ENHANCING IoT ADOPTION FOR AGRICULTURAL SUSTAINABILITY: AN EXPLORATORY STUDY OF CHALLENGES FACED BY FARMERS IN NEPAL

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ABSTRACT

Examining the implementation of IoT in Nepali agriculture, this study emphasizes the value of thorough data collecting, expert consultation, and the resolution of questionnaire-related problems. The research highlights critical results on government assistance, hurdles, technology preferences, and demography, offering light on the difficulties in implementing precision agriculture in Nepal. The paper makes important recommendations based on the study's findings in order to fully utilize the potential advantages of IoT, including investments in infrastructure, farmer education programs, and legislative assistance. The report also offers future research directions aimed at accelerating IoT adoption within the Nepali agricultural industry while acknowledging the study's shortcomings.

Keywords: *Internet of Things, Precision Agriculture*

1. INTRODUCTION

The term "internet of things" (IoT) describes how actual objects, such as furniture, automobiles, and other machinery, have connections to the internet with the ability to gather and transmit data. Via the Internet, these gadgets can also be remotely managed. The goal of the IoT is to make everyday objects smarter and more connected to improve efficiency and convenience for users.

Precision Agriculture is a farming management system that uses technology and data to optimize crop growth and reduce waste. Site-specific management of crops and precision farming are other names for it. It gathers information about agricultural development and environmental parameters using a number of methods, including the Geographic Information System (GIS), Global Positioning System (GPS), remote sensing, sensors, drones, and IoT. In order to make informed decisions regarding planting, fertilization, irrigating, controlling pests, and other elements of managing crops, the data is then examined.

Agriculture is the primary source of income for a large majority of population in Nepal. In Nepal, rice, corn, wheat, barley, millet, and vegetables are the principal crops farmed. However, due to inadequate facilities, a lack of access to marketplaces and technology, and restricted access to loans and other materials, yield from agriculture in Nepal is comparatively low. Out of the 147,181 square kilometers of land in Nepal, 28% is utilized for agriculture, with 21% being used for cultivation and 7% as uncultivated. About 40% of the land is covered by forests, and the remaining 12% is used for grazing (Timilsina, Ojha, Nepali, & Tiwari, 2019).

IoT is quickly emerging as a key technology in the agricultural sector. IoT gadgets like cameras and sensors may be utilized to gather information on weather conditions, the state of the soil, and the health of the crops, among other aspects of the agricultural process. In order to make better choices about irrigating, planting, and controlling pests, this data can then be examined. In addition, certain operations, including irrigation and livestock monitoring, can be automated using IoT devices. This may result in higher production and more effective resource management. In general, it is anticipated that IoT usage in agriculture would increase during the years that follow. The Internet of Things (IoT) is being utilized more and more in agriculture, where cameras and sensors are employed to gather information on a range of agricultural activities, including weather, conditions of the soil, and crop development. Decisions are then made on the planting process, irrigation, and pest management utilizing this data. In order to increase productivity and effectiveness of resources, these devices may be used as well to automate specific farming work, such as watering and livestock surveillance. It is projected that applications for IoT in agriculture would grow more in the years to come (Rifat, Patel, & Babu, 2022).

2. OBJECTIVES OF THE STUDY

a. To examine the optimal precision agriculture practices and equipment for the agricultural conditions in Nepal.

b. To identify the connection between interference and IoT adoption in agriculture.

c. To investigate the connection between resource optimization and IoT adoption in agriculture.

d. To investigate the connection between IoT implementation in agriculture and scalability.

3. RESEARCH HYPOTHESIS

A number of interrelated aspects must all work together for IoT technology to be successfully implemented in Nepal's agricultural sector, with a focus on the use of precision farming methods. These aspects include the efficient optimization of agricultural resources, the reduction of interference problems, the scalability of IoT devices, and the creation of custom IoT solutions catered to the particular requirements and conditions of Nepal's agricultural sector. The theory contends that confronting these complex issues head-on is not just essential but also absolutely necessary if IoT adoption in Nepali agriculture is to reach its full potential. The removal of infrastructure barriers, the improvement of connectivity, the skillful management of agricultural data, and the allaying of worries regarding data privacy and security are essential to this. The goal of the study is to examine the intricate interactions between these factors in order to gain knowledge that will help Nepal transition to an agricultural future that is more productive, efficient, and sustainable. The study aims to provide useful recommendations and strategic directions that can aid policymakers, agricultural stakeholders, and technology providers in their efforts to overcome obstacles and take advantage of opportunities presented by IoT technology in Nepali agriculture by thoroughly examining these dynamics.

4. SIGNIFICANCE OF THE STUDY

This document is useful for learning more about precision agriculture practices and equipment that are best suited to Nepal's particular agricultural circumstances. Making better educated choices regarding the precision agriculture methods to use will aid farmers and other stakeholders. Below is a list of the audience members that will gain something from the research report.

a. **Researchers:** IoT adoption in agriculture will be further understood by academics or scientists that perform the research and analyze the study's data.

b. **Farmers:** Participants will learn more about how precision agriculture may be used in the field as study participants or subjects by sharing information about their agricultural techniques, IoT experience, and experiences with precision agriculture.
c. **Agronomists:** People with technical experience and guidance on IoT and precision agriculture will gain a better understanding of farmers and their current methods of farming.

Government officials: People who submit information and data on programs and initiatives linked to IoT and precision agriculture in Nepal will gather a wealth of useful data that may be utilized further throughout the nation.

5. SCOPE

The research for IoT application in agriculture is conducted in the context of Nepal's agricultural industry. Since it is extremely doubtful that all of Nepal could be visited or studied, the research's scope only considers the Kathmandu valley when presenting the results of applying precision agriculture. Farmers and agronomists who operate in Kathmandu are among the participants in this study. This study concentrates mostly on precise agricultural methods and difficulties related to scalability, resource optimization, and interference with IoT gadgets.

6. LIMITATION OF RESEARCH

Although this study takes into account a number of research-related factors, it's vital to recognize some limitations. First of all, because only respondents from the Kathmandu Valley will be included in the online survey used to collect data, the full agricultural landscape of Nepal may not be accurately represented. Additionally, this survey's sample size is small, which could have an impact on how generalizable its results are. Second, even though this study examines a number of IoT adoption-related topics in Nepali agriculture, including resource optimization, scalability, interference, and precision agriculture techniques, it may not fully address all relevant factors. It's important to understand that IoT adoption is a complicated phenomenon affected by a wide range of factors. Within the constraints of its scope and available funding, this study primarily focuses on particular aspects of this complex landscape.

7. LITERATURE REVIEW

Farooq, Riaz, Abid, Abid, & Naeem (2019) elaborates the main mechanisms of IoT based smart farming. The paper describes about necessary infrastructure, collecting data, computing, and evaluation are the four basic pillars of precision agriculture. The physical framework is the most crucial element in order to prevent any undesired consequences. The system as a whole manages the sensors, controls, and devices. The two fundamental components of data analysis are control and monitoring. The key elements of IoT-based farming, including creativity, market structure, and national policies, have been addressed in this article to assist different interested parties. The interconnected era and economic variables that might influence the deployment of IoT-based farming, such as the availability of resources or the potential effect on current inequalities in the agriculture business, are not covered in this study.

Piramuthu (2022) analyzed cattle farms, where the use of precision farming and tracking helps to cut back on the amount of energy and resources needed to provide food. By reducing food supply chain waste, IoT and networked sensors have the potential to contribute to overall efficiency. The amount of treatment required can be decreased with the use of remote sensing information and variable flow techniques on farm equipment, saving time, money,

and boosting profitability. Precision farming helps farmers comply with regulations while also having a lesser effect on the environment, including less water use and pesticide waste. This study investigates how wasted energy might be reduced in agriculture by using networked sensors and IoT. The study disregards the privacy problems, technological risks, and possible data leakage is associated with using IoT and sensor systems.

Shrestha & Khanal (2020) argues that precision agriculture may be implemented and utilized in Nepal to improve agricultural output, raise profitability, and lower risks while simultaneously addressing problems with the nation's food security and environmental sustainability. The study makes the case that precision agriculture, which maximizes profitability, efficiency, and sustainability for the environment, can be a workable strategy for boosting agricultural productivity in Nepal. In order to lower risks and boost productivity in farming, this paper discusses precision agriculture in the context of Nepal. It also offers strategies for developing precision agriculture in Nepal. No negative effects or downsides connected to the use of precision farming techniques are discussed in this research.

Wicaksono, Suryani & Hendrawan (2022) studied increase in productivity of rice plants based on IoT (Internet of Things) using Smart Agriculture using System Thinking approach while considering issues with climate change, dwindling land supply, irrigation issues, and financial difficulties. The paper describes the challenges involved in increasing rice production, such as land transpiration, deteriorating soil fertility, farmers' lack of experience, irrigation and funding constraints, and climate change, and suggests precision agriculture and smart farming as potential solutions. This study discusses the construction of an IoT system for intelligent farming in Indonesia, with a focus on increasing the productivity of rice agricultural land by taking a variety of factors into account. This study does not address any potential negative effects of IoT use in agriculture, such as dependence on potentially dangerous fertilizers and pesticides.

8. THEORIES AND MODELS

Exploratory research is a form of study done to learn as much as possible about a topic or situation. When little is known about a subject or when a researcher wishes to come up with fresh theories or concepts, it is frequently used. Instead of testing particular theories or hypotheses, the aim of exploratory research is to find areas of interest and prospective routes

for further investigation. A questionnaire for this study contains open-ended questions that will be utilized in an online survey.

Perceived usefulness and ease of use are the two key factors that determine whether someone wants to use new technology, and one of the most well-known models of technology acceptance is the Technology Acceptance Model (Sciencedirect, 2022).

9. RESEARCH GAPS

It is crucial to recognize the study's limitations even if they provide useful insights into the issues and views surrounding the implementation of IoT technology in Nepali agriculture. First off, the study's reliance on information gathered via an online survey could lead to biased sampling, as participants who have access to the internet and are accustomed to doing surveys online might not fairly represent the total agricultural community. Additionally, because of the study's cross-sectional design, it is only able to capture participants' beliefs and behaviours as they change over time. Additionally, there may be knowledge gaps due to the paucity of qualitative data and the scant examination of government policy regarding IoT deployment in agriculture. Despite these drawbacks, the study offers an elementary understanding of the problems at hand and emphasizes the need for additional study and specialized tactics to effectively boost IoT adoption in Nepali agriculture.

10. METHODOLOGY

Since IoT in agriculture in Nepal is still a relatively new concept, there are a number of challenges that must be overcome. The major objective of this study is to learn more about the difficulties in adopting precision agriculture, such as resource optimization, interference, and IoT device scalability. The study intends to investigate the application of IoT in Nepali agriculture, with a focus on precision farming methods. Hence mixed research approach has been considered for this research.

Data source

The two basic types of data sources are primary and secondary data sources. The primary data source for this study will be an online survey that will take place.

Research sample size

Farmers and agronomists from the valley of Kathmandu will take part in this survey. 350 people will take part in the study's online sample size, which will be equally divided between various people in the Kathmandu valley.

11. DATA ANALYSIS

Farmers, agronomists, and other important Kathmandu Valley stakeholders are surveyed online. Use Likert scale questions to evaluate attitudes and views about IoT in agriculture. You will be able to get quantitative data by doing this in order to examine relationships between variables like interference, resource optimization, scalability, and efficient IoT installation.

This research begins on an exploratory trip to identify the barriers faced by farmers in embracing IoT technology in pursuit of a sustainable agricultural future in Nepal. An online questionnaire is used as a key tool in this investigation. We explore the complicated landscape of agricultural practices in Nepal through this questionnaire, which was given to a broad group of 350 respondents, as well as the challenges of using IoT solutions. This study uses technology to show the way toward sustainable agricultural methods, providing insightful information that might encourage improvement in Nepal's agricultural industry.

12. EVALUATION

In order to better understand the challenges and misunderstandings surrounding the implementation of IoT (Internet of Things) technology in Nepali agriculture, the study conducted an online questionnaire analysis. The majority of respondents were male, between the ages of 26 and 41, and had a range of educational backgrounds, according to key findings. Precision agricultural concepts were less common, even though the majority of respondents showed a high level of knowledge with IoT technology. The majority of respondents said

they had not taken part in IoT training programs, although they were very supportive of such educational activities. As being most ideal for Nepal's agriculture, respondents preferred a combination of precision agricultural techniques, including drones and IoT.

It is necessary to gather information on how farmers who have implemented IoT technology have optimized their resources in comparison to those who have not in order to study the relationship between resource optimization and IoT deployment in Nepali agriculture. Researchers may evaluate resource optimization by looking at things like energy usage, fertilizer application, and water use efficiency. If a connection between resource optimization and IoT adoption is significant, statistical tests or regression analysis can be used to prove it. This investigation can show whether IoT contributes to agricultural resource use optimization.

It will take a variety of approaches to successfully implement precision agriculture in Nepal in order to increase agricultural yields, lower prices, and safeguard the environment.

Education of Farmers: Run training and instructional initiatives to improve farmers' familiarity with IoT and precision agriculture. Workshops, seminars, and demos on the efficient use of IoT devices and data analytics technologies can fall under this category.

Access to IoT Devices: Make it easier to get hold of trustworthy and reasonably priced IoT gadgets like sensors, drones, and weather stations. These technologies may be more affordable for farmers with the help of government incentives or collaborations with technological companies.

Platforms for Data Sharing: Create networks or platforms where farmers can exchange data and best practices. In agriculture, collaborative data sharing can improve decision-making and result in better informed decisions.

Individualized Solutions: Develop IoT solutions that are specifically suited to the requirements and circumstances of Nepali agriculture. To ensure the practicality and effectiveness of IoT technology, take into account elements such as regional crop kinds, weather patterns, and geography.

Government assist: Encourage the adoption of government policies and programs that assist precision agriculture. This may involve monetary rewards, legal restrictions, and research funding.

Infrastructure Improvement: To ensure that IoT devices can operate efficiently, address issues with internet access and infrastructure in rural regions.

Environmental Awareness: Promote the advantages of precision agriculture for the environment, such as less pesticide use and better resource management. Emphasize the role that these techniques have in sustainable farming.

Research and Development: Invest in research and development to advance and modify precision agriculture technology for the Nepali environment. Work together with nearby educational and research institutions.

Precision agriculture may be successfully applied to benefit farmers, the environment, and the entire agricultural business by combining these tactics and customizing them to the unique difficulties and opportunities of Nepal's agriculture sector.

13. CONCLUSION

Through the adoption of precision agriculture, IoT has the potential to totally alter Nepal's agricultural sector. Before the full potential of IoT can be tapped into, a number of obstacles must be overcome. Infrastructure, connection, and data management difficulties are a few of these. IoT technology implementation costs and concerns about data security and privacy are other challenges that need to be addressed. Despite these obstacles, there is still a sizable chance for IoT to boost agricultural productivity and efficiency in Nepal, especially by utilizing precision agriculture methods. Thus, it is crucial to keep making investments in and developing the technologies and infrastructure required to enable the expansion of IoT in Nepal's agricultural sector.

It is crucial that farmers and other agricultural industry stakeholders receive training and education on how to use and handle the data produced by IoT devices. This will guarantee

that the information is put to good use in making decisions that can increase crop yields and farm productivity. IoT has the potential to revolutionize Nepalese agriculture, but first it's critical to address the issues and make the necessary investments in infrastructure and technology.

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