APLIKATIF
Journal of Research Trends in Social Sciences and Humanities
DOI: https://doi.org/10.59110/aplikatif.v4i2.618
Vol. 4 No. 2, June 2025, pp. 119-132

Transforming Rural Communities through IoT: Socio-Digital Challenges and Opportunities in Afghan Agriculture

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ABSTRACT
This study investigates the challenges and opportunities associated with implementing Internet of Things (IoT) technologies in Afghanistan's agricultural sector. Using a mixed methods approach comprising surveys, interviews, and focus group discussions with 200 participants across various regions the research assesses awareness, adoption, and perceived value of IoT among Afghan farmers. Findings show that while 60% of respondents were aware of IoT, only 30% had adopted such technologies. Key barriers include inadequate infrastructure, high costs, and limited technical expertise. Social factors—such as digital illiteracy and unequal access to technology—further restrict uptake, especially in marginalized rural communities. Despite these constraints, significant opportunities exist in areas like smart irrigation, crop health monitoring, and data-driven farming. These technologies hold promises for enhancing efficiency and sustainability while promoting digital inclusion and reducing regional disparities. The study underscores the need for targeted investment in infrastructure, training, and awareness to enable broader adoption. Its insights are critical for policymakers and stakeholders seeking to advance inclusive, technology-driven agricultural development in Afghanistan.

Keywords: *Adoption; Afghanistan; Agriculture; Internet of Things (Iot); Challenges.*

INTRODUCTION

Agriculture is a vital sector for Afghanistan, engaging approximately 80% of the population and contributing nearly 31% to the country's Gross Domestic Product (GDP) (Rasooli, Bhushan, & Kumar, 2020). However, despite its significance, Afghanistan's agricultural sector faces numerous challenges, including water scarcity, limited market access, low productivity, and outdated farming practices (Sharifi & Karim, 2024). The introduction of Internet of Things (IoT) technologies in agriculture presents a promising pathway to address these persistent issues by enabling smarter, more efficient, and sustainable farming practices (Qasimi, Shahidzay, & Fazli, 2024;

Prakashan et al., 2017).

IoT has the potential to revolutionize agriculture through real-time monitoring, data-driven decision-making, and resource optimization. By deploying interconnected sensors and smart devices, farmers can monitor soil moisture, crop health, and environmental conditions, leading to improved yields and reduced waste (Abu et al., 2022; Krishnababu et al., 2024). In neighboring countries like India and Pakistan, IoT applications have already demonstrated success in areas such as precision farming, irrigation control, and livestock management (Degada et al., 2021), offering a regional blueprint for Afghanistan to follow.

Nonetheless, the implementation of IoT in Afghanistan's agriculture is not without significant challenges. Infrastructure limitations, such as unreliable electricity and internet connectivity, present immediate barriers (Ray., 2017). Additionally, economic constraints make the acquisition and maintenance of IoT devices difficult for many smallholder farmers (Ado & Abubakar, 2024). Privacy and cybersecurity concerns also emerge as critical issues, given the vulnerability of IoT systems to cyber threats (Boeckl et al., 2019; Ferrag et al., 2020).

Beyond technological and economic limitations, human and socio-cultural factors play a crucial role in shaping the trajectory of IoT adoption. Many rural farmers lack digital literacy, which hinders their ability to interact with or maintain IoT devices effectively. Socio-cultural resistance to new technologies—driven by distrust, generational knowledge systems, or limited exposure to digital tools—further complicates adoption efforts, particularly in marginalized or remote communities (Tzounis et al., 2017; Haddud et al., 2017; Antony et al., 2020). These issues highlight the importance of recognizing farmer agency, social disparity, and the need for community-centered capacity-building initiatives as part of any technology implementation strategy.

Despite these hurdles, the opportunities offered by IoT technologies—such as smart irrigation systems, automated pest control, and predictive analytics for crop management—remain significant (Nigussie et al., 2020; Bacco et al., 2020; Farooq & Akram, 2021). Recent advances in smart sensor technologies and energy-efficient IoT devices further enhance the feasibility of deploying these tools in resource-constrained settings like Afghanistan (Pau et al., 2023; Barge & Mary, 2024). If implemented inclusively, IoT technologies could foster rural empowerment, bridge the digital divide, and promote more equitable access to innovation.

Thus, exploring both the opportunities and challenges of IoT implementation is crucial for shaping the future of agriculture in Afghanistan. A comprehensive understanding of these technological and social dynamics will not only inform policymakers and stakeholders but also pave the way for sustainable, inclusive agricultural development in a country where food security and economic resilience are deeply interlinked.

Problem Statement

Agriculture remains the backbone of Afghanistan's economy, yet it continues to face critical challenges such as water scarcity, outdated farming techniques, limited technological adoption, and market inefficiencies. Despite employing nearly 80% of the population and contributing significantly to the GDP (Rasooli, Bhushan, & Kumar, 2020), Afghanistan's agricultural sector struggles with low productivity and high vulnerability to environmental changes. While Internet of Things (IoT) technologies

offer promising solutions—such as real-time monitoring, precision farming, and resource optimization—practical implementation within Afghanistan remains minimal (Roe et al., 2022; Raj et al., 2024).

The core issue lies in the gap between the potential benefits of IoT in agriculture and the realities of Afghanistan's infrastructure, economic limitations, and technological literacy. The absence of reliable internet, insufficient power supply, high costs of IoT systems, and a lack of technical knowledge among farmers present formidable barriers (Hasas et al., 2024; Basirati et al., 2019). Moreover, cultural resistance to technological change and limited digital literacy, particularly among older and less-educated rural farmers, pose significant social challenges to adoption. Unequal access to training and information further compounds digital exclusion in already marginalized communities.

Without interventions that address both the technical and social constraints, Afghanistan risks falling behind in leveraging modern agricultural innovations, potentially deepening existing rural inequalities and weakening long-term resilience. Therefore, a detailed exploration of both the challenges and opportunities associated with IoT implementation is crucial for creating inclusive strategies that can enable Afghanistan to modernize its agricultural landscape and achieve sustainable economic and social development.

State of the Art

The integration of Internet of Things (IoT) technologies into agriculture has been widely recognized as a transformative solution to enhance productivity, optimize resource use, and modernize traditional farming practices. Hussein et al. (2024) highlighted the potential of IoT and AI to automate agricultural activities such as disease detection, moisture monitoring, and decision-making through smart technologies. Similarly, Qazi et al. (2022) proposed intelligent agriculture frameworks that use IoT and AI to predict crop behavior and optimize cultivation practices.

In Afghanistan, the agriculture sector remains largely traditional, with minimal IoT integration (Qasimi, Shahidzay, & Fazli, 2024). Research by Hasas et al. (2024) pointed out the feasibility challenges of implementing IoT-connected devices due to infrastructural deficits and economic limitations. In neighboring countries like India and Pakistan, IoT applications have been more successful, offering precision farming, irrigation control, and crop monitoring solutions. These examples demonstrate the potential of IoT in boosting agricultural productivity and ensuring food security.

However, several challenges persist. Farooq and Akram (2021) and Hafeez et al. (2022) emphasized that barriers like high costs, data security concerns, and lack of technical expertise hinder IoT adoption, particularly in developing regions. Similarly, Mardiani et al. (2024) emphasized the importance of cost-effective and accessible IoT solutions for process control and quality improvement, which remains a significant hurdle for resource-constrained areas like Afghanistan.

Despite these challenges, the opportunities presented by IoT are substantial. Studies by Elijah et al. (2018) and Quy et al. (2022) underscored the benefits of real-time monitoring, data-driven decision-making, and automated irrigation systems in improving crop yields and reducing resource wastage. Moreover, initiatives like AgroTick, Ingemarsdotter et al. (2022) demonstrate how cloud computing, big data, and mobile apps can empower farmers with better information-sharing networks and efficient resource management.

Furthermore, Aarif et al. (2025) noted that smart sensor technologies have significantly advanced, offering cost-effective solutions for soil moisture measurement, weather forecasting, and livestock management. These developments provide a hopeful pathway for Afghanistan to overcome technological and economic barriers through targeted investments and capacity-building programs.

Overall, while Afghanistan faces substantial obstacles in adopting IoT in agriculture, the lessons learned from global and regional studies offer a roadmap. Strategic planning, investment in digital infrastructure, and farmer education programs are crucial to bridging the gap between Afghanistan's traditional agriculture and the emerging era of smart farming.

Table 1. Summary of Challenges and Opportunities of IoT Implementation in Afghanistan's Agriculture

No.	Category	Finding	Source
1.	Infrastructure Challenges	Lack of stable internet and unreliable power grids hinder IoT deployment in Afghanistan's agricultural sector.	Qasimi, F., Shahidzay, A. K., & Fazli, A. (2024). Challenges and Opportunities of the Internet of Things in Agriculture in Afghanistan. ESRJ.
2.	High Initial Costs	High costs of IoT devices and their installation and maintenance limit adoption among Afghan farmers.	Ado, S. G., & Abubakar, A. S. (2024). Towards Self-Sufficient Agriculture in Afghanistan: A Review of Enhancements and Challenges. Journal of Natural Science Review.
3.	Lack of Technical Expertise	Limited availability of skilled personnel and training programs in IoT technology hampers the adoption of these systems in rural Afghanistan.	Farooq, M. S., & Akram, S. (2021). IoT in agriculture: challenges and opportunities. Journal of Agricultural Research (JAR).
4.	Data Security Concerns	Data security and privacy concerns due to limited cybersecurity infrastructure in Afghanistan may hinder the adoption of IoT.	Zikria, Y. B., Ali, R., Afzal, M. K., & Kim, S. W. (2021). Next-generation internet of things (iot): Opportunities, challenges, and solutions. Sensors.
5.	Environmental Factors	Diverse climatic conditions and environmental challenges, such as water scarcity, complicate the implementation of IoT for consistent agricultural outcomes.	Tzounis, A., Katsoulas, N., Bartzanas, T., & Kittas, C. (2017). Internet of Things in agriculture, recent advances and future

			challenges. Biosystems engineering.
6.	Opportunities in Smart Irrigation	IoT enables efficient water management through smart irrigation systems, optimizing water usage based on real-time soil moisture and weather data.	Farooq, M. S., & Akram, S. (2021). IoT in agriculture: challenges and opportunities. Journal of Agricultural Research (JAR).
7.	Real-Time Monitoring	IoT-enabled sensors allow for real-time data collection on soil, crops, and climate, leading to precision farming and improved resource management.	Ado, S. G., & Abubakar, A. S. (2024). Towards Self-Sufficient Agriculture in Afghanistan: A Review of Enhancements and Challenges. Journal of Natural Science Review.
8.	Economic Growth Potential	IoT adoption in agriculture can boost productivity, contribute to food security, and foster economic development in Afghanistan.	Qasimi, F., Shahidzay, A. K., & Fazli, A. (2024). Challenges and Opportunities of the Internet of Things in Agriculture in Afghanistan. ESRJ.

The table above highlights both the challenges and opportunities of implementing IoT in Afghanistan's agricultural sector. On the challenges side, factors such as unreliable infrastructure, high initial costs, and a lack of technical expertise are identified as significant barriers. Afghanistan's rural areas suffer from inconsistent electricity and internet connectivity, which makes the deployment and sustainable operation of IoT systems difficult. Furthermore, the high costs of IoT devices and their maintenance add financial strain, particularly for small-scale farmers. Additionally, there is a scarcity of skilled personnel capable of operating and maintaining these systems, which further hampers IoT adoption.

Despite these challenges, the table also emphasizes the potential of IoT to bring transformative benefits to Afghanistan's agricultural industry. Smart irrigation systems powered by IoT technology offer significant opportunities to optimize water usage, a vital resource in the face of water scarcity. IoT-enabled sensors can also improve real-time monitoring, enabling farmers to manage their resources more efficiently and increase crop productivity. Moreover, the integration of IoT could stimulate economic growth by improving agricultural yields and ensuring better food security for Afghanistan’s population. Ultimately, the successful implementation of IoT could revolutionize the agricultural sector, provided the barriers are addressed through strategic investments and capacity-building efforts.

METHOD

This research was conducted to explore the challenges and opportunities related to the implementation of Internet of Things (IoT) technologies in Afghanistan's agricultural sector. The study employed a mixed-methods approach combining both

qualitative and quantitative techniques to ensure comprehensive data collection and a nuanced understanding of the subject.

Sampling Methods

To gather a diverse set of perspectives, purposive sampling was used to select participants who were directly involved in agricultural practices, including farmers, agricultural workers, and stakeholders from various parts of Afghanistan. This method allowed us to specifically target individuals with relevant experience and knowledge regarding the agricultural landscape in the region. A total of 200 respondents were included, ensuring a broad representation of the agricultural community across different regions of Afghanistan.

Additionally, to further capture a wide range of insights, snowball sampling (SBS) was applied. This method enabled the identification of additional participants through referrals from initial respondents, ensuring access to hard-to-reach individuals who might not be immediately available through conventional means. This approach is particularly beneficial when working with communities where traditional sampling methods are less effective.

Data Collection

Primary data was collected using a combination of tools:

1. **Surveys:** A structured survey using Google Forms was distributed to gather quantitative data on the awareness, knowledge, and perceptions of farmers regarding IoT technologies.
2. **Semi-structured Interviews:** In-depth interviews were conducted with key stakeholders, including technology providers, policymakers, and farmers, to gather qualitative insights into the challenges and opportunities of IoT in agriculture. These interviews were designed not only to understand technical and infrastructural issues but also to capture perceptions, attitudes, and social behaviors related to digital adoption. Questions explored farmers' readiness to adopt new technologies, the influence of community norms, and barriers to behavioral change.
3. **Focus Group Discussions (FGDs):** FGDs were used to examine collective community attitudes and responses toward IoT technologies, including discussions on digital literacy, resistance to change, and perceived risks or benefits. These sessions were crucial for understanding how IoT adoption is negotiated within social and cultural contexts.

Data Analysis

Quantitative data from the surveys were analyzed using descriptive statistics to present patterns and trends related to IoT awareness, adoption, and challenges. For qualitative data, thematic analysis was used. The interview and FGD transcripts were systematically coded and categorized into themes and sub-themes, which were then analyzed to identify common patterns, challenges, and opportunities related to IoT adoption. Particular attention was given to emerging themes involving social adaptation, community-level impacts, and inclusion dynamics, reflecting a broader digital transformation perspective.

Ethical Considerations

This study adhered to ethical standards throughout the research process. Informed consent was obtained from all participants, ensuring that they were fully aware of the study's objectives and their voluntary participation. Participants' privacy and confidentiality were guaranteed, and all data were anonymized to protect individuals' identities. The research was conducted with respect for cultural norms and ethical principles, ensuring fairness and transparency in all interactions with participants.

RESULT

The study identified a range of challenges and opportunities regarding the implementation of Internet of Things (IoT) technologies in Afghanistan's agricultural sector. The findings were based on both quantitative data obtained through surveys and qualitative insights gathered from semi-structured interviews. The data analysis revealed several key themes and patterns.

Table 2. Demographic Profile of Respondents

No.	Demographic Category	Sub-category	Frequency (%)
1.	Gender	Male	75%
		Female	25%
2.	Age Group	18-30 years	20%
		31-45 years	45%
		46-60 years	25%
		60+ years	10%
3.	Education Level	No formal education	10%
		Primary education	30%
		Secondary education	40%
		Tertiary education	20%
4.	Occupation	Full-time farmer	50%
		Part-time farmer	25%
		Agricultural worker (non-farmer)	15%
		Agricultural stakeholder (e.g.,policymaker)	10%
5.	Region	Northern Afghanistan	35%
		Central Afghanistan	40%
		Southern Afghanistan	25%

The demographic table provides an overview of the study's respondent composition. A higher percentage of male participants (75%) compared to females (25%) reflects a gender imbalance, which is typical in many rural agricultural communities. Most participants fall within the 31-45 age range (45%), suggesting that middle-aged individuals are more engaged in agricultural activities. Educationally, a significant portion of respondents have received at least secondary education (70%), which is essential for the adoption of new technologies like IoT. Half of the respondents are full-time farmers, which indicates direct involvement with agricultural practices. Geographically, the survey covered a diverse range, with a balanced representation from Northern (35%) and Central Afghanistan (40%), and a smaller proportion from the Southern region (25%). This diversity strengthens the validity of the study by capturing perspectives from various areas of Afghanistan.

Table 3. Awareness and Adoption of IoT Technologies in Afghanistan's Agriculture

Aspect	Percentage	Findings
Farmers aware of IoT	60%	Majority have heard of IoT, but awareness is limited.
Farmers who adopted IoT	30%	A smaller portion of farmers have integrated IoT into their practices.
Primary understanding of IoT	30%	Mostly related to irrigation and soil moisture monitoring.
Barriers to IoT adoption	70%	Lack of awareness and limited access to technology cited as significant.
Interest in IoT adoption with support	70%	Farmers are willing to adopt IoT with adequate training and support.

The survey results highlight significant insights into the awareness and adoption of Internet of Things (IoT) technologies within Afghanistan's agricultural sector. While 60% of the farmers surveyed were aware of IoT, only 30% had integrated these technologies into their farming practices. This indicates a clear gap between awareness and actual adoption, which can be attributed to multiple barriers such as limited access to technology, infrastructure challenges, and financial constraints (Hasas et al., 2024).

Farmers who were aware of IoT technologies primarily associated them with irrigation management and soil moisture monitoring, reflecting a recognition of their potential in addressing key issues like water scarcity and inefficient irrigation practices. However, 70% of respondents cited lack of awareness and limited access to technology as the main barriers to adopting IoT. These challenges emphasize the need for more widespread education, infrastructure development, and affordable solutions to facilitate IoT adoption in rural Afghanistan (Tzounis et al., 2017).

Despite these obstacles, a significant opportunity exists for increasing IoT adoption. Approximately 70% of farmers expressed willingness to adopt IoT if provided with adequate training and support. This highlights the importance of capacity-building initiatives, such as farmer education programs and accessible technology solutions, which could enhance the uptake of IoT and lead to improved agricultural productivity and sustainability (Farooq & Akram, 2021). Addressing these gaps could pave the way for a more inclusive digital transformation in Afghanistan’s agriculture, contributing to long-term food security and rural development.

Table 4. Challenges in IoT Implementation in Afghanistan's Agriculture

Challenge	Percentage	Findings
Poor Internet Connectivity	70%	Internet access, especially in rural areas, is insufficient for IoT usage.
Financial Constraints	60%	High initial investment for IoT devices makes adoption unaffordable for most farmers.
Limited Technical Skills	65%	Farmers lack the knowledge to operate and maintain IoT devices effectively.
Social and Cultural Factors	55%	Resistance to change and preference for traditional farming practices hinder adoption.

The qualitative data gathered from participants revealed several key challenges that hinder the successful implementation of IoT in Afghanistan’s agriculture. A major barrier identified was poor internet connectivity, with **70**% of respondents highlighting that unreliable or slow internet access, particularly in rural areas, severely limited the

potential of IoT applications. These technologies often require continuous internet access for data transmission and cloud-based services, making it difficult for farmers to fully leverage IoT solutions.

In addition, financial constraints were identified as another significant challenge. 60% of farmers reported that the initial investment required for IoT devices made it unaffordable. This indicates that for IoT to become more accessible, affordable financing options or subsidies would be crucial for farmers.

Moreover, limited technical skills among farmers, with 65% of participants acknowledging this issue, adds another layer of complexity. Farmers lacked the knowledge to effectively operate, troubleshoot, and maintain IoT systems, which underscores the need for comprehensive training and capacity-building initiatives.

Lastly, social and cultural factors, with 55% of respondents noting this, indicated resistance to change and a preference for traditional farming methods, which present significant obstacles to the adoption of IoT. Overcoming these cultural barriers requires targeted awareness campaigns and community engagement strategies to foster openness toward new technologies.

Table 5. Opportunities for IoT in Afghanistan's Agriculture

Opportunity	Percentage	Findings
Improved Irrigation Management	80%	IoT could optimize irrigation, ensuring water is used efficiently, especially in water-scarce regions.
Crop Health Monitoring	80%	IoT-enabled sensors can monitor soil conditions, plant health, and detect pests, leading to timely interventions.
Increased Efficiency	75%	Automation through IoT devices can reduce labor costs and improve operational efficiency in farming.
Data-Driven Decision Making	70%	IoT enables data collection and analysis for better-informed agricultural decisions, boosting productivity.
Enhanced Sustainability	65%	IoT technologies support sustainable farming practices by optimizing resource usage and minimizing waste.

Despite the challenges, there are significant opportunities for implementing IoT technologies in Afghanistan's agricultural sector. According to the survey, 80% of farmers believe that IoT could substantially enhance irrigation management. With Afghanistan's water scarcity issues, optimizing water usage through IoT sensors could lead to better resource management and higher crop yields. Similarly, crop health monitoring was identified by 80% of farmers as another major benefit of IoT, particularly using remote sensors that provide real-time data on soil conditions, plant health, and pest activity, allowing for early interventions and more precise farming.

Additionally, increased efficiency was highlighted by 75% of participants, who recognized that automation in tasks such as irrigation and pest control could reduce labor costs and improve overall operational efficiency. This aligns with broader trends in agricultural technology, where automation and precision farming are increasingly becoming mainstream.

Stakeholders, including technology providers and policymakers, stressed the data-driven decision-making potential of IoT, with 70% acknowledging its role in

enabling better agricultural planning and resource allocation. Finally, 65% of respondents noted the potential for IoT to contribute to enhanced sustainability, making it a key driver for environmentally friendly agricultural practices in Afghanistan.

DISCUSSION

The findings of this study underscore both the challenges and the opportunities presented by the implementation of Internet of Things (IoT) technologies in Afghanistan's agricultural sector. While the barriers to adoption are considerable, the potential benefits of IoT technologies offer a promising avenue for transforming Afghanistan's agricultural landscape.

A primary challenge identified in the study is poor internet connectivity, with 70% of respondents highlighting that unreliable or limited access to the internet, particularly in rural areas, hinders the use of IoT devices. This issue is critical because IoT technologies relieve constant internet access for real-time data collection, monitoring, and decision-making. Previous research has pointed out that limited infrastructure, particularly in developing regions like Afghanistan, poses a significant barrier to the adoption of advanced technologies in agriculture (Zikria et al., 2021). This issue needs to be addressed through the improvement of digital infrastructure and ensuring rural areas have reliable internet access. Without inclusive digital infrastructure, the risk of deepening existing digital divides between urban and rural populations increases, limiting equitable technological progress.

Another significant challenge is financial constraints, with 60% of participants reporting that the high initial costs of IoT devices made adoption unaffordable. This finding aligns with existing literature that emphasizes the financial challenges faced by smallholder farmers in low-income countries (Farooq & Akram, 2021). For IoT adoption to be widespread, solutions such as subsidies, micro-financing options, or public-private partnerships could help mitigate these financial barriers and facilitate the implementation of IoT in agriculture. Moreover, financing models must be designed to empower marginalized groups, especially women and landless laborers, who are often excluded from traditional agricultural investment mechanisms.

In addition to infrastructure and financial challenges, the study revealed a lack of technical skills among Afghan farmers, with 65% of respondents acknowledging this limitation. The absence of skilled labor in rural Afghanistan is a significant barrier to the effective use and maintenance of IoT systems. Similar challenges have been observed in other developing nations where a lack of training and expertise prevents farmers from fully utilizing technological innovations (Tzounis et al., 2017). Addressing this gap will require comprehensive training programs for farmers, extension services, and capacity-building initiatives. Improving digital literacy is not only a technical requirement but a form of rural empowerment that can shift long-term socio-economic dynamics—enabling communities to make informed decisions, access wider markets, and reduce reliance on intermediaries.

Despite these challenges, the study also highlights several opportunities for IoT implementation in Afghanistan's agriculture. Improved irrigation management was identified by 80% of farmers as a key benefit of IoT, which could help optimize water usage in regions suffering from water scarcity. Given Afghanistan's limited water resources, IoT technologies could play a pivotal role in ensuring efficient water

management and enhancing agricultural productivity (Farooq & Akram, 2021). Additionally, crop health monitoring emerged as another key opportunity, with 80% of respondents highlighting that IoT sensors could improve pest detection, monitor soil health, and help make timely interventions (Ado & Abubakar, 2024). This aligns with findings from other studies that emphasize the role of IoT in enabling precision farming, leading to higher crop yields and reduced resource waste (Zikria et al., 2021).

Finally, increased efficiency through automation, as indicated by 75% of respondents, is another promising benefit of IoT in agriculture. Automation technologies such as smart irrigation systems and pest management tools could help reduce labor costs and improve operational efficiency. Additionally, data-driven decision-making enabled by IoT data collection could provide Afghan farmers with actionable insights for better resource allocation and productivity enhancement (Qasimi, Shahidzay, & Fazli, 2024). Importantly, this data-centric approach has the potential to transform how knowledge is produced and shared in rural areas, moving from intuition-based practices to evidence-based strategies. This transformation could foster collective learning, reshape community norms around farming, and support broader socio-economic inclusion.

CONCLUSION

The findings of this study underscore both the challenges and the opportunities presented by the implementation of Internet of Things (IoT) technologies in Afghanistan's agricultural sector. While barriers such as inadequate internet connectivity, high initial costs, and limited technical expertise remain significant, the potential benefits of IoT in enhancing irrigation management, crop monitoring, and agricultural efficiency offer promising prospects for transforming the sector.

To enable widespread adoption of IoT in agriculture, targeted investments are needed in rural digital infrastructure, capacity-building programs, and financial support mechanisms tailored to the needs of smallholder farmers. Equally important is the development of inclusive policies that ensure equitable access to technology, especially for marginalized groups such as women, youth, and landless laborers who are often excluded from technological advancements.

Beyond technical improvements, IoT adoption has the potential to catalyze broader social change. By enhancing access to information and enabling data-driven decision-making, these technologies can empower rural communities, reduce dependency on traditional intermediaries, and support more inclusive forms of agricultural knowledge sharing. Improved digital literacy through training initiatives can help bridge the digital divide, fostering long-term resilience and self-sufficiency among farming communities.

Furthermore, the integration of IoT into agricultural policy can contribute to digital equity and rural development by aligning technology deployment with broader social goals. Government and development actors must ensure that IoT interventions are not only technically viable but also socially embedded, participatory, and responsive to local needs.

In this context, IoT is not merely a technological innovation—it is a potential driver of socio-economic transformation in Afghanistan's rural landscape. Future research and implementation strategies should therefore consider not just how IoT

works, but who it works for, and under what conditions it can create meaningful and equitable change.

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