# Challenges and Opportunities of the Internet of Things in Agriculture in Afghanistan

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## ABSTRACT

The advent of the Internet of Things (IoT) has surfaced as a transformative technology with applications in various domains, including agriculture. This study investigates the challenges and opportunities of IoT in agriculture, focusing on the context of Afghanistan. With agriculture playing a pivotal role in the country's economy and food security, embracing the technologies of the Internet of Things (IoT) holds the capacity to bring about a revolution in the agricultural industry. Through a comprehensive literature review, surveys, and interviews, this research evaluates the integration of IoT in agriculture in Afghanistan. The study identifies several challenges, including limited infrastructure and technology access, inadequate farmer awareness, and scarcity of information and training resources. These obstacles hinder the effective implementation of IoT solutions, which can address issues such as water scarcity, limited market access, and low productivity. Through an examination of the influence of IoT on agricultural productivity, this research underscores the transformative capabilities of IoT within Afghanistan's agricultural industry. Real-time monitoring, precision farming, water management, and resource optimization represent a subset of the benefits provided by IoT technologies. The research aims to provide valuable recommendations for successful IoT implementation, considering a multi-stakeholder approach involving farmers, technology providers, policymakers, and other relevant stakeholders. The significance of this research lies in its potential to increase agricultural productivity and contribute to economic development and sustainability in Afghanistan. The findings and recommendations can also have implications for other developing countries facing similar challenges in their agricultural sectors. By shedding light on the benefits and challenges of IoT in agriculture, this study contributes to the global discourse on sustainable development and poverty reduction.

**Keywords:** Agriculture; Challenges; Agricultural productivity; Internet of Things (IoT); Opportunities; Resource management; Sustainable development

## Introduction

In the last ten years, notable attention has been given to the Internet of Things (IoT) concept, which has found applications across various domains such as industry, biomedicine, agriculture, smart cities, and environmental monitoring. The IoT connects physical devices through standard communication architectures to deliver novel services to end-users. These devices possess distinctive identifiers and can autonomously transmit data across a network (IoT Agenda, 2020). The primary objective of IoT is to establish a connected society where the realms of physical, digital, and virtual converge, giving rise to intelligent ecosystems that offer insights into areas such as power usage, safety, transportation, and beyond. Examples include smart homes and smart cities, which rely on real-time and low-power communication. As IoT technology dramatically grows, the number of interconnected devices are increasing, and (Monazzah, Safaei, Bafroei, & Ejlali, 2017) reported yearly statistics of IoT devices in Figure 1
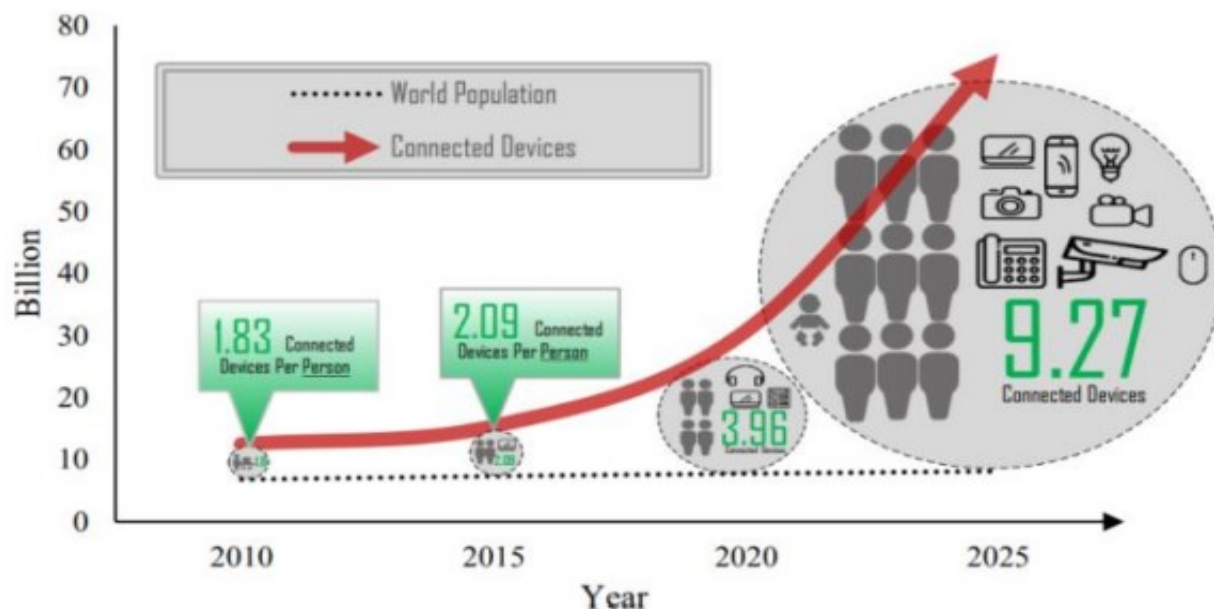
***Figure 1:*** *Projected Quantity of Connected Devices per Individual (Monazzah, Safaei, Bafroei, & Ejlali, 2017)*

Nevertheless, the pivotal role of Agriculture in the progress of any nation remains unchanged. In Afghanistan, agriculture holds unparalleled significance, with 80% of the population involved in agricultural and livestock activities, contributing approximately 31% to Afghanistan's Gross Domestic Product (GDP) (Rasooli, M. W., Bhushan, B., & Kumar, N. (2020). The amplification of the agricultural sector can be accomplished through integrating Internet of Things (IoT) technologies, particularly in the realm of Smart Farming. This strategy transforms agri-business by offering real-time monitoring of fields. IoT sensors play a critical role in interconnecting elements and gathering data. These IoT devices introduce novel techniques to farmers and remarkably improve their time management. Farmers can significantly reduce their time spent in the fields by implementing IoT. IoT-enabled devices undertake tasks on their behalf, leading to a substantial reduction in workload and the conservation of vital resources such as water for irrigation and electricity consumption, which are required for various electrical devices. Amongst the positive impacts, IoT adds to the agriculture sector, real-time monitoring aspects are easily facilitated through IoT devices, and real-time statistics and reports are delivered. IoT sensors play a critical role in interconnecting devices and gathering data. These IoT devices introduce novel techniques to farmers and remarkably improve their time management. In the meantime, Afghan farmers could optimize practices, minimize waste, and increase yields, thus enhancing food security and fostering economic growth.

On the Other hand, IoT adds the potential to transform and envision samples in agriculture toward smart agriculture. This entails remotely controlling aspects such as irrigation and temperature. Technologies like Wireless Sensor Networks (WSN), Wi-Fi, or ZigBee modules are required to manage crop-related variables (Rasooli, M. W., Bhushan, B., & Kumar, N. 2020).

Examining the integration of IoT in Afghan agriculture reveals the emergence of numerous hurdles and challenges. Privacy, environmental impact, and economic viability are among the hurdles addressed in this study. While the agricultural sector plays a crucial role in laying the foundation of Afghanistan's economy, engaging a considerable portion of the population and making a substantial contribution to the GDP, it simultaneously contends with challenges such as water scarcity, restricted market access, and diminished productivity. Therefore, IoT technology draws the path to address these challenges as it involves interconnected devices collecting, analyzing, and exchanging real-time data, enabling automation and informed decision-making in agriculture. The advantages include precision farming, real-time monitoring, and resource optimization. Table 1 contains a summary report of agriculture's economic contribution to the Gross Domestic Product (GDP). in neighbor countries and the status on how the IoT was implemented.

Table 1. *The economic contribution of agriculture to the Gross Domestic Product (GDP) and Role in Neighboring Countries.*

| Country | Population in Agriculture | Agriculture's Share of GDP | IoT in Agriculture |
|---|---|---|---|
| Afghanistan | 80 % | 25.5% (Rasooli, M. W., Bhushan, B., & Kumar, N. (2020) | o   No Practical Implementation |
| Tajikistan | 45.7 % | 22.6 % U.S. Agency for International Development. (2021, August 20) | o   monitoring soil conditions<br>o   Optimizing irrigation.<br>o   crop management decisions<br>o   Weather forecasting |
| Iran | 23 % | 26 % (Jurenas, R. (2003)) | o   soil moisture<br>o   weather forecasting<br>o   livestock management |
| Uzbekistan | 26% | 25% The World Bank. (2022) | o   Smart irrigation<br>o   Soil and weather management<br>o   Soil moisture |
| Pakistan | 38.2% | 19% Government of Pakistan. (2020-2021). | o   Weed mapping<br>o   Irrigation control<br>o   Crop monitoring<br>o   Precision Farming |
| India | 43.2% | 17-18% PTI. (2023, July 14). | o   Crop Monitoring<br>o   Weather Forecasting:<br>o   Livestock Management<br>o   Smart Irrigation |

## Literature Review

The global population is expected to be 9.6 billion by the year 2050. The continual increase in population necessitates advancements in the farming industry to meet the growing demand for

food supplies. The utilization of IoT holds significant potential for improving agricultural practices. Farmers can optimize crop cultivation with increased efficiency by incorporating IoT technologies, resulting in maximum productivity while requiring less effort. This approach becomes particularly crucial in addressing the challenge of fulfilling food requirements within the constraints of limited available land (Rasooli, M. W., Bhushan, B., & Kumar, N., 2020). As the world's population continues to grow rapidly, there is a heightened demand to ensure food security. Consequently, researchers actively investigate various aspects to propose solutions and advise the agricultural sector. The objective is to enhance productivity despite limited resources and smaller land areas. Accordingly, we will present the most noteworthy research conducted on the implementation of IoT in the agriculture sector, along with their findings and results in Table 2.

**Table 2.** *Literature Review Summary of Previous Studies on IoT in Agriculture*

| Author | Year | Title | Findings |
|---|---|---|---|
| Gondchawar, N., & Kawitkar, R. S. (2016) | June 2016 | Agricultural systems incorporating Internet of Things (IoT) technology for enhanced efficiency and automation. | The authors aim to transform conventional agricultural practices in this document by proposing an automated approach utilizing an IoT system and a remotely controlled robot equipped with Smart GPS technology. The intended tasks for this system include spraying, moisture sensing, weeding, and protecting crops from birds and animals. |
| Abhijith, H. V., Jain, D. A., & Rao, A. A. (2017). | 2017 | Intelligent Agriculture mechanism using IoT | In this paper, the authors proposed a system using simulations for IoT devices; in this document, the authors seek to revolutionize conventional agricultural practices by introducing an automated approach employing IoT and a Smart GPS-controlled robot. This system is designed to execute various tasks such as spraying, moisture sensing, weeding, and protecting crops from birds and animals. The authors present a conceptual framework for this system using simulations to represent IoT devices and data mining techniques proposed to do prediction tasks from data collected by sensors and to ascertain the factors necessary for the improved cultivation of crops. |
| Patil, K. A., & Kale, N. R. (2016) | 2016 | A framework for intelligent agriculture employing the Internet of Things (IoT) | In this research, the authors developed an ICT-based system. Ubi-motes are used for data generation, and Android-based applications are used as task controllers. The system provides solutions to control Temperature, Fan Control, Irrigation Control (Sprinkler Control), Moisture Monitoring for Soil, Light Control |

| | | | |
|---|---|---|---|
| Prathibha, S. R., Hongal, A., & Jyothi, M. P. (2017) | 2017 | Monitoring System for Smart Agriculture Utilizing IoT | In this paper, the authors have presented a system for crop monitoring utilizing IoT. They utilized a CC3200 temperature and humidity sensor to observe temperature and humidity levels. A camera, integrated with the temperature and humidity sensor, is employed to capture images of the crops periodically. |
| Amandeep, B., Das, P., Basu, D., Roy, S., Ghosh, S., Sayan, & Rana, T. K. (2017). | July 2017 | Smart Farming Using IOT | This paper introduces two systems, one dedicated to user control and the other for device control, intended for deployment in the field. The authors have suggested a remotely operated vehicle capable of executing tasks like soil moisture sensing, obstacle avoidance, cutting, and spraying. Similarly, the second system is designed to manage the irrigation system in the field, automatically regulating the pump to control water irrigation by turning it on and off. |
| Padalalu, P., Mahajan, S., Dabir, K., Mitkar, S., & JavalE, D. (2017) | Jan 2017 | Intelligent Water Dripping System for Agriculture/Farming | Here, the authors present a system for automated irrigation utilizing temperature, moisture, and pH sensors. An analog temperature sensor (LM35) with a range spanning from -55 degrees Celsius to +150 degrees Celsius was employed. The SM300 was utilized for moisture detection, providing readings across a moisture content range of 0% to 60%. |
| Roy, S., Ray, R., Roy, A., Sinha, S., Mukherjee, G., Pyne, S., Mitra, S., Basu, S., & Hazra, S. (2017) | May 2017 | A Hybrid System for Smart Agriculture Utilizing IoT, Big Data Science & Analytics, Cloud Computing, and Mobile App Technologies | The authors introduced AgroTick, a novel hybrid system for intelligent agriculture. Based on the Internet of Things (IoT), this system incorporates a mobile interface that utilizes cloud computing, embedded systems, and big data for data generation and analysis. The primary objective is establishing a network for farmers to exchange agricultural knowledge. AgroTick aims to tackle two crucial challenges: Rainwater Harvesting and forecasting the efficient utilization of the collected rainwater. |

## Challenges IoT in Agriculture in Afghanistan

**High Costs**: One major hurdle in implementing IoT in agriculture is the substantial expense associated with sensors, devices, and other essential equipment required for data collection and analysis. These expenses pose a notable obstacle for numerous farmers, especially those in developing nations or small-scale farming.

**Connectivity**: IoT devices rely on a reliable and robust network connection to transmit data. In remote or rural areas, internet connectivity can be unreliable or non-existent, making it challenging to use IoT technology effectively.

**Data Security and Privacy**: With IoT technology, large amounts of data are collected and transmitted to different parties. This creates security and privacy concerns, as sensitive data could be compromised or hacked.

**Integration**: Integrating IoT devices with existing farm equipment and systems can be challenging, particularly for older or legacy systems. This can result in complex and costly integrations, which may not always work seamlessly.

**Data Management**: With large amounts of data being generated, managing and storing this data effectively can be complex. A robust and scalable data management system is required to handle the quantity of data IoT devices produce.

**Lack of Awareness**: Numerous farmers lack awareness regarding IoT technology's potential advantages and applicability to enhance their agricultural operations. This lack of awareness poses a challenge in adopting and integrating the technology into their farming practices.

**Opportunities of IoT in Agriculture in Afghanistan**

**Precision Farming**: Farmers can utilize IoT technology to gather data on soil moisture, temperature, and nutrient levels and monitor variables like weather patterns and pest infestations. This collected data becomes valuable in optimizing planting, fertilizing, and watering practices, leading to increased yields and reduced wastage.

**Livestock Management**: IoT sensors can be used to monitor the health, activity, and feeding patterns of livestock, providing farmers with real-time insights into their herd's health and well-being. This can help farmers identify potential issues early and improve their livestock management practices.

**Supply Chain Management**: IoT technology enables the tracking of products across the entire supply chain, spanning from the farm to the shelves of the retail stores. This can aid farmers and retailers in optimizing control over inventory, reducing wastage, and improving the overall efficiency of the supply chain.

**Environmental Monitoring**: Utilizing IoT sensors for monitoring environmental elements, including air and water quality, can aid farmers in minimizing their environmental footprint and adhering to regulatory requirements.

**Remote Monitoring**: IoT technology enables farmers to remotely monitor their operations, responding quickly to issues and making informed decisions. This can reduce labor costs and increase operational efficiency.

**Pest Management**: IoT sensors facilitate the monitoring of potential pest infestations, enabling farmers to detect issues early and implement measures before the infestation escalates.

**Weather Monitoring**: Utilizing IoT sensors for monitoring weather conditions empowers farmers to make well-informed decisions regarding the optimal timing for planting, fertilizing, and harvesting crops.

**Irrigation Management**:  Leveraging IoT sensors for monitoring soil moisture levels and tracking water usage empowers farmers to optimize their irrigation practices. This optimization can potentially decrease water usage while increasing crop yields.

**Greenhouse Supervision:** IoT sensors can monitor temperature, humidity, and light levels in greenhouses, allowing farmers to optimize plant growth conditions. This can increase yields and reduce waste.

**Analysis**

The survey questionnaire was formulated to evaluate the level of familiarity among respondents in Afghanistan regarding Internet of Things (IoT) concepts and their applications in the agricultural sector. A total of 50 individuals participated in the survey, including farmers, agricultural engineers, Agri-economists, professionals from the information technology sector, students, teachers, doctors, and engineers. Conducting professional face-to-face interviews with experts such as Agri-economists, agriculture engineers, professors from agricultural universities, and responsible personnel from agriculture sectors. The results indicated that many respondents are unfamiliar with IoT applications in agriculture in Afghanistan. This suggests a few levels of awareness and understanding of IoT among the surveyed participants. Regarding the perceived importance of IoT implementation in various sectors, 66% of the respondents recognized the potential benefits of IoT adoption, believing it would improve efficiency and productivity in Afghanistan. However, the survey also highlighted several challenges associated with implementing IoT technology, including limited internet connectivity, inadequate technical infrastructure, lack of awareness, high implementation costs, and concerns related to security and privacy.

**Interviews** were conducted with experts in the field, including agri-economists, agricultural engineers, professors from agricultural universities, and personnel from the government's agriculture sectors. The interviews aimed to gain insights into the role of these experts in facilitating agricultural and livestock development, promoting the adoption of new technologies, and enhancing knowledge transfer within the agricultural community. The interviews revealed that these experts are crucial in introducing new technologies and providing information to farmers, encouraging them to adopt IoT technologies and apply scientific approaches in managing production resources. They emphasized the importance of leveraging scientific principles in resource management, product marketing, and ultimately improving the productivity and livelihoods of the farming community.

**Findings**

**Familiarity with IoT:** A few percent of the respondents reported being somewhat familiar with IoT concepts.

**IoT Application and Devices:** 54% of the participants reported encountering IoT applications or devices in Afghanistan, while 46% were unfamiliar with IoT applications or devices in the country.

**Importance of IoT Implementation:** 48% of the respondents considered IoT important, and 40% believed it was extremely important to implement it in different sectors.

**Potential Benefits of IoT in Agriculture:** The potential advantages and opportunities identified were increased crop yield and productivity (68%), improved management of resources (76%), enhanced decision-making through real-time data (62%), better control of pests and diseases

(54%), increased efficiency and cost savings (56%), and improved market access and traceability (38%).

**Challenges and Barriers to IoT Adoption:** The primary challenges identified were lack of reliable internet connectivity and limited technical infrastructure (selected by 78% of respondents), lack of awareness and understanding (66%), high implementation costs (58%), and security and privacy concerns (22%).

**Sufficiency of Infrastructure:** 30% of the participants believed that Afghanistan's infrastructure is insufficient to support the implementation of IoT technologies, while 30% thought it is sufficient, and 40% were unsure.

**Capacity of Afghan Organizations:** 62% of respondents expressed confidence that Afghan organizations can implement IoT technologies in their operations, 26% had a high level of trust, and 12% were not confident.

**Sectors with Significant Impact:** Agriculture was identified as the sector where IoT implementation can significantly impact 90% of respondents. Healthcare (58%), transportation (62%), education (74%), and energy (45%) were also considered important sectors.

**Government Support for IoT:** 64% of respondents believed the government should provide strong support and investment for IoT initiatives.

**Familiarity with IoT in Agriculture:** 40% of participants reported being very familiar with IoT in agriculture, 38% described themselves as moderately familiar, and 22% indicated unfamiliar with the concept.

**Challenges of IoT in Agriculture:** The major challenges identified in implementing IoT in agriculture were limited internet connectivity (80%), high costs associated with IoT devices and infrastructure (66%), lack of technical expertise and knowledge (70%), insufficient access to training and resources related to IoT in agriculture (54%), and regulatory or policy obstacles (18%).

**Based on the research findings,** it is concluded that IoT presents a significant opportunity to improve agriculture productivity and sustainability in Afghanistan. It can enable real-time monitoring and decision-making, enhance resource efficiency, and provide numerous benefits recognized by farmers. However, there are challenges to overcome, such as limited internet connectivity, lack of technical expertise, data security concerns, and the need for government support and investment.

**Opportunities** to unlock IoT's potential in Afghan agriculture collaborative government-private sector efforts are essential, focusing on infrastructure, training, data security, and enabling policies. IoT integration offers opportunities for enhanced productivity, sustainability, and economic growth. Applications like farm automation, mobile market access, weather forecasting, and financial inclusion can simplify tasks, provide vital information, and boost overall productivity, transforming the lives of farmers and stakeholders. This emphasizes IoT's

transformative potential in farm management, precision agriculture, supply chain optimization, market access, financial inclusion, and capacity building. IoT can significantly improve incomes and livelihoods for Afghan farmers and stakeholders, indicating sustained growth in agriculture through ongoing technology integration.

## Conclusion

The research conducted on the utilization of IoT in agriculture in Afghanistan highlights the potential for improving productivity, sustainability, and livelihoods in the agricultural sector. The analysis reveals that IoT technologies can offer numerous benefits, including real-time monitoring, precision farming, effective resource management, and improved decision-making. However, several challenges hinder the widespread adoption of IoT, such as limited connectivity, high costs, lack of technical skills, and inadequate infrastructure. To overcome these challenges, the research suggests enhanced connectivity and infrastructure development, customized IoT solutions tailored to local needs, capacity building and training programs, integration of data platforms, collaboration among stakeholders, and monitoring and evaluation of IoT implementation. The findings emphasize the importance of addressing these areas for future work to leverage IoT's potential in Afghan agriculture fully. By focusing on these aspects, stakeholders can work towards overcoming barriers, improving technology adoption, and ultimately enhancing agricultural productivity, sustainability, and the livelihoods of farmers and other stakeholders in the agricultural value chain.

## Recommendations for Future Research

This research aimed to identify the difficulties and possibilities associated with integrating IoT in agriculture in Afghanistan. In addition to conducting a comprehensive survey, reviewing relevant literature, and conducting structured interviews, several areas require attention as future work to ensure the successful implementation of IoT in agriculture. These points include:

- Implementation of Demo Project on a Greenhouse for Water Management, Weather Forecasting, and Disease/Pest Detection

- Implement IoT in water management, disease and pest detection, and weather forecasting.

- Enhance connectivity and infrastructure for widespread IoT adoption.

- Develop customized IoT solutions for local agricultural needs.

- Provide capacity-building and training programs for farmers and stakeholders.

- Foster collaboration and partnerships among stakeholders.

- Monitor and evaluate the impact of IoT technologies in Afghan agriculture.

- Sharing a comprehensive proposal on the implementation of IoT in Agriculture in Afghanistan with the Ministry of Agriculture and livestock

- Study the implementation of demo projects on irrigation and water management in greenhouses.

- Economic Impact Analysis, Community Engagement Models, Socioeconomic Impact Studies, Environmental Impact Assessment, Participatory Research, In-Depth Case Studies, IoT Device Development, Comparative Studies, Technical Feasibility Studies, Government Policy Analysis

By addressing these areas of future work, we can continue to advance the utilization of IoT in Afghan agriculture, which aims to enhance productivity, sustainability, and the livelihoods of farmers and various stakeholders within the agricultural value chain.

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