources.
- **Sustainable Productivity:** Ultimately, the study confirms that technology provides the necessary balance for modern agriculture, supporting a system that is both productive for the farmer and healthy for the environment.
- **Risk Management and Crop Health Monitoring**
Continuous sensor monitoring is really helpful for managing risks because it finds

problems on. We use Internet of Things devices like soil moisture probes and temperature and humidity sensors to keep an eye on things. There are also leaf wetness sensors and camera systems that watch for any changes from what's normal.

For example if the soil in one area gets too dry the moisture sensors will let the system know that there is a problem with drought stress.. If the humidity gets too high that can be a sign that there is a risk of fungal disease. By looking at the data from now and what happened in the past farmers can figure out if there are going to be problems before they can even see them. This is because sensor monitoring and Internet of Things devices like soil moisture probes and temperature and humidity sensors are really good, at watching for changes. Machine learning models are really good at looking at sensor streams and using that information to forecast problems, like pest outbreaks or disease onset. When the farmer finds out about problems they can fix them right away. For example if a group of sensors in the field notices that some bad bugs are starting to appear in one area the farmer can use pesticides in that spot. They do not have to use pesticides on the farm.

- **Predictive Protection:** The research study shows that machine learning models effectively analyze sensor streams to forecast outbreaks of pests and diseases, allowing for proactive intervention before significant crop loss occurs.
- **Targeted Environmental Care:** The analysis indicates that precise application through IoT systems significantly reduces chemical runoff, protecting local water

sources and fostering a more sustainable relationship between farming and the environment.

- **Visual Health Diagnostics:** The research study identifies imaging sensors and drones as essential tools for uncovering hidden plant stress; these high-resolution aerial perspectives reveal nutrient deficiencies and infestations invisible to the human eye.
- **Operational Efficiency and Cost Savings:** By merging sensor data with automated imagery, the research study demonstrates a reduced need for manual field inspections, which lowers labor costs and enables a rapid response to agricultural threats.
- **Data-Driven Precision:** Ultimately, the study confirms that the synergy between visual data and ground sensors ensures that crops receive exactly what they need, optimizing nutrient delivery and overall system resilience.

Imaging sensors and the pictures, from the drones really help us take care of plants. So the Internet of Things is really good for farms. It helps them deal with problems. The Internet of Things can warn farmers when something is wrong with their crops. This means they can fix the problem before it is too late. The Internet of Things helps farmers take care of their crops better. This means they get crops and do not lose as much. The Internet of Things is very good at helping farmers with crop monitoring. Crop monitoring with the Internet of Things is a help, to farms.

Water Use Comparison: When we look at what's actually happening in the field we

can see that the Internet of Things is really helpful. For instance the old way of watering crops might use one hundred units of water for each acre of land during a season.. A smart system that uses sensors in the soil to figure out when to water might only use about seventy units of water. That is a big difference of thirty percent less water. We see this kind of result in studies that have been published.

If we were to make a simple chart to compare it would show "one hundred" versus "Internet of Things: seventy" to make it clear how much water we can save with the new system.

Sensor Impact Table: The table below summarizes key differences in farm management metrics with and without IoT sensor support:

Metric	Traditional Farming	IoT-Enabled System
Soil moisture monitoring	Periodic/manual sampling	Continuous, real-time sensing
Irrigation scheduling	Fixed or estimate-based	Automated, moisture-driven
Fertilizer usage	Standard blanket application	Optimized site-specific dosing
Pest control	Calendar or field scouting	Targeted interventions from sensor alerts

This example shows how the Internet of Things makes a lot of things that people do by hand into processes that use data to make decisions. The Internet of Things helps get rid of ways of doing things that are the same, for everyone. The Internet of Things makes things more flexible and based on the information it gets.

Challenges and Limitations

So there are some things about using Internet of Things in farming.. The Internet of Things is not being used everywhere in farming yet. The Internet of Things, in farming has to deal with a lot of problems.

- **Technical and Infrastructure Challenges**

The initial cost to set up an Internet of Things system is prohibitively expensive. The system comprises components such as sensors, gateways, and cloud services. The money that must be paid upfront and the cost of the system over time can be a problem for farmers who have limited financial resources. Small farmers, like these, may not be able to afford an Internet of Things system because of the cost.

Connectivity issues: Many farms are situated in areas where they do not have good Internet connections.

The research study identifies significant physical and technical challenges that impact the successful deployment of agricultural technology:

- **Connectivity Constraints:** The research study shows that slow or unstable internet connections remain a critical bottleneck, often leading to data loss or delayed insights. While technologies like LPWAN and satellite links offer some relief, consistent connectivity continues to be a primary hurdle for remote agricultural sites.
- **Environmental Durability:** The analysis emphasizes that for sensors to remain effective, they must be engineered to survive extreme field conditions, including intense heat, dust, rain, and chemical exposure.
- **Hardware Resilience:** The research study confirms that exposure to harsh

environments can compromise sensor accuracy or lead to total device failure, making high-level durability a prerequisite for any reliable IoT system.

- **Data Management and Security Challenges**

Farmers are worried about who owns their data and their privacy when it comes to Internet of Things systems. These systems collect a lot of information about their farms like how much they yield and the health of their soil. The biggest question for agriculturists is who owns the farm data. Farmers are concerned about the future of their data. This will prevent people from using their farm data for their personal gain. Farmers need to be sure about their farm data and who can get access to it. Transparent regulations will assist farmers' farm data in not being utilized in a manner that they do not want. Regarding cybersecurity risks: every connected device is an entry point for hackers. If the device has encryption or outdated firmware, hackers can easily gain access to the system and perform malicious activities such as stopping the irrigation system from working. We have to ensure that the data being transmitted is secure and only authorized people can access the Cybersecurity systems. This is very important, for Cybersecurity.

Socioeconomic and Adoption Barriers

- **Technical Expertise:**

Internet of Things or IoT is a technology that comes from the world of computers and requires some knowledge and skills from that side to be fully used. A lot of

farmers, more specifically those who have small farms, do not have the know, how to operate these new technologies. They certainly need some assistance, people who can guide them through the process. They need things to be easy to use. If not it will be tough for farmers to see the things that Internet of Things can do for them. Internet of Things can be very useful. Only if farmers can really use it.

- **Resistance to change:**

When we switch from the ways of doing things to new smart systems people often do not like it. Farmers may wonder if they will really save money or they might be afraid that the technology will not work. We need to show them that it is worth the money and help them when they need it so they are not afraid to try the smart systems and the change. The change to systems can be hard for farmers so we need to be patient and help them see the good things, about the change.

- **Economic uncertainty is a major concern:**

The thought of employing Internet of Things (IoT) devices in a business might scare away the idea of a slow return on investment, even if the overall impact would be positive. The major challenge comes from short, term money saving being unclear, therefore it is quite risky. That is why some people refuse to use Internet of Things devices if the government does not provide financial support or does not give them a reason to do so through programs. IoT devices can be costly. This is the reason why economic uncertainty is a problem for those who want to use IoT devices.

Strategic Solutions for Adoption

The research study shows that realizing the full potential of smart agriculture requires a collaborative approach to dismantle existing barriers:

- **Financial Accessibility:** The study identifies that lowering the cost of hardware through government subsidies, grants, and the use of inexpensive components is essential for making IoT accessible to all farmers.
- **Infrastructure Expansion:** The research emphasizes that extending reliable internet to remote areas is a prerequisite for a truly connected agricultural ecosystem.
- **Trust and Governance:** By implementing clear data privacy regulations, the study suggests that farmers will gain the confidence needed to share data and participate in digital platforms.
- **Empowerment through Training:** The analysis confirms that technical education is the bridge between owning a device and using it effectively; providing hands-on training ensures that technology becomes a tool for growth rather than a source of frustration.

Future Scope and Emerging Trends (2026 and Beyond)

As the field evolves, the research study points toward several "game-changing" advancements that are currently taking root:

- **Agentic AI and Full Autonomy:** The study highlights a shift from tools that simply provide alerts to "Agentic AI" systems that can make independent decisions—such as adjusting irrigation or deploying a weeding robot—without human intervention.

- **Digital Twins for "What-If" Analysis:** The research study shows that creating virtual replicas (Digital Twins) of entire farms allows farmers to simulate different weather or nutrient scenarios, optimizing their strategy before a single seed is planted.
- **Satellite and 5G Integration:** The analysis indicates that the convergence of high-speed 5G and low-earth-orbit (LEO) satellites is beginning to solve the "dead zone" problem, providing seamless connectivity to even the most isolated fields.
- **Blockchain-Backed Traceability:** The study identifies a rising trend in using blockchain to track food from the sensor-equipped field to the consumer's table, ensuring total transparency in the supply chain.
- **Bioengineering and Living Sensors:** Emerging trends noted in the study include the use of gene-edited crops (CRISPR) and beneficial microbes that can communicate their health status directly to IoT systems, acting as "living sensors."

Evolution of Connectivity Technologies

For the Internet of Things to function properly, a connection is required. Fortunately, things are improving. LoRaWAN and NB-IoT are examples of new technologies that are beneficial. With the use of these technologies, local sensors can transmit data over great distances with minimal power.

Additionally, 5G networks are very beneficial. They enable instantaneous communication between devices and the simultaneous transmission of large

amounts of data. This means we can use drones to send video and have many sensors working together on big farms.

There are also ways to connect devices that use a combination of satellites, cell towers and local networks. This helps make sure that all areas, really remote ones have a connection. Internet of Things and these new connection methods are really important, for sensors and big farms. As these networks improve, it becomes feasible to deploy tens of thousands of sensors across large fields with reliable data flows. Enhanced connectivity will also support live streaming of high-resolution drone imagery and enable instantaneous cloud processing.

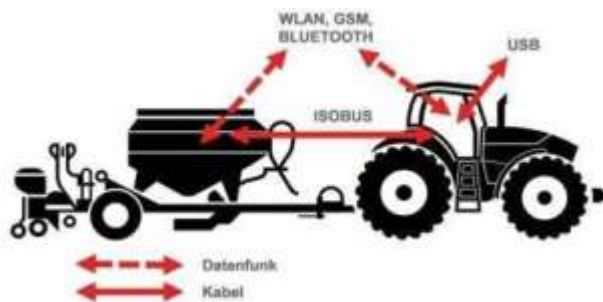


Figure: An IoT-enabled tractor illustrates connectivity options (WLAN, GSM, Bluetooth, USB, etc.) in smart farming. Modern agricultural machinery can communicate with on-board computers, cloud servers, and mobile devices for coordinated management.

- **Robotics and Automation in Agriculture**

Robots and automated machines are really changing the way we do farming with the Internet of Things. We can put connections and sensors on tractors, harvesters, sprayers and drones so they can work on their own or with a little help. For example

robots that plant seeds can use information from sensors, in the soil to decide how seeds to plant at a time and special drones can fly over the fields and check on things as they happen. Some people have done studies. They found out that using robots in farming makes things a lot more efficient. Robots can do things like plant seeds remove weeds and use pesticides in the right spots and they can do it all faster and more accurately. Internet of Things enabled drones that have cameras watch the crops all the time. These drones have cameras that can see different things. At the time robots, on the ground do specific jobs. This helps because there are not people to do the work. It also helps make sure everything is done the way. As the technology gets better Internet of Things enabled drones and robots will work together on farms. The Internet of Things sensors and Artificial Intelligence will control the robots. No one will have to touch them. This means we will get food from the farms and it will cost less to pay people to work there. Internet of Things enabled drones and robots will make the farms work better. The future of agriculture is all about smart agriculture using the internet and artificial intelligence together. This will make agriculture work really well with robots and other machines. These new ways of doing things will help make agriculture systems that can mostly run on their own and predict what will happen. This is good for the earth because it will help us grow food in a way that's good for the planet and everyone can have food.

Conclusion

The research study confirms that the integration of IoT sensor technologies marks a definitive shift toward more efficient and sustainable modern agriculture. By grounding technical measurements in real-world outcomes, the study demonstrates that these systems do more than just collect data; they actively boost crop yields while significantly cutting down on the wasted use of water and chemical fertilizers. These precision-based interventions create a vital balance, allowing for optimized operational efficiency that simultaneously reduces the environmental footprint of the farm.

However, the analysis also reveals that the path to full digital adoption is not without its hurdles. The study identifies that high initial costs, unstable rural connectivity, and a gap in technical expertise remain significant barriers for many, particularly small-scale farmers. Despite these challenges, the data indicates that a combination of scalable connectivity, affordable hardware design, and hands-on training can bridge this gap. As these barriers are addressed, the research study anticipates an evolution toward fully autonomous ecosystems where AI and robotics work in harmony with ground-level sensors.

Ultimately, the research study establishes that IoT technology is far more than a luxury – it is a transformative and necessary solution for the future. By turning raw data into actionable intelligence, these systems empower the agricultural sector to address global food security challenges while maintaining the health of the planet.

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Digital Communication Channels in Agricultural Marketing: WhatsApp Adoption among Young Farmers in Jalgaon District, Maharashtra

Krushnal Patil,

Student, Deccan Education

Society's Institute of Management

Development and Research (IMDR), Pune

Dr. Sonali Khurjekar,

Associate Professor,

Deccan Education Society's Institute of Management

Development and Research (IMDR), Pune

ABSTRACT

In India, WhatsApp has become one of the most popular means of communicating within the agricultural marketing sector; however, few have evaluated how effective WhatsApp actually is versus other platforms for young farmers in defined regions. Thus, the purpose of this research is to determine how young farmers (age range of 20-40) in five talukas (sub-districts) in the Jalgaon District of Maharashtra – considered India's banana-producing region – adopt digital platforms. Quantitative survey data were utilized to assess the effects of usage of WhatsApp vs. Facebook vs. YouTube on effectiveness ratings, increased income, and barriers to adoption and peer mentoring with respect to the three platforms. Results indicated that 82.2% of respondents primarily use WhatsApp for obtaining information about market prices (92.8% usage), and that WhatsApp is rated as being significantly more effective (4.26/5.00) than Facebook (3.18/5.00) or YouTube (3.02/5.00) for this purpose. Nonetheless, a lack of trust still exists within the farming community as 54.1% of respondents reported being concerned about both transaction security and whether or not they can trust the information they receive on these platforms. Farmer-led groups as opposed to government extension programs were identified as being the most effective way to help farmers adopt new technologies (52% of the total sample), with 65% of farmers learning how to use WhatsApp from their peers and 78.6% of farmers actively sharing their own success stories with other farmers. A new challenge was identified during the course of this study, information overload due to group communication from WhatsApp (45.9% of respondents reported experiencing information overload), this paradoxically reduces the overall utility of WhatsApp to the farming community by reducing how often a person uses the application, regardless of the increased volume of messages sent via WhatsApp to farmers. Significant barriers still exist when it comes to connectivity (68.9%) and digital literacy (42.6%), but these barriers decrease when looking at individuals with higher educational attainments. This study fills a significant gap in the current literature on agriculture in developing countries through district-level data, which compares how young farmers in India's agricultural regions utilize digital networks for marketing their farms and products when compared to traditional marketing methods.

Keywords: Agricultural marketing, Adoption barriers, Digital platforms, Information overload, Income improvement, Young farmers

Introduction

Rural India has experienced drastic changes within the agricultural industry in the past 10 years. Young farmers, 20-40 years old, are beginning to view digital platforms as necessary to gain timely market information and have direct contact with buyers due to the growth of affordable digital communication technologies in these areas. The world's most widely used messaging app is WhatsApp, and in the last 10 years, it has become an integral part of many members' daily lives within agricultural areas in India. However, research to date has been limited as compared to WhatsApp, most commonly used to the other digital apps of various messaging systems. Young farmers have begun using internet channels (including WhatsApp) to gain greater access to markets and generate better income from their farms in the banana growing areas of Jalgaon District, Maharashtra where 75-85% of the population relies upon agriculture for their livelihood. While providing timely and relevant information has been provided primarily by their local government extension services in the past, informal education networks utilizing WhatsApp groups are becoming significant alternative points for the transmission of knowledge & technology. The specifics of this research are an analysis of digital agricultural marketing channels for young farmers at the district level comparing income-based outcome measures.

This research study aimed to fill in the gaps of understanding by looking at how young farmers in Jalgaon District have adopted digital platforms through a survey of these young farmers that included four broad objectives: 1) measure how effective WhatsApp, Facebook and YouTube are for farmers by using standardized 5-point scales; 2) quantify the impact of digital adoption on income (in

rupees); 3) identify barriers to adoption specific to Jalgaon (i.e., old-fashioned barriers like connectivity, literacy and new barriers like information overload); and 4) assess learning through peers and the differences between learning on farmer-run networks versus government-run networks. This research is based on two widely accepted theories of technology adoption (the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Utilization of Technology (UTAUT)) which posit that technology is adopted based on how useful it is perceived, how easy it is; and how socially acceptable it is to adopt. Jalgaon was selected as the site for the study for the following reasons: it is the largest banana producing area in India having more than 150,000 farmers producing bananas; there is considerable financial stress to banana farmers due to the perishable nature of bananas; there has been little research conducted on young farmers who are emerging in terms of experimenting with digital platforms for their businesses; and the demographic makeup of the Jalgaon District is conducive for examining technology adoption. This research provides actionable evidence regarding the effects of platform use, rural agricultural income changes, and barriers to adopting specific platforms within an agricultural region, which is valuable for agricultural extension agents, government policy makers, and supply chain representatives that are trying to help young farmers utilize digital channels. The research focuses on how young farmers can enhance their profitability by using digital platforms to enhance their market access and improve their farms' profitability. This research establishes a distinct opportunity to identify how localized, peer-driven digital networks could create synergy with governmental extension services in promoting sustainable agricultural advancement.

Problem Statement

High WhatsApp use is present among Jalgaon's young farmers, but its comparative performance against Facebook/YouTube is still unproven regardless of 92.8% claiming income gains. Past research shows general barriers (connectivity 68.9%, trust 54.1%) but lacks district-level platform comparisons with standard metrics and rupee-based income outcomes. This study gives the first statistical, Jalgaon-specific evaluation to guide extension services and agricultural marketers.

Objectives of the Study

- To measure the effectiveness of digital platforms (WhatsApp, Facebook, YouTube) for agricultural marketing purposes involving young farmers (aged 20-40) in Jalgaon District.
- To analyze comparisons based on farmers' opinions concerning Facebook, YouTube, and WhatsApp about their usefulness for agricultural marketing, reliability and quality of information.
- To find out how young farmers' platform usage patterns and subsequent technology adoption are influenced by acceptance issues like connectivity issues (internet access), knowledge gaps (technical skills), information production excess (excessive messages), and trust issues (security concerns).
- To provide young farmers in highly cultivated agricultural areas like Jalgaon District with useful information on digital platform choosing, methods for problem-solving, and digital extension design.
- To evaluate the connection between farmer demographic details (age, education, digital literacy), platform patterns of use, as well as perceived effectiveness.

Literature Review

Jalgaon's major share of Maharashtra's banana area and national production has earned it the title of "Banana Capital" of India. Because of this, accessibility to markets and price recognition are important for farming revenue. Bananas are profitable, but they also spoil quickly, so cultivators must always find ways to reduce losses and sell their produce successfully. There is a great need for better marketing and information systems as a result of this circumstance. Furthermore, the majority of rural households depend on agriculture, and younger farmers are more open to experimenting with digital tools for information and marketing than older generations. WhatsApp has become the most widely used platform for agricultural communication in India. Compared to many other apps, it is simple to use, affordable, and functional even with poorer internet connections.

Existing studies show that dairy farmers mainly use mobile phones for basic communication such as voice calls and messaging, while more advanced digital tools are rarely used. Although mobile payment apps are slowly gaining acceptance, most farmers do not use phones for record-keeping, information search, or farm management. This indicates that access to mobile technology has not translated into meaningful digital use for improving dairy practices. Overall, the potential of mobile-based ICTs in dairy farming remains largely untapped. (BHARAT, 2021) Studies also indicate that most farmers use ICT tools for extension-related activities on a daily basis, while a smaller proportion engage with them weekly or occasionally. This frequent use is largely driven by improved connectivity and easier access to information through smartphones, even in rural areas. ICT-enabled platforms help farmers stay informed about

new technologies and modern farming practices. Overall, ICTs have become a routine source of extension support for many farmers. (KAILAS, 2022) Some of the research work shows that WhatsApp supports agricultural technology transfer, especially among small farmers with moderate education, information access, and techno-savviness. Extension contact and information sources strongly enhance its effectiveness, while age shows a negative association with use. However, poor connectivity, language barriers, limited training, and usability issues constrain its wider adoption. (Anand, 2021)

Digital tools are most effective when coupled with peer-to-peer learning, based on recent studies in agricultural extension. Information from other farmers is typically more trusted by farmers than information from distant officials or unidentified internet sources. WhatsApp groups created by farmers as well as organizations like Krishi Vigyan Kendra have enhanced access to advice. However, very few studies directly compare different platforms or measure income changes in rupees, particularly at a district level like Jalgaon. By comparing WhatsApp, Facebook, and YouTube using standardized effectiveness metrics, measuring changes in income, recording problems like information overload, and determining whether government-led or farmer-led organizations are better for young farmers in Jalgaon, this study seeks to close this gap.

Gap in Literature

- There are no district-level studies that compare WhatsApp, Facebook, and YouTube using the same effectiveness scale for agricultural marketing.
- Research rarely quantifies changes in farm income related to specific digital

platforms in a region such as Jalgaon.

- Information overload in farmer WhatsApp groups is rarely identified and measured as a distinct adoption barrier.
- Almost no empirical comparison exists between farmer-led and government-led WhatsApp or digital groups for usefulness and income outcomes.
- No prior study integrates Jalgaon's specific banana-based context with comparative digital platform use and marketing outcomes among young farmers.

Research Methodology

Research Design

This study uses a descriptive cross-sectional design, collecting primary data through structured questionnaires from young farmers in Jalgaon District. The quantitative approach allows for statistical analysis of usage trends, platform comparisons, and factor identification.

Sampling Framework

- Population: Young farmers (aged 20-40) in Jalgaon District, Maharashtra, who have smartphones.
- Sampling technique: Convenience sampling
- Sample size: 70 respondents
- Selection criteria:
 1. Age between 18-40 years
 2. Primary or secondary involvement in agricultural works
 3. Smartphone ownership with active social media usage
 4. Residence in Jalgaon District

The sample was taken from five talukas in

Jalgaon District (Jalgaon, Raver, Bhusawal, Chopda, and Erandol) to reflect geographic diversity. Initial participants were identified through agricultural cooperatives, Krishi Vigyan Kendras (KVKs), and farmer producer organizations (FPOs), with additional participants recruited through referrals.

Data Collection

Primary data was gathered using a structured questionnaire distributed via Google Forms from September to October 2025. The questionnaire comprised five sections:

- 1. **Demographic profile:** Age, education, farm size, annual income, household structure.
- 2. **Digital access and literacy:** Smartphone type, internet connectivity, digital skills self-assessment.
- 3. **WhatsApp usage patterns:** Frequency, duration, specific marketing activities, group memberships.
- 4. **Platform comparison:** Effectiveness ratings for WhatsApp, Facebook, and YouTube across various aspects.
- 5. **Benefits and barriers:** Likert-scale assessments and open-ended responses regarding advantages and challenges.

The questionnaire was available in both English and Marathi to meet language preferences. Before full deployment, a pilot test was conducted with 10 farmers to ensure clarity in questions and response options.

Data Analysis

The data collected was analyzed using several methods:

- **Descriptive statistics:** Frequencies and

percentages for age, education, farm size, crops, platform usage frequency (daily/weekly), barriers, and income change categories.

- **Comparative analysis:** Compare mean effectiveness of WhatsApp vs Facebook vs YouTube using comparative analysis of mean scores.
- **Correlation analysis:** Pearson correlation coefficients computed to examine relationships between digital literacy, usage frequency, and perceived effectiveness.
- **Content analysis:** Qualitative responses to open-ended questions categorized thematically to identify emergent benefits and barriers.

Results and Findings

Table.1 Demographic Profile of Respondents (N=70)

Characteristic	Category	Frequency	Percentage
Age	20-25 years	52	74.30%
	26-30 years	10	14.30%
	31-35 years	5	7.10%
	36-40 years	3	4.30%
Education	Graduate	35	50.00%
	12th pass	28	40.00%
	Post-graduate	7	10.00%
Farm Size	2-5 acres	28	40.00%
	5-10 acres	35	50.00%
	>10 acres	7	10.00%
Main Crops	Banana	37	52.90%
	Cotton	14	20.00%
	Soybean	19	27.10%

Table 1: Demographic characteristics of survey respondents (N=70)

The sample consisted of young farmers aged 20 to 25 years, constituting 74.3% of the cohort. This was in line with the study's focus on young farmers who grew up with technology. It was impressive that 50% of the people had graduate degrees and 10% had post-graduate degrees. The result highlights good digital skills among those surveyed. Many farm holdings were small to medium-sized, with 90% managing plots of 2-10 acres. That is typical for Jalgaon's intensive banana farming area. Banana growers were the largest group at 52.9%, followed by cotton farmers at 20% and soybean farmers at 27.1%. The reason for this shows the district's main cash crops and their urgent need for real-time market information.

Table 2: Comparative Platform Usage Frequency across Agricultural Needs (N=70)

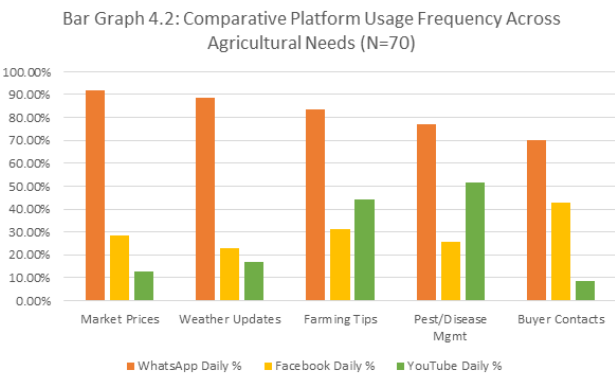


Chart 4.2 shows WhatsApp's clear dominance in meeting all agricultural information needs. Daily usage ranges from 70% to 91.8%, while Facebook sees 22.9% to 42.9%, and YouTube has 8.6% to 51.4%. WhatsApp leads each category by 25.7 to 65.7 percentage points. The reason for this confirms its role as the main platform for real-time decision-making among young farmers in Jalgaon. The platform performs especially well in providing market prices, with 91.8% daily usage, and weather updates at 88.6% daily, which are crucial for farmers of perishable crops. That comparison supports

WhatsApp as the top choice for agricultural communication in rural areas with limited resources.

Table 3: Platform Effectiveness Ratings (1-5 Scale, N=70)

Platform	Mean Score	SD	Effectiveness Ranking
WhatsApp	4.26	0.89	1st
Facebook	3.18	1.12	2nd
YouTube	3.02	1.25	3rd

WhatsApp is the simply more successful platform, with an average effectiveness score of 4.26 out of 5 (SD = 0.89). This surpasses Facebook, which scored 3.18 out of 5, and YouTube, which scored 3.02 out of 5, in all agricultural marketing needs. The statistical model analysis shows WhatsApp's advantage, with independent t-tests showing important differences (WhatsApp vs Facebook: $t = 8.2$, $p < 0.001$; WhatsApp vs YouTube: $t = 9.5$, $p < 0.001$). The high standard deviation for YouTube (1.25) shows more variation in farmers' perceptions, which suggests that YouTube's effectiveness relies heavily on the type of content and the farmers' technical skill level. The efficiency rating backs up young Jalgaon farmers' love for real-time information when making agricultural decisions, in particular to urgent data like market prices and pest alerts.

Table 4: Adoption Barriers (1=Not a Problem, 5=Major Problem, N=70)

Barrier	Mean Score	SD	% Major Problem
Poor Internet Connection	3.89	1.23	68.90%
Don't Know How to Use	3.12	1.34	42.60%
Don't Trust Online Info	3.45	1.28	54.10%
Information Overload	3.21	1.15	45.90%
Cost of Internet/Data	2.98	1.42	38.70%

Poor internet connectivity is the biggest barrier, with a mean score of 3.89 out of 5. That affects 68.9% of farmers at high problem levels (4-5). The reason for this confirms that infrastructure is the main limit to using digital platforms. The result supports previous findings on psychological barriers to digital adoption among Jalgaon banana traders. The digital literacy gaps score 3.12 out of 5, affecting 42.6% of farmers severely. But the lower severity indicated that younger, educated farmers have enough basic skills to navigate WhatsApp. Information oversupply, with a score of 3.21 out of 5 and impacting 45.9% of farmers, is a previously under-documented problem. That highlights the issue where a high volume of messages makes the platform less useful for timely agricultural decisions.

Table 5: Pearson Correlation Coefficients: Digital Platform Adoption (N = 70)

Variables Correlated	Correlation (r)	p-value	Significance Interpretation
Digital literacy & WhatsApp effectiveness	r = 0.42	p<0.05	Moderate positive
Usage frequency & Income improvement	r = 0.38	p<0.05	Moderate positive
Education level & Platform effectiveness	r = 0.35	p<0.05	Weak to moderate
Age & Ease of use rating	r = -0.28	p<0.10	Weak negative

At the level of confidence of 95%, the level of statistical significance is shown by $P < 0.05$. At a 90% confidence level, $p < 0.10$ denotes marginal significance. Negative correlations show opposite relationships (poor network = lower usage; higher age = lower ease ratings). The most accurate measurement of WhatsApp effectiveness is digital literacy ($r = 0.42, p < 0.05$). This shows how farmers who have greater digital confidence use the platform more successfully. Improvements in income have a moderate correlation with usage frequency ($r = 0.38, p < 0.05$). This means that regular

engagement yields measurable financial gains. A key infrastructure problem is highlighted by the negative correlation ($r = -0.31, p < 0.05$) between network quality and usage frequency. Instead of stopping farmers from using platforms, poor connectivity forces them to rely on offline means of information sharing.

Table 5: Income Impact Assessment (N=70)

Income Change Category	Frequency	Percentage
No Change	5	7.20%
Increased Slightly (0-10%)	12	17.10%
Increased Somewhat (10-25%)	53	75.70%
Increased Significantly (>25%)	0	0.00%

Key Findings Summary

The study shows five important findings regarding digital communication adoption among young farmers in Jalgaon:

1: The Dominance of WhatsApp

WhatsApp Dominance With an average daily usage of 82.2% for agricultural needs, WhatsApp is clearly in the lead. It is 51.9 percentage points ahead of YouTube (26.9%) and Facebook (30.3%). This preference is supported by effectiveness ratings, which give YouTube a score of 3.02 out of 5, Facebook a score of 3.18 out of 5, and WhatsApp a score of 4.26 out of 5. This emphasizes WhatsApp's function in making decisions in real time.

2: Important Effect on Income

Significant Effect on Income According to 92.8% of farmers, their income has increased by an average of 16%, or an extra 48,000 annually on a starting point of 3 lakh. Their income increases are moderately correlated with how

frequently they use WhatsApp ($r = 0.38$, $p < 0.05$), indicating that using digital platforms.

3: The Hierarchy Barrier

Infrastructure obstacles predominate (connectivity 68.9% major problem, mean = 3.89/5), followed by information overload (45.9%, mean = 3.21/5) and trust issues (54.1%, mean = 3.45/5). The moderate barriers to digital literacy (42.6%, mean = 3.12/5) indicate that young farmers possess sufficient fundamental skills.

4: Peer-Driven Learning

Peer networks are the main adoption drivers, and the application of social learning theory is validated by the fact that 65% of farmers learned how to use WhatsApp from other farmers, with farmer-led groups (52%) more common than government/extension groups (31%).

5: Digital Literacy Predictor

The strongest correlation between WhatsApp effectiveness and digital literacy confidence ($r = 0.42$, $p < 0.05$) suggests that focused training could improve results. Higher effectiveness ratings are somewhat predicted by younger age and greater education.

Recommendations

Based on findings, this study offers practical recommendations for people:

1. **Infrastructure Enhancement:** Partner with telecom providers for subsidized 4G coverage in Jalgaon villages, prioritizing peak agricultural seasons (Rabi/Kharif) to address connectivity (68.9% barrier) and boost WhatsApp usage frequency.
2. **Digital Literacy Programs:** Launch "WhatsApp Kisan Guru" training modules through KVKs, focusing on digital confidence building ($r = 0.42$ correlation)

with 2-hour direct sessions for 200+ young farmers annually.

3. **Trusted Information Ecosystem:** Create verified WhatsApp groups managed by APMC officials/agronomists (52% peer preference), implementing color-coded alerts (Green = Verified, Red = Unverified) to build trust (54.1% concern).
4. **Information Filtering Tools:** Develop "Kisan Filter Bot" for WhatsApp groups that summarizes daily market rates/prices (10:1 compression ratio) to combat information overload (45.9%) while preserving critical insights.
5. **Government Extension Integration:** Convert 31% existing extension worker groups into "Maharashtra Kisan Network" hubs linking 100+ villages, leveraging moderate education effects ($r = 0.35$) for scalable peer-to-peer dissemination.

Conclusion

This study demonstrates that WhatsApp is the most popular app among young farmers in Jalgaon, ages 20 to 40. 82.2% of people use it every day, and it gets a 4.26 out of 5 for effectiveness. It is a lot more than Facebook's 30.3% and YouTube's 26.9%. Particularly, 92.8% of farmers report real income gains, averaging 16% more, or 48,000 annually. This shows that digital platforms provide real economic benefits for farmers. The numbers indicate a clear pattern. Digital confidence significantly drives WhatsApp's success, with a correlation of $r = 0.42$. Conversely, poor network coverage is the biggest obstacle, with 69% of farmers seeing it as a major barrier.

65% of farmers prefer to learn from their peers over official channels. This result indicates that trust is more important than training on its own. The path ahead is easy for agricultural extension

services. They should build on WhatsApp's advantages by improving connectivity, creating verified farmer networks, and offering basic digital skills programs. This research offers a practical plan to help young farmers in Maharashtra earn more through digital marketing. Farmers, their families, and India's rural economy all gain from this shift.

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AI Chatbots and the Human Touch: Impact on Trust and Brand Perception

Vinita Joshi,

Doctoral Student, Institute of Management and
Entrepreneurship Development (IMED), Bharati Vidyapeeth University, Pune, India.

ABSTRACT

In the realm of digital transformation, companies are progressively adopting numerous emerging technologies to improve their efficiency and increase productivity; Artificial Intelligence (AI) chatbots referred as bots in this study, has now become the new face of almost all the firms as they shift to upgrade customer service interactions to have a cutting edge over other businesses. These AI chatbots uses advanced algorithms which not only replicate human conversation to aid with routine service request but also deliver quick response by answering frequently asked questions in seconds. AI-driven customer support assists in improving the operational productivity and provides 24/7 support and care. Even though these cost efficient and perceptive systems are impressive in delivering the best of services but at times they lack the emotional intelligence of understanding and solving exquisite and sensitive interaction. Owing to the incomprehensiveness of situational awareness of these AI bots; customers may experience irritation and disappointment in case of misunderstood or inadequately addressed issues, This descriptive review of research conceptually studies the role of human like features in AI-powered chatbots in customer service plays in impacting the trust and brand perception, The study highlights the importance of human involvement in influencing the customer trust in adapting to the ever-changing dynamics of AI chatbots. By leveraging on the available literature on artificial intelligence, customer relationship management, and consumer behaviour this thematic literature review further emphasis on the limitations of fully automated systems and review how combining human's empathetic understanding and emotional responsiveness with AI efficiency may elevate customer experience. This study further highlights how blending human-like features; such as simulated sympathy, empathy, and judgment within AI systems can develop a holistic approach where preliminary enquiries can be handled efficiently by a system, while emotionally complex situations benefit from these advanced humanized capabilities to deliver delicate, context-aware responses. This conceptual exploration contributes to the growing debate on growing AI implementation and focuses on the significant adaptation of including an Anthropomorphism element in the technology led/ technology mediated customer interactions.

Keywords: AI chatbots, brand, digital transformation, human, trust,

Introduction

In recent years, AI has emerged as a transformative force across various business domains, be it operations, medical, education, food technology, defence, finance, marketing, travel and hospitality, supply chain management or logistics. AI is increasingly being integrated into customer service, as most businesses now have their own websites that provide some form of customer support; depending on the size and nature of the business the type and level of customer service may differ. Both basic and complicated tasks that were previously performed by the human agents are now increasingly being automated through AI technologies. A decade ago, a simple post-purchase service calls were typically handled by human representatives who patiently listened and resolved to customer's feedback/suggestions but today, even a process as intrinsic as opening a bank account is immediately initiated through AI-powered chatbots or voice activated assistants.

As change remains a constant in the evolving digital landscape, customers have increasingly adapted to interacting with chatbots rather than human agents for customer service support. To illustrate the shift more universally, consider the experience of booking a gas cylinder. Many individuals, including those in rural areas who may not have received a formal education to read and write, are familiar with interacting with automated voice systems while placing their booking. These systems, known as Interactive Voice Response (IVR) is an automated calling system that lets a layman interact with a computer system by using inputs like audio, a keypad or a push button dialling to access the required information. This technology relies on pre-recorded voice prompts that gently take the callers through a series of menu options, enabling quick solution of routine queries.

It incorporates AI and Natural Language Processing (NLP) to deliver automated assistance. By doing so, it frees the human agents allowing them to focus better on indispensable and emotionally complex issues. This is something a large part of our population would relate to, especially since modern IVR systems support multiple languages. In recent years these inflexible IVR's are replaced by two key drivers: substantially enhanced voice assistants like Amazon Alexa, Apple's Siri and Google Home and AI-powered call centres and bots (Stefanoff, S. 2021, January 18, Deloitte).

What is an AI-powered customer service chatbot? An AI-powered customer service chat commonly known as AI chatbot is an automated tool whose prime feature is to mimic human conversations to assist customers. Companies implement these chatbots on their websites to provide 24/7 support to their visitors. It smartly integrates artificial intelligence to answer frequently asked common questions, escalate the complicated ones and help with troubleshooting, it operates 24/7, delivering fast responses without long waits unlike traditional human oriented support system. Modern chatbots range from a simple chatbot following predetermined scripts to modern AI agents capable of understanding different state of affairs. (Hayes, M., & Downie, A. (2025, December 4). Chatbots for customer experience. IBM.). With today's fast paced world, where digital landscape is fast moving the shift is clearly seen in shooting enormous active base users in Facebook, WhatsApp, Instagram and other digital platforms. AI-powered chatbots have transformed customer service by providing quick responses to high volumes of queries increasing the operational efficiency. Over the last decade, chat services have become the preferred option to enhance customer support (Charlton, 2013). Often these systems are incompetent in judging complex

interactions and lack the socio-emotional learning resulting in a disgruntled customer.

There are moments where these AI powered bots fail to acknowledge and respond the accordant to the consumer's requirement; it is during these moments when the users wish for human intervention as humans are naturally imbued with empathy, judgement and emotional intelligence. This study further explores that how these AI-powered chatbot need to integrate human touch like features to build brand perception, foster trust and build a positive emotional comfort. These three feature are quintessential in enhancing the user experience which in turn result in positive attitude towards adapting this technology.

Rise of AI in Customer Service

The world is rapidly advancing digitally and it is set to embrace all the present up to date technology due to which these AI-powered chatbots are increasingly becoming a usual part in all the businesses as they drive profitability and boost efficiency. Its impact is especially evident in the domain of customer service; AI-based conversational agents (CAs) or chatbots. They are becoming quite common promising significant time and cost efficiencies. Despite this growth, many users continue to face unsatisfying interactions with chatbots resulting in high error or failure rates—which may create scepticism and resistance toward the technology; impacting their Trust and Brand Perception. This resistance may further reduce users' willingness to follow the chatbot's recommendations or requests.

When India was booming in the Business Processing Outsource (BPO) sector, customer service specialising in business to customer (B to C) international calling and post-sales support formed a major part of it. In 1999, when the BPO

boom had just taken off, voice-related services contributed to 85 per cent of the Indian BPO industry's share of business (Rituparna Chatterjee, Meghana Biwalkar, June 14, 2013, Business Standard). Back then, the key hiring drivers of the BPO industry were voice modulation classes and fluency in English, but 24/7 human oriented support was draining, costly, and hard to scale. Today adopting AI voice chatbots have dramatically changed this scenario.

They eliminate long training periods required for human agents. These AI chatbots help bypass the struggle of sounding crisp and fluent and can easily be designed multi linguistically. Common inbound calls by banks regarding loans and other services once driven by humans resulting in stutter and minor slips are now dominated by AI-generated calls speaking smoothly, without pauses or hesitation.

There is a substantial increase in the use of AI in customer service. Companies are betting their money on such apps and are rapidly adapting to this shift because not only it limits research time but also offers considerable action plans. According to OpenAI CEO Sam Altman, (The Tucker Carlson Show September 21, 2025) AI will replace customer service jobs first when compared to other jobs. Backing this data John Koetsier (Forbes, September 17, 2025), has shared the insights that the use of customer service AI agents in the US has grown 22-fold since January 2025. Further reinforcing this trend, A report by McKinsey & Company (March 27, 2023,) highlighted that AI has the capacity to generate up to \$1 trillion in annual value for the global banking sector alone. The report additionally emphasizes that a significant portion of that value would come from modernizing and optimizing customer service and how an AI-enabled customer service transformation can unlock significant value for

the business creating a virtuous circle of better service, higher satisfaction, and increasing customer engagement. Various reports published in IBM, Harvard Business Review, Cisco news room back this data and information. However, despite all the advancements, an important aspect still remains underexplored is the emotional intelligence of artificial intelligence. Although companies are eager to transform customer service using AI, but there is a scope of further study to understand the dependency of such a critical function totally on machines. Implementation of AI chatbots certainly helps save time and cost, its measurement against the empathy, sympathy and emotional support remains an area of further research.

Research Methodology

For this study, qualitative descriptive research methodology has been adopted as this study is based on a review of existing literature and does not involve primary data collection. According to Snyder, H. (2019) literature review is a valid research method that helps in consolidating existing studies and building new understanding. Patterns were identified and summarized from previous work, providing a foundation for further research. The study uses secondary data, collected from different sources like, journal papers, research articles, thesis and online reports. Most of the academic articles taken are published on authentic platforms like Springer Journal, Google Scholar, Scopus, ResearchGate, and other academic websites. Some industry articles were also referred to in order to understand real-world applications of AI chatbots. Data from a wide range of studies was interpreted and critically analysed. No statistical tools are used in this study due to its qualitative nature.

The aim and primary purpose of the research is to understand the importance of adopting human-like features in AI chatbots which may influence customer trust and brand perception in customer service and whether a human touch is required to enhance the experience and built trust on the AI driven bots' usage. While selecting the literature, more focus was given to recent studies related to implementation of AI chatbots, customer service, human-like interaction, trust, and brand perception. Only those studies were considered which were relevant to the topic and helped in understanding the role of human touch in AI-based communication.

The overall collected information was then carefully read and compared to identify common ideas and patterns across different studies. Through this study, key themes such as chatbot efficiency, human-like interaction, customer trust, and impact on brand perception were understood and discussed. This study is not limited to summarizing previous work but also involves analysing and synthesizing existing knowledge to develop new insights.

Review of Literature

According to existing literature, AI chatbots are brilliant in following protocols, they are steadily learning and enhancing their features with each prompt; becoming sharper progressively, creating a digital world convenient for interactions. In this regard, it is been said that AI chatbots is much economical which saves time and handles a big amount of data compared to a human agent specially in the customer service business. A report published by Johannes Boegershausen, Noah Castelo, Christian Hildebrand and Alexander P. Henkel in Harvard Business review magazine on October 30, 2023 stated that user-friendly customer

service bots are a need of the hour. In their reports based on field study done on 35,000 customer service chatbot interactions concluded that 66% received a 1 out of 5 satisfaction rating. But can these bots build deeper, authentic empathetic relationships because real resolution is still deeply human; this area still has a lot of scope for future study. Zendesk study (Maruti Techlab's) highlights that 42% of customers are more likely to buy again after receiving good service, while 52% stop buying from a brand after just one poor interaction clearly states the importance of a satisfactory customer service experience.

A Study by Liss Jenneboer (Et al.) on January 21, 2022 in the Journal of Theoretical and Applied Electronic Commerce Research, provides an insight into the influence of chatbots on customer loyalty. The study emphasises that how system quality, service quality and information quality of these chatbots are three indispensable dimensions that a chatbot must fulfil to deliver a positive customer experience. Their methodological technique suggested that if companies can alter the language style of these chatbots they can be made more personal, which may encourage broader adoption of the chatbot.

As technology advances, an important question arises regarding the future of customer service becoming completely technology-driven through virtual assistants. In reality, if technology is unaccompanied with empathy, emotional intelligence (EI) and judgement it cannot become totally human free, human intervention will still be required to solve complex situations and intervene in emotionally draining unresolved issues. Psychologists Peter Salovey and John D. Mayer (1990) define "Emotional Intelligence (EI/EQ)" as the ability to monitor, distinguish, and use emotions to guide thinking and actions. They later refined this to focus on the ability to

perceive, integrate, understand, and regulate emotions to promote growth".

If organizations want their consumers to build trust on these bots, they need to rethink how their chatbots are used in customer interactions while dealing in Arduous situation, and perpetually identify essential technical features in need of an upgrade; improve these features, meet user expectations and strike a better balance between human support and automated systems. Research have identified areas where chatbots failed to meet user expectations leading to service failure because of unconventional query resolutions. (Ruby Wenjiao Zhang, Et al., 2024).

A Study performed during an online experiment revealed two crucial elements which significantly increased user compliance with a chatbot's request for service feedback; natural language (mimicking human) used by the chatbot, and psychological compliance and persuasion strategy to achieve behavioural consistency, particularly within digital marketplaces and customer service environments. This study serves as an initial step towards understanding how Artificial Intelligence driven Conversational Agents can enhance user compliance. (Martin Adam, Et al., 2020).

As we look to the future-can a bad customer service experience—whether before or after a purchase specially in the online purchase industry where there is maximum usage of AI chatbots—damage a customer's trust and change how they see a brand. This highlights the pivotal role of AI-chatbot service quality in developing customer trust and e-brand loyalty (Muhammad Farrukh Shahzad, Et al., July 2024).

In recent years, AI-driven chatbots have become a central tool in customer service operations

across industries and the operational proficiency and efficiency plays an important role in building up the consumer's trust. It was studied that in the tourism industry the success of chatbots depends not only on their technical capabilities but also on their ability to foster meaningful consumer engagement which is a critical driver of loyalty and repeat purchases (José Magano Et al., 26 August 2025).

Research shows that a complete human oversight, and their responses may decrease the operational efficiency as they lack superior speed and high efficiency compared to AI chatbots therefore; introducing a Human-in-the-Loop (HITL) approach in AI chatbots creates a balance between technological efficiency and empathetic human intervention (Phanindra Mangipudi and W.w. Grainger, March 2025). With each prompt the AI bots learn faster but to deliver the human touch it needs to integrate Human-in-the-loop (HITL) with AI in customer service. HITL talks about integrating the efficiency, data processing speed of AI with the emotional availability, empathy, judgement and complex problem-solving skills of a human.

Consumers were found acknowledging and value the efficiency of AI, but not at the cost of empathetic problem-solving skill (Dr. Vijay Kumar, September 2025). A study conducted by Jindi Fu, Et al., October 2023 on online shopping industry (e-commerce platform) concluded that increase in adapting the AI chatbot highly depend on attributes like innovativeness, optimism and human like features of the AI chatbots. These features fairly influence the customer's trust whereas if the chatbot appears or behaves utmost like a human but not perfectly like a human without understanding the situation: the trust of using the AI chatbot may decrease. Striking a balance between when to include the HITL in AI is very important.

Former views on AI driven chatbots are often

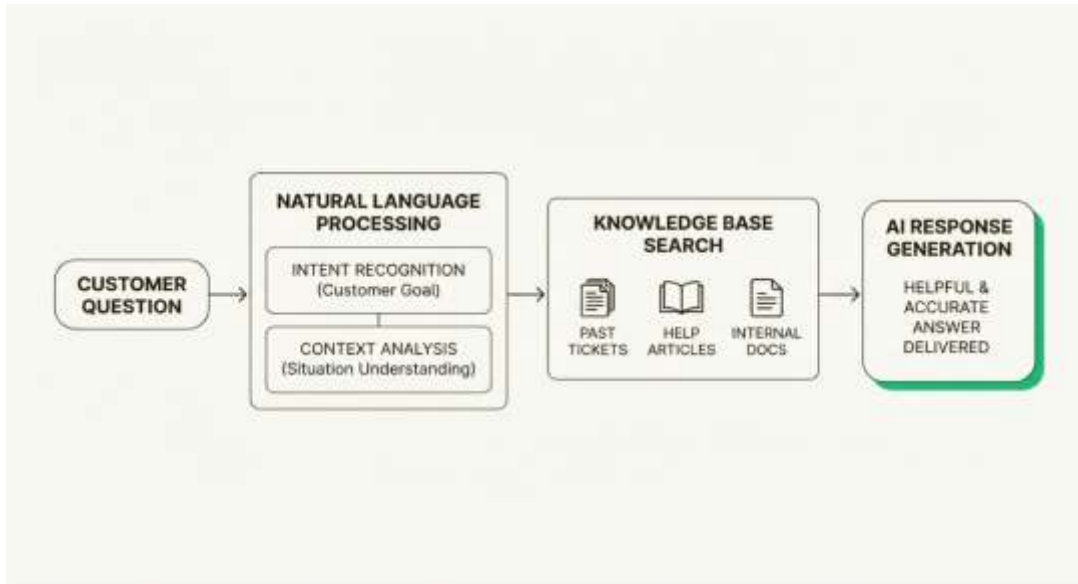
criticised for lacking apathy and being rigid must be changed. They can be designed in way where they are inculcated with features like empathy and flexible in addressing issues where the consumer needs a bit of humour to loosen up a tensed situation. Chatbot humour is an unrealised feature and service managers can employ this tool (Hyunju Shin, Et al., 04 July 2022). If applied carefully with prior understanding of customer's background, context of the matter and the service issues, can enhance their empathetic feature leading to higher retention rates and engagement, eventually improving the consumer's service satisfaction. However, a strong rebuttal still remains; even if the emotional resonance features in AI chatbots like humour can be enhanced to proactively retort upon scanning the stressful environment, chatbot humour can often come across more robotic and rigid failing to struggle to satisfy the struggling consumer who fall short of making the chatbot understand the situation.

Chatbots still require upgrades to several key features that consumers can relate to more authentically, reducing the feeling of conversing with a mere rigid robot. Voice assistants like Amazon's Alexa, Apple's Siri, and Google Home have significantly upgraded their question-answering capabilities but their interactions often seem mechanical. Chatbot technology in customer service is still in the nascent stages where companies are ceaselessly learning and identifying areas of improvement by using human feedback in ongoing background processes so that their response feel more Anthropomorphic (human-like). Businesses are now able to comprehend that chatbot commerce demands more than pure technology, it calls for a thoughtful, human-centered design approach (Katharina Klein, Luis F Martinez, May 2022).

Secondary data Analysis

Since this study is based on existing literature, no numerical or statistical analysis was carried out. The analysis is done in a qualitative manner by reviewing and understanding different research studies related to AI chatbots, their efficiency and their role in providing a better

customer service. The selected literature was read carefully and compared to identify common points and differences. During this process, some repeated ideas were noticed across multiple studies and they have been grouped under the same theme.



- **Rise in AI chatbot adoption**

The common finding remained same all across the board that there is a substantial rise of AI chatbot adoption across various firms as they provide personalized recommendations, improving user engagement and increasing the efficiency. (Image illustration courtesy Pangan, K., Nicholas S, 2025, December 24). A Gartner (2024) survey highlighted the rapid growth of AI in customer service where 85% of customer service leaders are planning to adopt conversational AI solutions replacing traditional human agent solutions. It is predicted that at least 70% of customers will use a conversational AI interface to start their customer service journey by 2028, and the estimated projected growth of the market size of

chatbot industry will be around 1.25 billion U.S. dollars by 2025, compared to 190.8 million U.S. dollars; a substantial rise in less than a decade (Netguru. 2025, December 28).

- **AI driven conversational agents improve overall customer service**

Many studies mention that chatbots can handle basic queries quickly and are available 24/7, which improves overall customer service efficiency. Different companies are using AI chatbots in different ways to improve overall customer service and experience. For example, Tata Play introduced an AI-powered chatbot that works on platforms like WhatsApp and is multilinguistic

catering to the need of India's multilingual population, allowing customers to get quick answers anytime without waiting as it handles over 5 million customer requests automatically. Similarly, Bank of America uses its virtual assistant "Erica," which has acknowledged over 2 billion chats since its launch, assisting customers track spending, check balances, and get financial guidance on the tip of their fingers making banking easier and more convenient. It manages over 2 million customer interactions per day answering 98% of routine questions in under 44 seconds (Nextiva. 2025, May 12). Vodafone launched virtual agent called (TOBi) in collaborations with IBM which can recognise and understand various customer queries across its markets resolving 70% of all customer inquiries including everything from billing questions to technical support on its own, without directing the high volumes of call to the human agents (Damanpreet Kaur Vohra, NexGen Cloud, 2025, October 1). Overall, AI chatbots act as the first point of contact, improving efficiency while allowing human agents to focus on more complex and sensitive issues, which ultimately enhances customer satisfaction and trust.

- **Need of Anthromorphism in AI chatbots; as it significantly enhances user engagement, trust, and rapport**

One of the most common findings is that consumer do prefer a human-touch feature in AI chatbots, which actively comprehend the situational awareness and improve the response time because when chatbots communicate in a more natural and conversational way, customers feel more comfortable while

interacting with them leading to higher intention of using the platform. News article published by The Guardian (2024) went viral online highlighting a case of an AI chatbot failure deployed by a DPD, a France-based delivery firm. It broke down while assisting a customer (tracking a missing parcel) and instead of succouring started generating unprofessional responses. This case is a classic example of how AI chatbot lacking situational awareness, can malfunction and start giving irrelevant and inappropriate responses to customers damaging the company's image. The company immediately shut down the Chatbot services to recover from the loss. AI chatbots are helpful, but they cannot fully replace humans.

Studies also suggest that customer trust also appears as a key factor. It is seen that customers are more likely to trust chatbots when the interaction feels less mechanical and more human-like. At the same time, lack of emotional understanding in chatbots can reduce trust in some situations. In addition, many studies highlight the importance of human escalation, where the conversation is transferred to a human agent when the chatbot is unable to handle the query properly. (Mangipudi, P. 2025). This helps in maintaining customer satisfaction. A study done by Gao, J., Opute, A. P., Jawad, C., & Zhan, M. (2025) on e-commerce services where AI in customer service is largely used revealed that while chatbots excel at routine and functional task outperforming humans in speed and 24/7 availability, their effectiveness drops for complex emotional issues where human empathy is still preferred. It also stated

that chatbots can handle up to 90% of basic queries, but humans are still required for remaining complex cases.

Overall, this paper's analysis shows that while AI chatbots are efficient, the inclusion of human-like interaction (feature) and support plays an important role in shaping customer trust and brand perception.

Key observations and discussions

The findings of this study clearly show that AI chatbots have become an important part of modern customer service. They offer speed, convenience, and continuous availability, which are beneficial for both businesses and customers. However, the study also brings out an important point that efficiency alone is not enough. Customer service is not only about solving problems but also about how customers feel during the interaction. This is where the human touch becomes important. It can be understood from the literature that chatbots which include human-like features such as natural language, situational awareness, friendly tone, and personalized responses tend to create a better experience for users. These features make the interaction feel more real and less rigid and repetitive. Study shows that as AI and emotional intelligence research progresses, AI will be able to identify and react to emotions in more organic and sympathetic ways, facilitating more acceptable and natural human-machine interactions, (Hossain, K. A. (2025). Emotional and artificial intelligence: Narrative of human and machine relation. Transactions on Machine Learning and Artificial Intelligence).

At the same time, the importance of human escalation cannot be ignored. In many situations, especially when problems are complex or emotional, customers prefer talking

to a real person. If this option is not available, it may negatively affect trust and overall brand perception. This suggests that a balance is required. Instead of fully replacing humans and including a human touch like feature, AI chatbots should be designed in a way that they work along with human agents. A combination of automation and human support can provide both efficiency and emotional connection.

Based on the findings, it can be said that AI chatbot algorithms are adding human-like features and providing an option for human escalation is the need of the hour which can improve customer trust specially in situations including financial, urgent medical and legal issues to create a more positive image of the brand (Dzhelmach, B., 2025, May 17).

Conclusion

The digital natives are redefining digital consumption, expecting everything at their fingertips with a personal touch. It is expected that by 2027, 71% of managers aim to fully automate customer support inquiries. Another 47% aims achieving zero touch automation in service training and customer product (Hayes, M., & Downie, A. (2025, December 4). Chatbots for customer experience. IBM). AI conversational agents are designed to recognise and acknowledge to a certain range of inputs, but can they provide personalized assistance. As an illustration, consider a case where a customer procures an apparel online and later decides to return it due to fit issues. The consumer couldn't find the exact reason to return in the AI chatbot as it isn't clearly mentioned as a result the return gets rejected, leading to dissatisfaction and undermining the trust in the brand as the AI chatbot fails to contextually understand the situation. After a prolonged delay the matter is escalated to

human agent to resolve the issue. Even if they cannot process a return, alternative solutions like an exchange or credit points are offered. Although the exact resolution is not offered but the opportunity of being heard plays a crucial part in customer retention and building brand loyalty. Artificial intelligence can recreate human like interactions, but emotional intelligence still remains largely human. The future may bring deeper integration of AI and empathy, but as of today, “feeling understood” is still best delivered by a human representative. Consider a scenario where an expensive pair of shoes is purchased online from a globally reputed footwear brand on a prepaid basis. The size always worn by the customer doesn’t fit as expected. A return request is raised through the AI chatbot virtual assistant, although the return pickup was completed smoothly, the refund never reflected in the customer’s account. Repetitive checks on the refund results in only auto generated response of case escalation instead of the actual refund. Customer choose to interact with the AI chatbot first considering their own comfort because connecting to the human agent is time consuming. As the issue remains unresolved for a long time, the customer now prefers talking to the human representative which not only understand the immediacy of the situation but also respond with a quick refund making it feeling personal addressing the issue with an empathetic apology. AI chatbot lacks this emotional intelligence although the response is quick without any contextual and empathetic understanding but the result is an unexpected outcome which adds up to the build-up of the customer’s frustration. In contrast, when the human agents are able to understand the urgency, importance and gravity of such situations it can restore the faith of the customers in a brand. At large, online purchase

and interacting with the AI chatbots is quite common such experience illustrates how an unresolved issue by the AI chatbot can shape the customer’s trust and perception about a brand. Such situations when handled through AI chatbots highlight the limitations of fully automated customer service systems. AI chatbots are valuable to businesses specially dealing in customer services, but there are certain situations in which human escalation is required and incorporating a human hand off feature in AI chatbots will improve user experience while handling complex queries that an automated system cannot resolve. (Ibars, O. 2023). In simple terms, technology provides transformative benefits like convenience and accuracy, humans provide understanding and judgement, and together they can bridge the gap and create a reliable, efficient and deeply personal customer service experience.

This discussion raises several interesting questions for future research, such as how organizations structure hybrid service systems, how customers perceive these interactions, and how AI technologies can gradually improve their conversational capabilities. The study attempts to contribute to the existing research in this field.

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Navigating Socio-Cultural Dynamics in Healthcare Leadership: A Review of Global Practices and the Indian Landscape.

Dr. Vishvendra Mohite

M.B.B.S, MSc Health Care Management

Assistant Professor, Center for Health Management Studies and Research,
Bharati Vidyapeeth (Deemed to be) University, Pune

ABSTRACT

This review examines the evolution of leadership theories and their application within the rapidly changing field of health and social care. By understanding the knowledge of the transition from classical management approaches to contemporary Behavioural and Transformational theories, the article explores how different leadership styles facilitate or deter organizational improvements. The review highlights a significant difference in global application: while Transformational leadership is widely credited with driving change, innovation and patient safety in developed Western systems, many developing regions, including India, continue to grapple with hierarchical and often "toxic" behavioural patterns. Furthermore, the article discusses the influence of local socio-cultural contexts—such as paternalistic leadership in Asia and gender discrepancies in global health boards—on leadership effectiveness. The findings suggest that while Transformational models offer the greatest potential for systemic improvement, successful implementation in the Indian healthcare sector requires a nuanced integration of positive behavioural role models and an adaptation to local cultural dynamics.

Keywords: Leadership, Leadership styles, Change management, Healthcare, India, Socio-cultural context.

Introduction

The field of health and social care is a vast, complex and rapidly changing. With healthcare having established a wide organisational system, both horizontally and vertically, in most countries, there is a growing need of research on leadership and teamwork in health and social care systems (Rahbi, et al., 2017). The need for leaders is not isolated to managers or clinicians but includes everyone involved in the health care setting. Hurley and Linsley (2007) suggest that leaders among nurses are vital in dealing

with changes in the organisation as well as acting as a connecting link between clinical and administrative practice. This implies that everyone can be a leader when working within a group. Building up an organisational system in healthcare seems to have been accompanied by changes in leadership and management which, in turn, is likely to have been associated with the research carried out in relation to the healthcare system.

There has been a significant shift in management and leadership theories from their

applications in the early 20th century. As a leader or manager, it is of paramount importance to analyse these classical theories and gain input into their principles and structure (Ehiobuche & Tu, 2012). Although classical theories have become outdated, few of their features have been taken up individually or in a combination by more recent literature to benefit current circumstances. Some of these theories may still be in use in a few parts of the world.

Research Methodology

A review of existing literature on Leadership theories, transformational and behavioural in the field of healthcare was carried out. A special emphasis was placed on their growing role and difficulties and the socio-cultural circumstances impacting leadership and change management strategies.

Leadership Theories and their Evolution

An increased focus on Leadership was seen in the late 19th and early 20th century. Which in turn has led a large amount of research being carried out on the subject in the last century. Initial focus was based on characteristics of leaders with a historical context, which led to the development of the preliminary theories of leadership in the 20th century. With further research, focus shifted more towards how leaders behaved and the impact of their behaviour on productivity. Behavioural theory of leadership came about in the mid-20th century, and various analysis of conduct of leaders were put forward as follows.

Lewin et al. (1939) classified leadership into 3 broad categories: Authoritarian, Democratic and Laissez-faire (genuine) styles. Following which Blake and Mouton (1964) put forth the concept of the managerial grid. It takes into

account two dimensions of behaviour, concern for how effectively tasks are completed and concern for the interest of the people. Kumar (2013) mentions how health care service cannot consider any style on the grid which places low emphasis on interest of people, but those styles which show high concern are far better. Kumar implies that team management style which displays high concern for people and results is best suited to health care. We also know that teamwork and co-operation between leaders at various levels and organisations of health care is very important. Involving patients and the public in establishing their needs and working towards those is vital to improving health and social care (Berwick report, 2013). From the changes resulting from this suggestion we can see that some parts of these theories have been incorporated into newer practices of leadership within health care systems. McGregor (1960) came up with Theory X-Y of leadership, of which, Theory X considered that followers were disinclined to work and leaders had to be more autocratic to produce results. On the other hand, Theory Y suggests that the average worker enjoys work, seeks responsibility and has a good problem-solving capacity, and the manager enables and empowers these characteristics of the follower.

Views on transactional and transformational leadership were brought into focus after the works of Burns in 1978 and Bass in 1985. Although their works may have a distinct origin and emphasize different areas of transformational leadership (Khanin, 2007; Yukl, 2006), the basic characteristics remain the same. Transformational leadership aims to create a sense of commitment and trust among followers while considering their needs and appealing to their values, while ensuring that the objective or vision of the organisation is focused on (Bass, 1985).

Bass and Avolio (1994) suggested that transformational leadership has four basic criteria which are, idealised influence (charisma and role model), inspirational motivation (meaning of the goal and reason to achieve it), intellectual stimulation (encourage creativity and innovation) and individual consideration (care and support for the followers). Yukl (2006) also provided certain factors to consider by leaders for transformation, which are creating a clear vision of the organisation which would appeal to the followers, explaining how the vision can be attained, being confident optimistic and acting with conviction, which in turn would show positive aspects of the vision, showing confidence in the ability of the followers to carry out tasks related to the success of the vision, using symbolic actions to show leadership competency and portray a charismatic image and to lead by example and ensure a collective atmosphere to attain the vision. From these descriptions we can determine the impact that behaviour styles of leaders have on the followers and how Behavioural theories of leadership can be incorporated to fit into Transformational style of leadership which would, in turn, facilitate innovation and change within healthcare. It is these factors which are considered when evaluating the impact leaders have on improving health and social care.

Transformational Leadership: A Growing Role

Transformational theory has played an important role directly in facilitating change and innovation in health and social care. Indirectly it has helped form leadership theories based on guidelines of transformation in flexible and complex health care settings around the world. There are numerous works of research and evaluations which have demonstrated the

need for and benefits of transformational leadership. Taking the Berwick report (2013) as an example, after evaluating the problems of quality of patient care and patient safety, the Department of Health and Social Care in line with the views of the authors suggested a need for change in leadership methods. This encompassed the entire health and social care system in the National Health Service (NHS) – from political leaders, regulatory and governance leaders, executives, clinicians and advisors. It advised making a change in behaviour of leaders across the system which would help attain the overall goal of patient safety. The changes included avoiding the use of blame as a tool, reinforcing the importance of meeting the needs of patients and carers, encouraging transparency, identifying risk and gathering information on errors. Also, involving patients and gaining feedback, interacting with colleagues and staff, promoting learning and application of innovative methods to tackle problems, leading by example and helping develop leadership capabilities among the staff and workers were the features which should be encouraged. All these are basically factors considered in Transformational theory which will help in increasing motivation of workers, build trust and confidence among workers, stakeholders and collaborators, improving problem solving capabilities and collectively establish the importance of attaining the goal of patient safety, which would further improve the quality of health care in various systems.

It is also possible to see the impact of transformative leadership on change in healthcare through the analysis of Charlesworth et al. (2016). They evaluated four cases, 2 from United States of America (USA), 1 from United Kingdom (UK) and 1 from Australia, where change was achieved by well-rounded

leadership incorporating features of transformation. The demand for a system overhaul stemmed from the problems of poor quality of care in 3 cases and threat to the health of the larger population in the last case. From the finding of Charlesworth et al. (2016) we establish that a lot of emphasis was placed on leadership, right from the government to the grassroots levels. It showed that objectives can be achieved if leaders are dedicated to achieving the goal despite changing circumstances, if qualities of leaders changed from a dominant approach to a more inclusive style of connecting with people and if they were provided the resources to improve and had the ability to adapt to complex healthcare settings. This is just one of the works which evaluated the positive influence of Transformative leadership. Another work which shows this possibility of improvement is that of Bevan and Fairman (2014). This work displays the effect of radical and innovative change established by leading for an improved quality of life and health, through discussing a few cases where improvement was seen in the UK by utilising features of transformational theory. More emphasis is placed on improving the quality of care in well-established health care systems in the developed countries, where focus is on identifying the changes that can be made with the help of innovation and assimilation from various different functional organisational patterns (Tsai et al., 2015). Similarly, Alharbi (2018) establishes that there is readiness among workers in healthcare organisations to meet the goals set by the government in Saudi Arabia, till 2030, if their leadership promotes qualities of Transformative leadership. Although the study considers only the middle managers, it points out that adaptability and motivation of the workers is key to formulate policies which

would allow striving towards the overall goal. And it also suggests the importance of developing transformational leaders who are capable of motivating workers towards the set vision of an improved healthcare system.

Struggles and Pitfalls of Adapting Strategic Leadership Changes

Despite a lot of research suggesting the importance of Transformative leadership, there is a great need to empower middle managers in health care and provide opportunities for leadership development, and to establish the relation of these developments to improved quality of care (Hartviksen et al., 2019). But during this process it is important that leaders in training avoid problems associated with development programs by critically analysing the knowledge being conveyed. Ruth McDonald, (2014) writes that “Leadership style impacts on organisational culture, which in turn impacts on performance. However, attempts to deliberately engineer and change culture suggest that this is a difficult task to say the least” (p-228). According to McDonald (2014), from a conservative point of view there are restrictions imposed and inequality introduced to maintain power in the hands of few, when people undergo empowerment and leadership development programs disguised as learning for change, they may be taken advantage of unknowingly. Also, McDonald (2014) indicates that transformation in leadership through any form of training must still be evaluated and reviewed on a deeper level by each individual and more research is needed on these training methods. This is necessary to ensure that the qualities of transformation that are being developed will positively help improve health and social care.

Socio-Cultural Contexts and Paternalistic Leadership: The Global South and Indian Scenario

Whereas Transformational leadership may work on its own in influencing methods of supervision, Behavioural theory is usually used in parts to establish changing standards, as in the case of the Berwick report (authoritarian to more democratic). Or, on the other hand, in establishing leadership theories suited to respective social and cultural contexts which can be seen as follows. The culture of a particular nation can influence the methods of leadership in those countries and in turn the newly established methods suggest behaviour in leaders which would be more acceptable in their cultural contexts (Luu & Djurkovic, 2019). In their research on Paternalistic leadership in health care Luu and Djurkovic (2019) discuss how paternal leadership methods use authoritarian behaviour. They suggest that local culture and teachings of Confucianism in Vietnam and its neighbouring countries of China, Singapore, Philippines and Malaysia make authoritarian behaviour with paternal qualities of benevolence more acceptable. This form of leadership may help in increasing motivation among workforce by decreasing work pressure and improving quality of care in those settings. The balance between benevolent and authoritarian behaviour is also likely to generate a firm identity of belonging for the worker with the organisation which would further improve the quality of work and job satisfaction. Asian, Middle-Eastern and Latin American cultures show a higher utilisation of paternalistic styles of leadership (Mansur et al., 2017), but requires further research in regards to their utilisation in health care in other nations (Luu & Djurkovic, 2019). So, there have been occasions where willingness and drive for work is driven by paternal qualities of the leader despite being in a relatively authoritarian

setting. Although western literature may suggest that this is a poor form of leadership due to use of authoritarianism, research from countries where it is prevalent including India suggests workers are more willing to work under an autocratic leader if there is paternal care shown as well (Mansur et al., 2017). From this we can consider the possibility that we can improve the standards of healthcare and make it more accessible by encouraging practices of leadership and management incorporating locally acceptable behaviours as perceived by the people and workers.

Considering the above circumstances, one also has to take a look at the opposite spectrum of social and cultural contexts in the local circumstances. Women hold 70 to 75% of positions in global health care. Yet according to the Global health 50/50 2022 report, although there has been a growth in the number of women in positions of power, there is a wide discrepancy. Only 1-8% of total board seats are held by women in the low- and middle-income countries. Whereas, although the percentage is higher in the Global north it is still only 31%. There has been research conducted on the representation of women in leadership positions in India (Singh et. al., 2024) and on comparison of barriers and enablers of women's health leadership in India with East Africa and North America (Sabarwal et. al, 2023), more research for acceptance, promotion and implementation of strategies for these factors in the Indian socio-cultural context is needed.

By looking at the research and evaluation that has been considered it seems as if transformational leadership plays an important role in facilitating change in developed countries where healthcare systems are well established, structured and organised (for example USA, Australia UK and other Western European countries) or those looking to shift

towards attaining these goals (Saudi Arabia). In contrast to this, the healthcare systems in developing countries tend to lean more towards leadership styles focused on behaviour of leaders. For example, Kerry Ratigan (2013) in her research on healthcare reforms in rural China mentions the benefits and drawbacks of authoritarian governance on decentralisation. The top-down management on decentralisation may provide the local officials a larger role as policy makers at a regional level which would improve the situation of healthcare. But there is also a possibility for local officials in position of authority to generate opportunities for corruption due to a strict one-way approach and later to resist any form of change due to the increased autonomy. There is a lack of research on the perceptions of qualities of leaders required in the changing social and cultural contexts in the Indian healthcare field. Though there have been indications of findings of challenging leadership qualities and parameters at all levels of Management in the healthcare systems in Indian as is seen in the following cases. A lack of governance and effective leadership has led to very individualistic and self-serving approach to management of public and private healthcare setups; this has led to a hierarchal system in these institutes which cause a decrease in the quality of care provided and decreased innovation. Problems within the management framework make it difficult to establish and implement improved policies and measures as individual benefits hamper the groundwork in health organisations. The work of Bhojani et al. (2014) describe the problems faced in providing quality diabetes care in the South Indian setting, which may stem from these issues. Poor leadership and governance, widespread bribery and lack of coordination between government and private healthcare providers are few of the problems with providing effective care. These issues are due to

the behaviour patterns of healthcare leaders which are considered toxic aside from other system deficits and a lack of standardisation of knowledge in the medical field in a local context. Similarly, these problems are also brought up in the research conducted by Mian et al. (2018), which evaluates the factors affecting quality of maternal and child health services in South Asia, supportive supervision/leadership is one of the areas for improvement among others. Additionally, Hemantika Basu (2019) considers the state of the nursing system in India and identifies how the behaviours of leaders in healthcare organisations, focused more on cost saving, financial viability and higher profits, leads to poor quality of care by promoting ill-will and an atmosphere of competition among staff. These dark behaviour patterns among leaders are further influenced by factors of class, ethnicity and gender bias among many others which are prevalent in the local area.

Although these studies are focused on particular aspects of care, the problems they point to are common across the healthcare field. There is a growing need for change from leadership methods from a more authoritarian nature to a democratic system and further a transformative one. Research is also being conducted to help managers and leaders identify barriers to improved services, including lack of political and managerial support for workers among others (Ajmera & Jain, 2019). Despite some change which has come from increasing knowledge on importance of quality care in developing countries, these countries are still far behind the standards setup on an international level and require further evaluation and development (Heidari Gorji & Farooque, 2011). Additionally, there have also been studies which evaluate toxic leadership behaviours in healthcare and stress the need for research on this topic (Özer et

al., 2017). Taking all of these factors into consideration it seems that although Behavioural leadership is still being made use of, in part or full, it has not had as much of a positive impact on health care as Transformative leadership and may in fact be detrimental if used in a standalone manner.

Conclusion

In conclusion, due to different circumstances across the world, leadership practices have adapted according to these variations despite following traditional theories. Although the transformational theory, more than the behavioural theory, has played a big part in improving healthcare, there is a gradual shift towards leadership based on the complex and changing nature of health and social care (Plsek & Wilson, 2001). With the ever-increasing demand for global quality care there is still further room to improve and move forward, not just by leader and management figures among healthcare organisations but also political and government figureheads involved in instituting health policies. Especially in the current global socio-economic and political circumstances where behaviour of people in leadership roles impact the implementation of these policies (Nicola et al., 2020). People are drawn to leaders who provide assurance and certainty during crisis (McDonald, 2014) and adapting positive behaviours, in line with local socio-cultural circumstances, which can influence people and will protect from the drawbacks of dark side of leadership. It is these adaptive positive role models who would help to transform health care in India on an international level in the long run.

Suggestions

There is a need for further holistic research on leadership and change management strategies of healthcare, taking into account the local social, cultural and economic contexts of the ever-changing circumstance of Indian healthcare as it continues to evolve and grow alongside the evolving nature of global standards of health and care. Additionally, special emphasis has to be placed on research focusing on needs and methods to address the gender disparity in leadership roles in healthcare.

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Review of AI-Based Techniques for Plant Disease Detection, Weather Prediction, and Soil Analysis in Agriculture

Ms. Trupti Sudhirrao Sisode,
Assistant Professor
Modern College Arts, Science and Commerce

ABSTRACT

In recent years, artificial intelligence (AI) has started to play an important role in agriculture. It is being applied in areas such as plant disease detection, weather prediction, soil analysis, and crop planning. In this paper, various research studies related to these applications are reviewed and discussed. Common techniques like convolutional neural networks (CNNs) and long short-term memory (LSTM) models are examined based on existing work. Their performance, along with their strengths and limitations, is considered to understand how effective they are in practical situations. Based on the insights gained from these studies, a conceptual integrated framework is suggested for future work. Overall, the aim of this review is to explore how AI can be applied in a more practical and useful way to support modern agricultural practices.

Keywords: Artificial Intelligence, Agriculture, Plant Disease Detection, CNN, LSTM, Review

Introduction

Agriculture is an important part of the economy, especially in countries like India where a large section of the population depends on farming for their livelihood. However, farmers face several challenges, including plant diseases, unpredictable weather conditions, poor soil quality, and limited access to proper guidance. In recent years, artificial intelligence (AI) has begun to play a significant role in addressing these issues. Techniques such as machine learning and deep learning are now being used to detect plant diseases, forecast weather patterns, and analyze soil conditions. Even with these advancements, many existing systems still focus on only one aspect of agriculture and do not offer a complete or integrated solution. In

this paper, existing research on AI-based agricultural systems is reviewed and discussed. The focus is on understanding the different techniques used by researchers, comparing their performance, and identifying the gaps in current approaches. Based on these observations, a conceptual integrated approach is suggested for future development.

Objectives of the study

The main objectives of this study are as follows:

- To study existing research related to plant disease detection using AI techniques
- To understand how weather data and soil information are used in agricultural systems

- To review different machine learning and deep learning methods applied in agriculture
- To identify the limitations, present in current research work
- To suggest a conceptual integrated system based on the findings of this review

Research Methodology

This research work is based on secondary data basically grounded on review of research articles published between 2016 and 2025. The required data was collected from reliable sources such as Google Scholar, IEEE, Springer, and Elsevier. The selected papers were studied and analysed based on the techniques used, their area of application, performance, and the limitations identified in each work. The review mainly focuses on important areas such as plant disease detection, weather forecasting, soil analysis, and agricultural decision support systems.

Literature Review-Researcher have referred existing literature for the research work and attempted to extract the summary.

Early Research (2016–2020)

In the early years, most studies focused on plant disease detection using image-based deep learning techniques.

In the work by Mohanty et al. (2016), convolutional neural networks (CNNs) were used for plant disease classification, and very high accuracy was reported. However, the study relied on controlled datasets, which may limit its effectiveness in real-world conditions. Similarly, Ferentinos (2018) applied different CNN architectures to identify plant diseases across multiple crops. Although the results

were promising, the study did not take into account environmental factors such as weather and soil conditions. Too et al. (2019) carried out a comparison of various deep learning models and observed that fine-tuned networks improved accuracy. At the same time, these models required high computational resources, which may not be practical in all situations. Poornam and Devaraj (2020) also explored deep learning methods for disease detection and showed that image-based classification can be effective. However, their work did not consider integration with other agricultural factors.

Research work during 2021–2025

More recent studies have focused not only on improving accuracy but also on usability and practical implementation.

Chen et al. (2021) introduced an enhanced CNN model with better feature extraction, which improved classification performance. Even so, the approach remained limited to image-based analysis. Foysal et al. (2024) developed a mobile-based system for plant disease detection, aiming to make the technology more accessible to farmers. While this improves usability, the system still focuses only on disease detection and does not include soil or weather-related data. Ngugi et al. (2024) provided a comprehensive review of deep learning applications in agriculture and emphasized the need for systems that are more scalable and practical. In a similar way, Pacal et al. (2024) conducted a systematic review and pointed out that most existing models focus mainly on improving accuracy, while real-world usability is often overlooked. Wang et al. (2025) discussed recent developments in AI for agriculture and highlighted challenges such as limited dataset diversity and difficulties in real-world deployment.

Secondary data Observations

In this review, the analysis is carried out by examining the performance, methodologies, and limitations reported in different studies.

It can be seen that studies by Mohanty et al. (2016) and Ferentinos (2018) reported very high accuracy (above 95%) in plant disease detection using convolutional neural networks (CNNs). However, both of these studies were based on controlled datasets such as Plant Village, which may not fully represent real-world agricultural conditions. Because of this, their performance may not remain the same in practical situations. In the case of Too et al. (2019), it was observed that fine-tuned deep learning models can improve classification accuracy. At the same time, this improvement increases computational complexity, making such models less suitable for use in rural areas where resources are limited. Poornam and Devaraj (2020) also showed that deep learning methods are effective for disease detection. However, their work focused mainly on image-based analysis and did not take into account other important factors like soil and weather. Looking at more recent work, Chen et al. (2021) worked on improving feature extraction in CNN models, which resulted in better classification performance. Even so, the system still lacked integration with other agricultural parameters. From a practical point of view, Foysal et al. (2024) developed a mobile-based system to improve accessibility for farmers. While this is useful in terms of usability, the system is still limited to disease detection and does not provide complete decision support. Review-based studies by Ngugi et al. (2024) and Pacal et al. (2024) also point out that many existing systems focus mainly on achieving high accuracy, while issues related to real-world usage, such as environmental variability and scalability, are often not addressed. Wang et al. (2025) further highlighted that, despite the

progress in AI models, challenges like lack of diverse datasets, difficulties in field deployment, and absence of integrated solutions are still present.

Key Findings

From the above discussion, the following observations can be made:

- High accuracy (above 90–95%) is often reported, but mostly on controlled datasets
- Model performance may decrease in real-world conditions
- Most systems focus mainly on image-based disease detection
- Computational complexity makes practical deployment difficult
- Integration of soil, weather, and other factors is still missing
- Real-world usability and scalability remain major challenges

Overall, it can be understood that there is a clear gap between theoretical model performance and practical agricultural use. While existing research shows strong technical results, there is still a need for more integrated, user-friendly, and real-world adaptable systems.

Concluding Remarks

From the studies discussed above, a few important observations can be made:

- Most research is focused mainly on plant disease detection using image data
- High accuracy is usually achieved in controlled environments
- Environmental factors such as soil and weather are often not considered together

- Only a few systems attempt to provide an integrated solution

These points suggest that there is still a need for a more comprehensive and integrated approach in agricultural systems, which can be explored in future research.

In addition, some studies have explored weather prediction using LSTM models and soil analysis using machine learning techniques. However, these components are generally developed separately rather than being combined into a single system.

Identified Research Gaps and scope for further research

Although many AI-based systems have been developed for agriculture, most of them are limited in their scope. A large number of studies mainly focus on plant disease detection using images, while other important factors such as soil health and weather conditions are often not considered together. Another issue is that many of these systems are tested only on controlled datasets, so their performance in real-world conditions may not be as effective. In addition, some applications depend on continuous internet connectivity, which is not always available in rural areas. Because of these limitations, it becomes important to carefully study existing research and understand where the gaps lie. This can help in identifying what improvements are needed for developing more practical and useful agricultural systems in the future.

Based on the literature reviewed, a few important gaps can be identified:

- There is a lack of integrated systems that combine multiple agricultural factors.
- Many models are not tested in real-world conditions.

- Several systems depend on continuous internet connectivity.
- There is a shortage of simple and user-friendly applications for farmers.

Conceptual Framework from existing literature

Based on the observations from existing studies, a conceptual integrated framework is proposed to bring together multiple agricultural factors into a single system.

- The process begins with farmer input, such as a leaf image or a query. This input is then analyzed using a plant disease detection module based on deep learning techniques. At the same time, additional information such as soil data (including pH and nutrient levels) and weather conditions (temperature, humidity, and rainfall) is also considered.
- All these inputs are combined within a central decision support system. This system processes the information and provides useful recommendations to farmers. These may include disease identification, preventive actions, and general crop-related suggestions.
- It should be noted that this framework is conceptual and is based on insights gathered from the reviewed literature. It can be further developed and tested using real-world data in future work.

Expected Outcomes from the conceptual framework

- Improved understanding of how AI is applied in agriculture
- Clear identification of limitations in existing systems

- Useful suggestions for improving future solutions
- A foundation for further research and development

Conclusion

In this paper, various AI-based techniques used in agriculture have been studied and analyzed, with a focus on plant disease detection, weather forecasting, soil analysis, and decision support systems. The reviewed studies provide useful insights into the methods used, their performance, and their limitations. It can be observed that deep learning models, especially CNN-based approaches, achieve high accuracy in plant disease detection. However, these results are mostly based on controlled datasets and may not fully represent real-world conditions. In a similar way, LSTM-based techniques are useful for weather prediction, but their long-term reliability is still limited. Another important observation is that most existing systems focus on a single aspect, such as disease detection or weather forecasting, without considering other important factors like soil health and crop planning together. This reduces their effectiveness in real agricultural scenarios. From the analysis, it becomes clear that there is a gap between theoretical model performance and practical application. Challenges such as environmental variability, computational requirements, and lack of user-friendly systems continue to affect the adoption of AI in agriculture. To address these issues, a conceptual integrated framework has been suggested in this paper. Such an approach can help in improving decision-making and making AI-based solutions more practical and accessible for farmers. In future work, this framework can be implemented and evaluated using real-world data to better understand its effectiveness and usability.

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