Perceived Usefulness and Adoption Intention of IoT-Enabled Smart Farming Technologies Among Agriculture Graduates in Maharashtra: A Quantitative Study

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Abstract

The swift adoption of the Internet of Things (IoT) technologies in the agricultural sector has changed the conventional farming process as it allows making decisions based on the data, optimizing resources, and producing sustainably. Although the use of smart farming solutions has become more relevant, the successful implementation of the solutions is mainly determined by the perception and intentions of future agricultural professionals. The proposed quantitative research paper focuses on the perceived usefulness of technologies and adoption intention of IoT-based smart farming technologies among the agrarian economy graduates in Maharashtra, a state with a heterogeneous agrarian economy and an increasing trend in technological involvement in agriculture.

It is based on the Technology Acceptance Model (TAM) and addresses the issue of getting the meaning of perceived usefulness on how it can impact the intention of graduates to adopt the IoT applications, i.e., smart sensors, automated irrigation systems, soil monitoring tools, and data analytics platforms. The primary data were gathered using a designed questionnaire that was given to the graduates in the field of agriculture at the selected universities and colleges in Maharashtra. The statistical methods used to evaluate relationships between perceived usefulness and adoption intention were descriptive analysis, correlation analysis, and regression analysis.

The results show that graduates with the major of agriculture tend to have a positive attitude towards the use of IoT-enabled smart farming technologies, as they see the opportunities to increase productivity and lower the input costs and sustainability of agricultural activities. The perceived usefulness was also found to be a strong predictor of the intention to adopt, which serves as an argument in favor of showing a practical advantage and applicability of smart farming tools in the real world. Nonetheless, the issues of cost, technical complexity, and lack of practical exposure were found to be the factors that can moderate the adoption decisions.

The research adds to the current body of literature by offering empirical data of the technology acceptance of the future agricultural practitioners in a developing agricultural setting. The findings have useful policy implications on policymakers, learning institutions, and technologists to develop specific training modules, curriculum implementation policies, and sensitization efforts that can empower IoT use in agriculture. Finally, increasing the perceived usefulness among the graduates of the agriculture profession may be the key factor in quickening the change in the smart farming technologies in Maharashtra.

Keywords: Internet of Things (IoT), Smart Farming Technologies, Perceived Usefulness, Adoption Intention, Agriculture Graduates, Technology Acceptance Model (TAM), Maharashtra

Introduction

The agricultural industry has undergone a revolution because of the fast evolution of the Internet of Things (IoT) technologies, and the concept of smart farming has been introduced. Smart farming technologies are IoT-connectable and can bring in sensors, data analytics, automation, and real-time to enhance the productivity and efficiency of agriculture, resources, and decision-making. In a place like India where agriculture was, and continues to be, one of the predominant income sources and has continually been impacted by such problems as climate changes, water shortage, soil erosion, and lack of labour force, the application of smart farming solutions is being perceived as a strategic pre-destination, rather than a decision.

The state of Maharashtra is one of the most agricultural in India that provides a special background to the study of the IoT-based technologies adoption in agriculture. The heterogeneous agro-climatic conditions, a mixture of conventional and commercial approaches to farming, and a growing policy emphasis on digital agriculture characterize the state. The agricultural graduates which are expected to be the innovators, the adopters of technologies, the extension agents and the future agripreneurs are one of the most crucial stakeholder groups in this change. Their performance towards innovations can be important in terms of implementing practices concerning smart farming in the grassroots.

One of the factors which have been observed to influence adoption of technology is the perceived usefulness that is applicable in technology acceptance and innovation diffusion theories. The probability of their intention to use and promote the technologies with the purpose of IoT-enabled smart farming technologies will increase in case their perception of the latter makes agriculture graduates assume that they can make their operations more productive, less expensive, and more sustainable. Conversely, the barrier to adoption despite technology availability can be low awareness, perceived complexity or lack of perceived value.

It is on this backdrop that this current study will seek to examine the relationship between perceived usefulness and intention to adopt IoT-enabled smart farming technology amongst graduates of agriculture in Maharashtra as a quantitative study. This segment of highly educated and powerful population is the target population of the study to provide information which can be used by the policymakers, educational institutions and other developers of technologies to develop more specific intervention to make sure that the smart farming solutions are adopted within the shortest possible period of time and provide the future of sustainable agricultural culture.

Background of the study

Agriculture is an important field of the Indian economy, and it plays a significant role in terms of the employment sector, rural lives, and food security. The sector has experienced a slow change in the recent years due to technological changes that seek to enhance productivity, efficiency of resources and sustainability. Internet of Things (IoT) based smart farm technologies have proven to be one of the promising solutions to solve the endemic problems of climatic variations and scarcity of water, soil degradation, lack of labour and market volatility. The IoT applications allow farmers to engage in precision farming, which can increase the yields of crops and maximize the utilization of inputs like water, fertilizers, and energy by enabling real-time data collection and monitoring, as well as automated decision-making.

Maharashtra is one of the most important agricultural states in India, which offers a distinctive environment of smart farming technologies implementation. The state is dynamics in terms of agro-climatic regions, degree of farm mechanization and frequent problems of drought and resource management. The government has reacted to this by introducing more solutions based on digital agriculture, such as sensor-based irrigation, smart weather stations, and data-driven crop management solutions. Successful adoption of these technologies, however, does not just rest on its technical capacity, but also on how future agricultural practitioners perceive, develop

capabilities and are willing to utilize and market the technology.

Agriculture graduates become critical in this transition process as they are supposed to be technology consumers, advisors, extensionists, and entrepreneurs in the farming ecosystem. Their attitude towards the utility of IoT-based smart farming technologies has the potential to play a significant role in influencing their desire to adopt, recommend, or use such systems in the field of agriculture. Perceived usefulness which is usually associated with efficiency, productivity and quality of decisions has been commonly identified as one of the most important predictors of technology acceptance. The process of agriculture students assessing the practical usefulness of IoT technologies, thus, is crucial to predicting the adoption pattern and understanding possible obstacles to its application.

Source: https://www.mdpi.com/
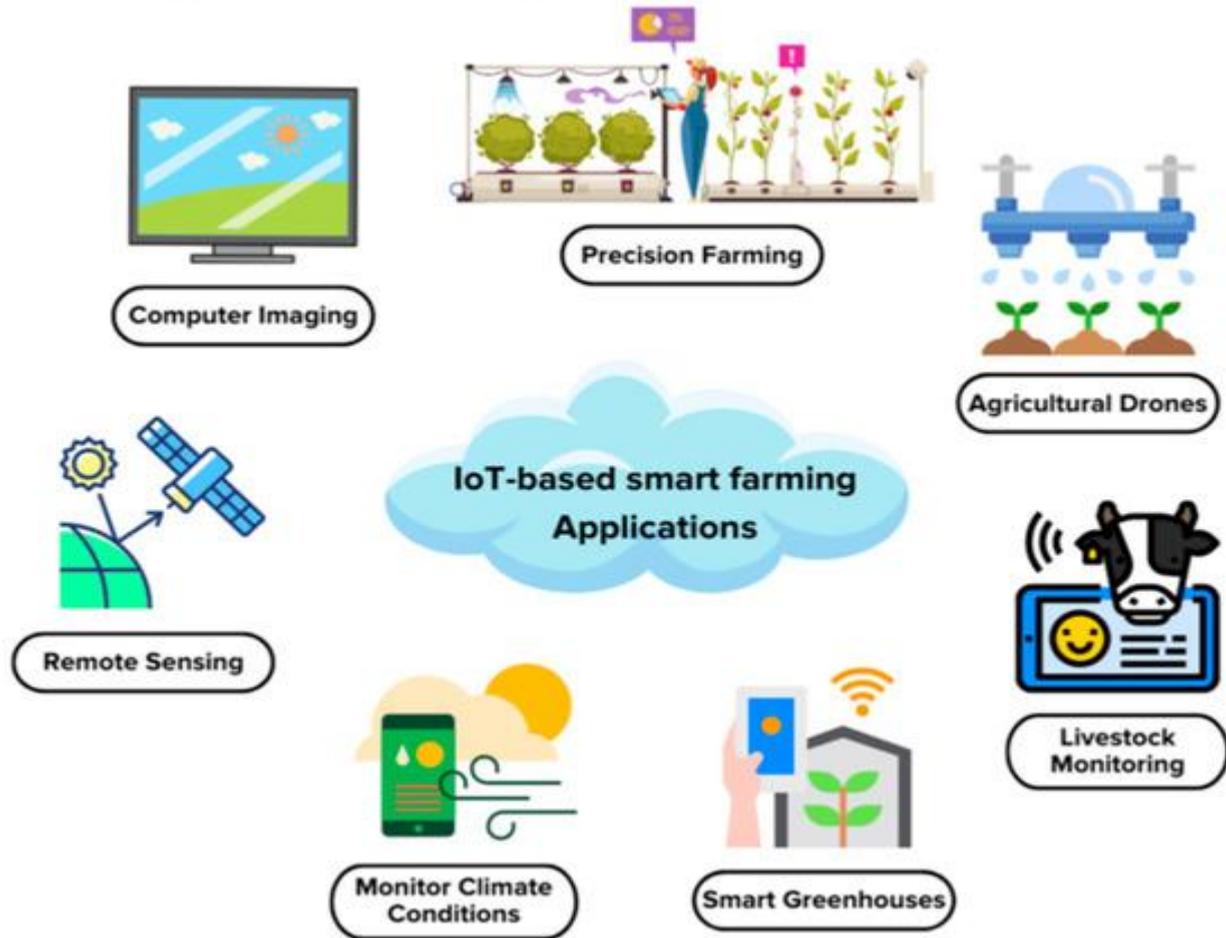
Although there is an increased trend toward smart farming, there is little empirical research that attempts to understand the adoption intention of IoT technologies among agriculture graduates in Maharashtra. Current research is mostly focused on the behaviour of farmers to adopt or on the technological viability, and there is a gap in the comprehension of attitudes of academical trained people who would probably define the future of agricultural innovation. This gap is important to be addressed so as to come up with effective educational programs, training programs and policy interventions that match the technological advancement and the readiness of the user.

It is against this background that the current quantitative research aims to investigate the connection between the perceived usefulness and adoption intention of the IoT-enabled smart farming technologies in Maharashtra on the basis of the agriculture graduates. Through this connection, the research will add to the general discussion on the adoption of technology in agriculture and offer information that can help inform the creation of human-focused

approaches to increasing the rate of uptake of smart farming solutions in the area.

Justification

India is in the process of changing agriculture slowly through incorporation of Internet of Things (IoT) technologies like smart sensors, automated irrigation systems, precision monitoring tools, and data-driven decision platforms. Although these technologies have high productivity potential, effective use of resources, and resilience in climatic conditions, their effective diffusion will significantly rely on willingness and readiness of future agricultural professionals to implement it, and espouse it. The agricultural graduates specifically trained in the modern agrarian practices are likely to be at the center of transferring the smart farming innovations to the field. There are, however, a few empirical studies on the perceptions of these graduates regarding the usefulness of IoT-enabled smart farming technologies and the effects these perceptions have on their intention to adopt them.

Maharashtra stands out as one of the most agricultural states in India with various agro-climatic regions and a rising trend in innovation based farming; hence it will be a perfect place to conduct this study. Although the government has created initiatives to embrace digital and smart agriculture, the adoption rates are not evenly distributed, which implies that there may be gaps in awareness, values, and confidence in the use of technology. These perceptual and behavioral facets among agriculture graduates can offer information on the human and educational aspects that influence the technology acceptance in the agricultural industry.

The study is legitimate because it uses quantitative method to undertake a systematic analysis of the correlation between perceived usefulness and the adoption intention of IoT-enabled smart farming tools. The research targets an understudied group of stakeholders (agriculture graduates instead of farmers) by concentrating on agriculture graduates instead of farmers alone, which has been found to serve as an interface between technological innovations and real-world application of agriculture. These results will be relevant to curriculum development in agricultural education, training requirements, and help inform policymakers and extension agencies to formulate specific measures to boost the use of smart farming.

Finally, the research paper will add to the overall discussion of sustainable agriculture and digital revolution by defining the major factors shaping the technology-acceptance inclination among future agricultural professionals, which will help to make informed decisions and promote the evolution of agriculture in the Maharashtra state in the long term.

Objectives of the Study

1. To determine how agriculture graduates in Maharashtra are aware and familiarized with the smart farming technologies that are enabled by IoT.
2. To consider the perceived usefulness of the IoT-based smart farming tools towards increasing the agricultural productivity, resource efficiency, and decision-making.
3. To examine the adaptation intention to use the IoT-enabled smart farming technologies among agriculture graduates.
4. To test the correlation between the perceived usefulness and intention to adopt IoT-enabled smart technologies in farming among agriculture graduates.
5. To determine the main technological and practical aspects that affect the adoption and desired utilization of smart farming solutions.

Literature Review

The studies done on the uptake of Internet of Things (IoT) technologies in agriculture reveal that the behavioral determinants are core to the description of the technology acceptance by farmers and potential users. The paper by Pillai and Sivathanu on IoT adoption by Indian farmers has determined that one of the significant reasons of adoption of IoT systems is perceived usefulness, along with relative advantage, social influence, and perceived

convenience, in rural settings (Pillai and Sivathanu, 2020).

TAM, which was initially put forward by Davis (1989), has been used extensively to examine technology adoption in different industries and it is especially applicable to examine the adoption of IoT-enabled smart farming. The model defines perceived usefulness (PU) as the degree to which the people think that the utilization of a particular technology will make them better at their work or their performance outcomes; in the context of agriculture, PU can be viewed as the ability of the technology in question to make them more efficient and productive and in decision making that they will be carrying out. Consistent empirical research in the agricultural field reveals that PU is closely related to intention to use innovative technologies (Davis, 1989; see also its use in agricultural TAM research).

As an illustration, a study that investigated smart farming technologies in Italy revealed that perceived usefulness had a positive relationship with a farmer intention to adopt technologies, including drones and sensor systems, even considering information source and other environmental considerations (Rogers et al., 2020). On the same note, in their quantitative study, the authors discovered that the best predictor of the IoT adoption intention was perceived usefulness among rice farmers; their qualitative study employed a Technology Readiness Acceptance Framework and established that respondents who saw the practical benefit of IoT were more likely to have an intention to adopt it (Yaakub et al. 2025).

A study carried out in Saudi Arabia also supports the significance of perceived benefits in the intention shaping. In a research about the viewpoint of farmers towards IoT in crop health observation, a statistical correlation of moderate positive relationship was observed between perceived advantages and readiness to embrace IoT technologies with awareness and training to also play a significant role (Al-Shahrani et al., 2025). The findings are consistent with the main idea of TAM, which suggests that positive performance expectation is a factor that enhances the intention to adopt.

Besides general populations in farming, research on urban farming and agricultural graduates indicate that the subjective norms and usefulness perceptions are among the factors that affect adoption intentions. Malaysian studies show that social influence, perceived usefulness, and facilitating conditions are among the factors in the intention to use smart farming technologies; thus, according to the research, the impact of peer effects and community encouragement can determine attitudes to the use of technology (Wee and Lim, 2022). Studies that involve the average holders of the agricultural degree also indicate that the knowledge of agricultural graduates about the IoT technologies, their attitudes to the usefulness, and perceived control affect their willingness to use the technologies in their professional practice (Zainal Abidin et al., 2024).

This trend has been reflected in studies that have adopted the use of TAM in plantation and crop projects, which have indicated that PU and perceived ease of use play a significant role in influencing adoption. As an example, the 2021 research comparing an IoT-based solution to maize plantation has shown that the level of influence of perceived usefulness on the acceptance and intention to use the system is very high among farmers (Phetchabun & Saengkrajang, 2021).

In addition to TAM, there are other associated theoretical viewpoints that support the usefulness hypothesis in the process of adoption. A study conducted in the Indian agricultural sector based on the Behavioral Reasoning Theory (BRT) established that perceived usefulness is a major positive factor that defines why farmers will use the IoT practices (Pillai and Sivathanu, 2020). Additionally, the research on the wider adoption of the Agriculture 5.0 technology depicts that behavioral intention is influenced by the perceived usefulness, as well as the psychological factors such as self-efficacy and social influence (Sharma et al., 2025).

Collectively, the literature confirms the assumption that perceived usefulness is a prominent predictor of adoption intention of smart farming technologies that are IoT-enabled. It has been observed to have an impact in various settings such as the population of farmers, smart farming programs, and student groups about to join the field of agriculture. In the Indian setting, where

the adoption of technology overlaps with the level of education, access to training and institutional support, the TAM model (particularly, the perceived usefulness construct) should serve as a solid foundation to explore how the Indian agriculture graduates develop intentions to use IoT applications in smart farming.

Material and Methodology
Research Design:
The research design used in the study was quantitative, cross-section study to explore the level of perceived usefulness and intent to adopt IoT-based technologies in smart farming among graduates in agriculture in Maharashtra. A descriptive-analytical method was applied in order to take current perceptions and behavioural intentions at one point in time. Technology adoption theory was used to base the research since it was presumed that the perceived usefulness is a determinant of intention to adopt smart farming solutions. The design allowed the statistical analysis of the relationships between constructs with the help of the numerical data gathered on a specific population.

Data Collection Methods:
The structured questionnaire that was used to collect primary data was created to be study specific. The tool was divided into two parts:
- the initial section usually involved a collection of demographic data (e.g., age, gender, level of education, specialization and exposure to smart farming technologies);
- the second part was an examination of the perceived usefulness and adoption intention on a five-point Likert scale between strongly disagree and strongly agree statement.

The questionnaire was also conducted both online and off line to reach more graduates of agriculture in various parts of Maharashtra. The questionnaire was checked carefully before complete implementation and its relevance and clarity were checked out, and a pilot test carried out to ascertain reliability and consistency of responses. The data obtained was coded and analyzed through the use of the relevant statistical methods.

Inclusion and Exclusion Criteria:
Inclusion criteria for participation in the study were:
- individuals who had completed a graduate or postgraduate degree in agriculture or allied agricultural sciences;
- respondents currently residing in Maharashtra;
- graduates with basic awareness of digital or smart farming technologies.

Exclusion criteria included:
- students currently pursuing undergraduate agricultural programs;
- professionals without an academic background in agriculture;
- incomplete or inconsistently filled questionnaires that could affect data validity.

Ethical Considerations:
The research was also done in strict adherence to ethical principles. The study was voluntary and the respondents were advised about the purpose of the study before the data was collected. Consent of all the participants was taken. Responsiveness anonymity and confidentiality were also assured and no personal identifiable information was gathered or released. Data collection was based on only academic research and was kept in a safe place to avoid unauthorized access.

Results and Discussion
Results:
1. Profile of the Respondents
The researchers used valid responses of 320 agriculture graduates in other districts of

Maharashtra. The demographics of the respondents are given in table one. Most of the interviewees were male (62.5%), which is indicative of the gender balance in the field of agricultural education. A majority of the respondents fell within the 21-25 years age bracket (58.4) which represents the young career graduates who will determine the future level of technology adoption in agriculture. Almost half of the surveyed (47.8) had an experience with smart farming technologies in their academic program.

Table 1: Demographic Profile of Respondents (n = 320)

Variable	Category	Frequency	Percentage
Gender	Male	200	62.5
	Female	120	37.5
Age (years)	21–25	187	58.4
	26–30	94	29.4
	Above 30	39	12.2
Education Level	UG	214	66.9
	PG	106	33.1
Prior Exposure to IoT	Yes	153	47.8
	No	167	52.2

Discussion:
The comparatively young age demographic implies the willingness to innovations and digital tools. Nevertheless, the fact that most of the respondents (more than half) have had minimal prior experience related to the IoT suggests that there is a mismatch between academic education and new technological solutions in the agricultural industry.

2. Descriptive Statistics of Key Constructs
A five-point Likert scale was used to measure Perceived Usefulness (PU) and Adoption Intention (AI). Table 2 shows the values of mean and standard deviation of the study constructs.

Table 2: Descriptive Statistics of Study Variables

Construct	Mean	Standard Deviation
Perceived Usefulness	3.92	0.71
Adoption Intention	3.68	0.76

Discussion:
The mean score of perceived usefulness is high, which demonstrates that agriculture graduates are largely convinced that technologies based on the IoT and smart farming can be used to increase productivity, optimize resource consumption, and decision-making. The intention of adoption, as such, is relatively weaker, indicating that good perceptions do not necessarily translate into immediate adoption intentions.

3. Reliability Analysis
Internal consistency was measured through calculation of the values of Cronbach alpha. Both constructs were more than the recommended level of 0.70, which ensured the reliability of the scale.

Table 3: Reliability Statistics

Construct	Number of Items	Cronbach's Alpha
Perceived Usefulness	6	0.86
Adoption Intention	5	0.83

Discussion:

The high reliability statistics show that the measurement items were consistently used to measure perceptions and intentions of the respondents, which is credible to the further inferential analysis.

4. Correlation Analysis

The Pearson correlation was carried out to investigate the connection of the perceived usefulness and adoption intention.

Table 4: Correlation between Perceived Usefulness and Adoption Intention

Variables	Perceived Usefulness	Adoption Intention
Perceived Usefulness	1	0.64**
Adoption Intention	0.64**	1

Note: $p < 0.01$

Discussion:

The findings indicate that there is a significant positive correlation between perceived usefulness and adoption intention that is of statistical significance. This observation is consistent with technology adoption theories, proposing that people are more willing to use smart farming technologies in case they believe in the evident functional and economic rewards.

5. Regression Analysis

Simple linear regression was used to test the effect that perceived usefulness has on intention to adopt.

Table 5: Regression Results: Effect of Perceived Usefulness on Adoption Intention

Predictor	β	t-value	p-value
Perceived Usefulness	0.64	14.72	<0.001
R²	0.41		
F-value	216.6		

Discussion:

Perceived usefulness is significant in predicting adoption intention with a 41 percent variance. It means that the beliefs on the improvement of efficiency, improvement of yields and cost optimization are the focal factors in the development of intention to use the IoT-based farming solution among graduates. Nevertheless, the amount of unexplained variance also indicates that other variables, including cost, infrastructure and institutional support, could also play a role in determining the adoption decision. The results indicate that Maharashtra-based agriculture graduates have quite positive attitudes to IoT-based smart farming technologies. Although the perceived usefulness is a significant factor shaping the intention to adopt, the moderate adoption readiness is a practical issue that could impede the adoption process immediately. Paucity of practical experience, doubtfulness over payoff, and lack of infrastructural facilities in rural localities probably dilute the positive attitude into adoption conduct. Increasing experiential, extension and policy-based incentives could thus help improve the adoption of smart farming technologies among future agricultural practitioners.

Limitations of the study

Although the current study provides an important view on the perceived usefulness and intention to adopt IoT-enabled smart technologies in the fields of agriculture among the agriculture graduates in Maharashtra, it is limited by some factors that must be considered when interpreting the results.

To begin with, the research is constrained by geographical area as only graduates of agriculture were used in the study in Maharashtra. The difference in the agricultural practice, provision of infrastructural facilities, climatic conditions, and policy support in various states can have different effects on perceptions and the adoption behavior. Thus, conclusions cannot be easily drawn to the applicability of the results to other geographical areas of India or other countries where agriculture graduates take place.

Second, the study is based on self-reported information, and there is a possibility of response bias. The usefulness perceptions and adoption intentions of the participants do not necessarily result in actual use behavior, especially in the real farming conditions where financial, technical and institutional obstacles are experienced.

Third, the research design used in the study is the cross-sectional, which records the responses at one time. Since the perceptions and intentions regarding smart farming technologies can change with exposure, training, or technological progress, the study fails to consider the shift of attitudes as time goes by.

Fourth, the target group is limited to the graduates of agriculture courses only without the inclusion of the practicing farmers that do not have formal training in agriculture. This narrows down the interpretation of the adoption process within the wider farming community, where educational level and working experience could be a major contributor to technology acceptance.

Lastly, the perceived usefulness and perceived adoption intention are the main areas of focus in the study whereas other important elements like cost, infrastructure preparedness, digital literacy, policy incentive, and technical support were not explored much. These variables may be included to have a more holistic view of the IoT technology adoption in agriculture.

The identification of these limitations gives a basis to the future study to expand the sample size, the design of a longitudinal study, and the mixed-method study to have an in-depth and more general understanding of the technology of smart farming adoption.

Future Scope

The current research concerning the perceived usefulness and adoption intention of IoT-enabled smart farming technologies among the Maharashtra-based agriculture graduates presents a number of avenues of future research and practical development. Although the results can be used to gather good points about the technology acceptance in a particular academic and geographical setting, wider research can be used to expand knowledge and usage. Future research can expand the study by involving practicing farmers, agri-entrepreneurs, extension officers, and policymakers to give a comparison between the perception gap between the academically trained graduates and those working on the ground. Comparative study on various states or agro-climatic regions in India would assist in detection of regional differences in adoption intention based on the infrastructure, crop patterns, and policy support. The longitudinal research designs might be used to investigate the changes in perceptions of usefulness and adoption intentions with time in response to the increasing exposure to smart farming technologies by graduates. These studies would provide more information on post-adoption behaviour, continued use and technology assimilation in actual agricultural contexts. Other constructs that can be added to the study in future research include perceived risk, cost sensitivity, digital literacy, environmental sustainability awareness, institutional support to come up with a holistic adoption model. Such qualitative methods as interviews and case studies can be used to add some contextual depth to quantitative results. In terms of technology, the

future research study can be centered on particular applications of IoT like accuracy irrigation, soil health, crop disease prediction, and supply chain traceability to determine the level of technology specific acceptability. This would also be a good extension to assess the impact of government schemes, start-up ecosystems and agri-tech incubators on adoption intentions. On the whole, broadening the target of the scope to include graduates, integration of various methodologies and matching research with the current smart agriculture developments can play an important role in ensuring sustainable agricultural growth and wise policy formulation in India.

Conclusion

In this quantitative research, the authors investigated how perceived usefulness affects the adoption intention of IoT-enabled smart farming technologies among graduates in the agricultural field in Maharashtra. The results suggest that the perceived usefulness is a determining factor that determines the willingness of graduates to use and recommend smart farming solutions. Technologies, which showed clearly the positive outcome in terms of increased productivity, effective use of resources, real-time decision making, costs optimization, were considered more positively, which further supports their applicability in the context of the contemporary agricultural practices.

The findings also indicate that as the future practitioners and change agents, agriculture graduates have a relatively positive orientation towards the digital and IoT-based innovations in the case when they are in line with real-life agricultural requirements and career goals. It seems that the exposure to data-driven agriculture in academic training improves awareness and acceptance, which shows the necessity to incorporate smart farming tools into the agricultural education and extension programs. Nonetheless, differences in adoption intention reflect to the contextual differences which include accessibility, availability of infrastructure, and trust in using technology.

Policy and practice-wise, the research highlights the necessity of specific capacity-building efforts, practical training, and demonstration projects that would provide a clear description of the practical benefits of the IoT application in agriculture. Further collaboration between technology providers and agricultural agencies and academic institutions can close the divide between what technology can do and what it can be doing.

Therefore, the perceived usefulness is a critical factor to consider in influencing the adoption intention of IoT-enabled smart farming technologies among agriculture graduates in Maharashtra. Practical issues and the strengthening of the visible usefulness of these technologies can help stakeholders expedite their implementation, leading to the sustainable agricultural sector, increased efficiency in the agricultural sector, and the overall modernization of the agricultural sector in the long run.

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