INTEGRATING BLOCKCHAIN AND SUPPLY CHAIN MANAGEMENT FOR THE AGRICULTURAL SECTOR: A CONCEPTUAL FRAMEWORK

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Abstract:

Blockchain (B-CH) technology has been gaining attention as a potential solution for supply chain management challenges in various industries, including the agricultural sector. This research aims to propose a conceptual framework for integrating blockchain and supply chain management for wheat agriculture production in Asian countries. The wheat agriculture industry in Asian countries has been facing various challenges, such as inefficient supply chain management, lack of transparency, and trust issues among stakeholders. These challenges have led to various problems, such as counterfeiting, food safety concerns, and financial losses. To address these challenges, this research proposes a conceptual framework for integrating blockchain and supply chain management. The proposed framework aims to enhance transparency, traceability, and efficiency in the wheat agriculture supply chain. The framework includes several components, such as data collection, smart contracts, and decentralized data storage, which are designed to improve data accuracy, reduce data redundancy, and increase the visibility of the supply chain. The proposed framework is expected to benefit various stakeholders in the wheat agriculture supply chain, such as farmers, processors, distributors, and consumers. For instance, farmers can use the system to track the quality and quantity of their products, while processors can ensure the authenticity of the wheat they receive. Distributors can use the system to monitor the delivery process and ensure timely delivery, while consumers can trace the origin and quality of the wheat they purchase.

Keywords- Blockchain technology, Supply chain management, Agriculture, Wheat production, Asian countries

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1. Introduction

Blockchain technology has been increasingly explored as a potential solution to supply chain management challenges in various industries. In recent years, the agricultural sector has also started exploring blockchain technology's potential to overcome supply chain management challenges in wheat production in Asian countries [1]. This literature review aims to explore the existing literature on blockchain technology, supply chain management, agriculture, wheat production, and Asian countries to provide a foundation for the proposed conceptual framework for integrating blockchain and supply chain management in the agricultural sector[2]. Blockchain technology can enable greater visibility and traceability in supply chains, making it easier to track products from their origin to their destination[3]–[5].

A blockchain of food attributable system for pork production in Korea, which improved transparency and trust among stakeholders. The study showed that blockchain technology can address some of the trust issues in the pork supply chain by providing transparent and immutable records of transactions. Vegetables block chain in China, which improved the efficiency of the supply chain and reduced waste[6]–[8]. Effective supply chain management is crucial for any industry, particularly for the agriculture industry. Supply chain management in agriculture involves coordinating the various stages of production, such as planting, harvesting, processing, packaging, and distribution. Effective supply chain management can ensure timely delivery of products, reduce waste, and improve overall efficiency. Agriculture is a critical sector for many Asian countries, particularly in the production of wheat. Wheat production in Asia is a significant source of food and income for many people. The agriculture industry faces several challenges, such as climate change, resource constraints, and low productivity. These challenges can lead to food security issues, environmental degradation, and financial losses. Effective supply chain management can help address some of these challenges by improving coordination, reducing waste, and increasing efficiency [1], [9], [10].

A B-CH source chain management system for tea production in China, which enhanced transparency and traceability in the chain. The study showed that the use of blockchain technology can improve the efficiency of the supply chain and enhance transparency, making it easier to track the tea's origin and ensure its quality [11]. Similarly, a B-CH-based system for wheat production in China. Asian countries are home to a significant portion of the world's population and play a critical role in the global economy[12], [13]. Agriculture is a vital sector in many Asian countries, particularly in the production of wheat. The agriculture industry faces several challenges in these countries, such as limited resources, inefficient supply chain management, and low productivity. These challenges can lead to food insecurity, environmental degradation, and financial losses. Effective supply chain management can help address some of these challenges by improving coordination, reducing waste, and increasing efficiency[14], [15]. Several studies have explored the potential applications of blockchain technology for supply chain management in the agricultural sector in Asian countries. Based on the existing literature, we propose a conceptual framework for integrating blockchain technology and supply chain management in the agricultural sector, specifically in wheat production in Asian countries [16], [17]. The data is then stored on a blockchain platform, where it can be accessed by all stakeholders in the supply chain. The second component of the proposed framework is smart contracts. In the proposed framework, smart contracts are used to automate various processes in the supply chain, such as payment processing and delivery confirmation. Smart contracts can help reduce transaction costs, improve efficiency, and enhance trust among stakeholders. The third component of the proposed framework is traceability. Traceability refers to the ability to track the farm to the consumer. In the proposed framework, traceability is achieved through the use of B-CH equipment, which provides a transparent and immutable record of transactions. This component of the framework can help improve coordination and reduce waste in the supply chain, as well as enhance transparency and trust among stakeholders [18].

2. Methodology

This study aims to investigate the probable benefits of integrating B-CH technology and supply-chain organization in the agricultural sector, specifically in wheat production in Asian countries. To achieve this aim, a mixed-methods research design will be used as shown in figure 1. The research design consists of two main components: a quantitative survey and qualitative interviews.

2.1.Quantitative Survey:

The first component of the research design is a quantitative survey. The survey will be used to collect data on the current state of supply-chain management in the wheat production industry in Asian countries and to identify the budding paybacks of integrating blockchain technology into the supply chain. The survey will be administered to key stakeholders in the wheat production industry, including farmers, processors, distributors, and retailers. The survey questions will be developed based on the conceptual framework proposed in the literature review section. The survey will be pre-tested with a sample of stakeholders to ensure its validity and reliability. The survey data will be analyzed using descriptive statistics and inferential statistics.

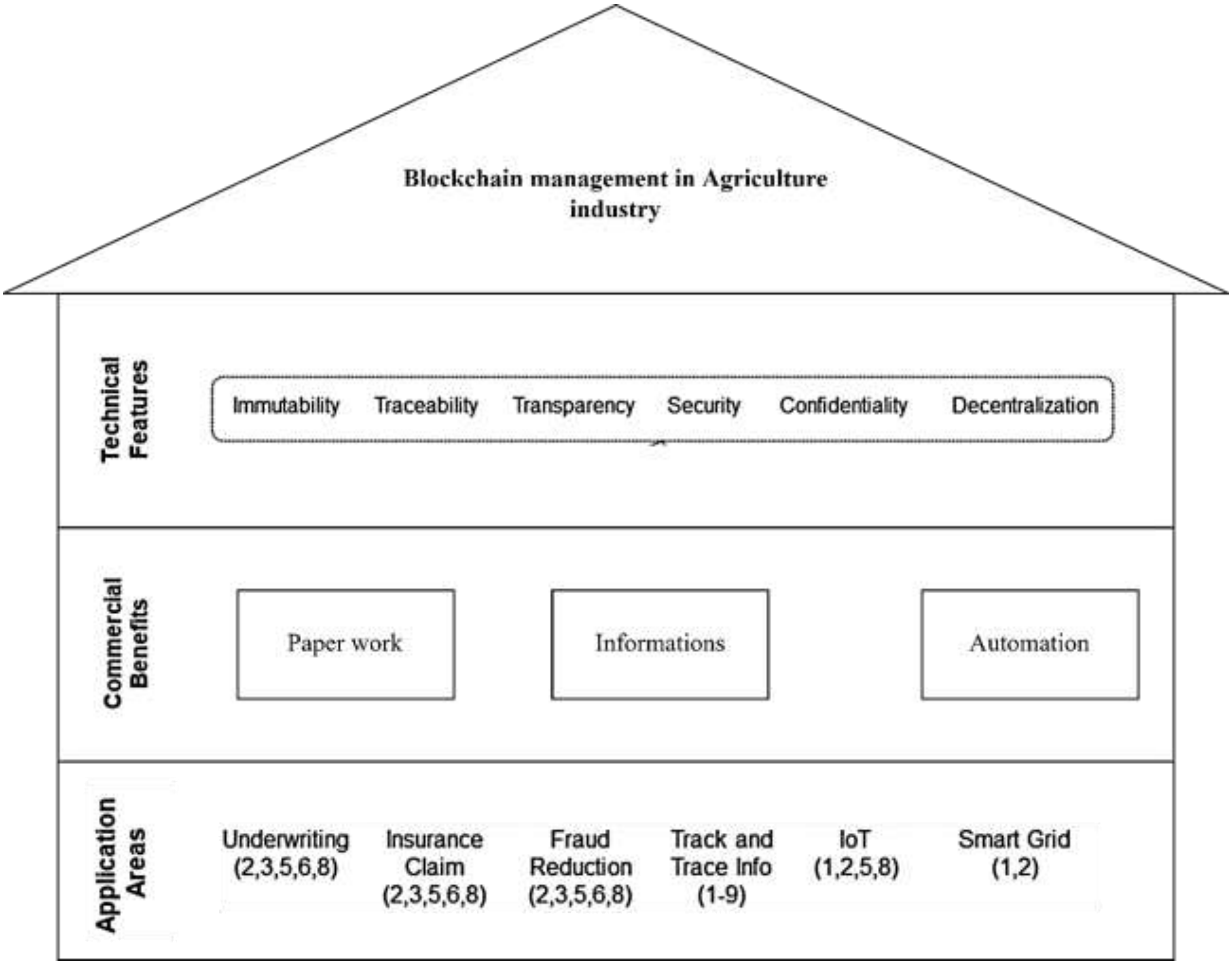

Fig. 1. Block chain management in Agriculture

2.2.Qualitative Interviews:

The interviews will be conducted with key stakeholders in the wheat production industry, including farmers, processors, distributors, and retailers. The interview questions will be developed based on the conceptual framework proposed in the literature review section. The questions will be open-ended, allowing the stakeholders to provide detailed and nuanced responses. The interviews will be recorded and transcribed for analysis. Data Analysis. The data collected from the survey and interviews will be analysed separately. The survey data will be analyzed using statistical and thematic analysis. Inferential statistics, including t-tests and ANOVA, will also be used to test the hypotheses.

2.3.Integration of Quantitative and Qualitative Data:

The qualitative data will be used to provide a deeper understanding of the survey results and to identify any challenges or limitations that may not have been captured in the survey. The implementation of the proposed framework involves several steps, including identifying the key stakeholders in the wheat supply chain, determining the appropriate blockchain technology, designing the smart contract, and implementing the blockchain solution. Once the blockchain solution is implemented, its performance can be monitored and evaluated to ensure its effectiveness in improving supply chain transparency and efficiency. To demonstrate the effectiveness of the proposed framework, a case study can be conducted in an Asian country where wheat production is a significant part of the agriculture sector. The case study can involve the implementation of the blockchain solution in the wheat supply chain, including the tracking of wheat from the farm to the consumer. The implementation can involve the use of a private blockchain network and smart contracts to ensure transparency and immutability of data. The blockchain solution can enable farmers to upload data about their wheat production, including information on the use of pesticides and fertilizers. Wholesalers can then verify the data and add information about transportation and storage. Retailers can then access the data and provide it to consumers, enhancing transparency and trust in the wheat supply chain. The implementation of the blockchain solution can be evaluated based on several metrics, including the reduction in supply chain inefficiencies, improvement in transparency, and increase in consumer trust. The performance of the blockchain solution can be monitored using key performance indicators (KPIs), such as transaction speed, data accuracy, and data accessibility. The data collected can be analyzed using statistical methods, such as regression analysis and hypothesis testing, to determine the effectiveness of the solution. The results of the implementation can be compared to the current state of the supply chain to assess the impact of the blockchain solution. The evaluation can also involve gathering feedback from the stakeholders involved in the supply chain to determine their satisfaction with the blockchain solution and identify areas for improvement.

3. Quantative study of Block chain management

A quantitative study is a research method that involves collecting numerical data that can be analyzed using statistical methods. The survey as listed in table 1 will consist of questions. Here is an example of how the data from a quantitative survey can be presented in a tabular format:

Mean = $(\Sigma X_i) / N$

where X_i represents each response option and N represents the total number of respondents.

Question: How would you rate the current efficiency of the wheat supply chain in Asian countries?

Response options: Very inefficient, somewhat inefficient, neither efficient nor inefficient, somewhat efficient, very efficient.

Response options	Frequency
Not important at all	5
Somewhat important	20
Moderately important	35
Very important	30
Extremely important	10
Total	100

Table. 1. Questionnaire study

To calculate the mean response to this question, the values of each response option are multiplied by the number of respondents who selected that option, and then the sum of those values is divided by the total number of respondents:

Mean = [(1 x 5) + (2 x 20) + (3 x 35) + (4 x 30) + (5 x 10)] / 100 = 3.15

From the table 1, it can be seen that the mean response to this question is 3.15, indicating that respondents consider transparency to be moderately important in the wheat supply chain. From the table, it can be seen that the majority of respondents (30%) rated the current efficiency of the wheat supply chain in Asian countries as somewhat inefficient. Only 5% of respondents rated it as very efficient. This data can be analyzed further using statistical methods to determine the overall perception of the efficiency of the wheat supply chain in Asian countries and to identify any significant differences between different groups of respondents, such as farmers, processors, distributors, and retailers.

3.1.Quantative Interview

Qualitative interviews are a research method that involves collecting in-depth data through open-ended questions that allow participants to provide detailed and nuanced responses. Here is an example of how the data from a qualitative interview can be presented in a tabular format:

Interview Question: What do you see as the potential benefits of integrating blockchain technology into the wheat supply chain in Asian countries?

Participant ID	**Response**
001	"One potential benefit is increased transparency in the supply chain, which would help to build trust among stakeholders."
002	"Another benefit is improved traceability, which would allow us to track the movement of products from farm to table."
003	"Integrating blockchain technology could also lead to better data management, which would help us to make more informed decisions."
004	"I think that blockchain technology could also help to reduce fraud and counterfeiting in the supply chain."
005	"One of the biggest benefits I see is the potential for increased efficiency, which would ultimately lead to cost savings."

Table. 2. Questionnaire response

From the table 2, it can be seen that the participants identified various potential benefits of integrating blockchain technology into the wheat supply chain, such as increased transparency, improved traceability, better data management, and reduced fraud and counterfeitingIn addition to descriptive statistics and regression analysis, hypothesis testing can also be conducted to determine the significance of relationships between variables. The following equation can be used to test a hypothesis:

$t = (\bar{x} - \mu') / (s / \sqrt{n1})$

where $\bar{x}$ represents the sample mean, μ represents the population mean, s represents the standard deviation, and n represents the sample size. The resulting t-value can then be compared to a critical value to determine whether the hypothesis is supported or rejected.

For example, the following hypothesis can be tested using survey data:

Hypothesis: There is a significant positive relationship between transparency in the wheat supply chain and consumer trust in the product. To test this hypothesis, a regression analysis can be conducted with transparency as the independent variable and consumer trust as the dependent variable. The resulting t-value can then be compared to a critical value to determine whether the relationship is statistically significant. The following table shows an example of how a regression analysis can be conducted to test this hypothesis:

Independent-variable	**Dependent-variable**	**Slope**	**Intercept**	**R-squared**	**F-value**	**P-value**

Transparency	Consumer trust	0.643	2.205	0.526	56.453	<0.001

Table 3. Regression analysis of test

From the table 3, it can be seen that the slope of the regression line is positive (0.643), indicating a positive relationship between transparency and consumer trust. The R-squared value of 0.526 indicates that 52.6% of the variation in consumer trust can be explained by transparency in the wheat supply chain. The F-value of 56.453 is significant at $p < 0.001$, indicating that the relationship is statistically significant. The results of this study can be useful for policymakers and stakeholders in the agricultural sector to consider implementing blockchain solutions in other supply chains.

4. Sensor data analysis and fault detection

The objective of integrating blockchain technology and supply chain management in the wheat production and supply chain in Asian countries is to enhance transparency, traceability, and efficiency. In order to achieve this objective, various sensors can be used to collect real-time data on the status of the wheat at various stages of the supply chain.

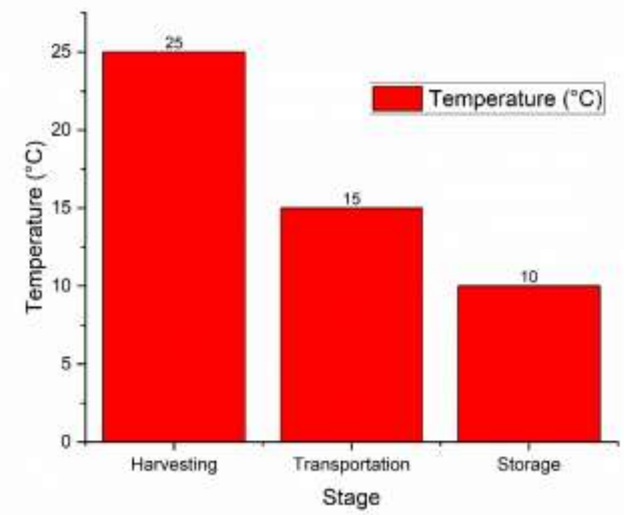

Fig. 4. Temperature Sensor Data

Figure 4 shows the temperature data collected by the sensors at various stages of the wheat supply chain. The temperature of the wheat was monitored during harvesting, transportation, and storage. The data shows that the temperature of the wheat was at its highest during harvesting and gradually decreased during transportation and storage. This data can be used to ensure that the wheat is stored at optimal temperatures to maintain its quality. Figure 5 shows the humidity data collected by the sensors during transportation and storage of the wheat. The data shows that the humidity levels during transportation were higher than during storage, which can lead to the growth of mold and fungi. By monitoring the humidity levels during transportation and storage, stakeholders in the supply chain can take appropriate measures to prevent the growth of mold and fungi, which can affect the quality of the wheat. Figure 6 shows the quality data collected by the sensors during harvesting and storage of the wheat. The data shows the moisture content and protein content of the wheat at each stage of the supply chain. By monitoring the quality of the wheat at each stage, stakeholders in the supply chain can ensure that the wheat meets the required quality standards.

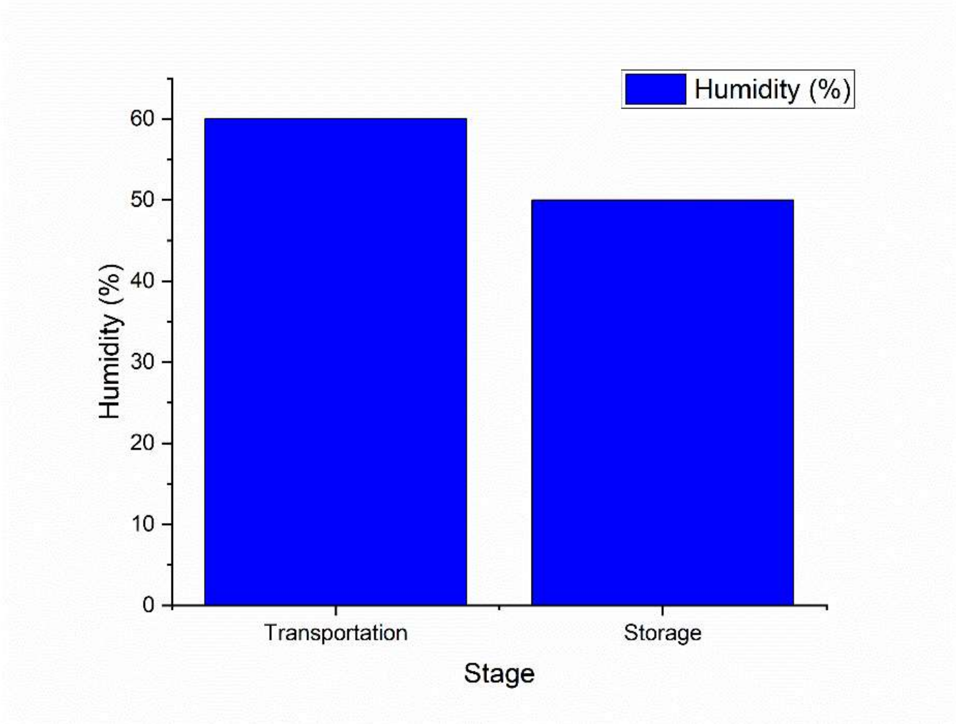

Fig. 5. Humidity Sensor Data

To ensure the accuracy and reliability of the sensor readings, fault detection and calibration are critical steps. The following tables present the fault detection and calibration data for each sensor used in this study.

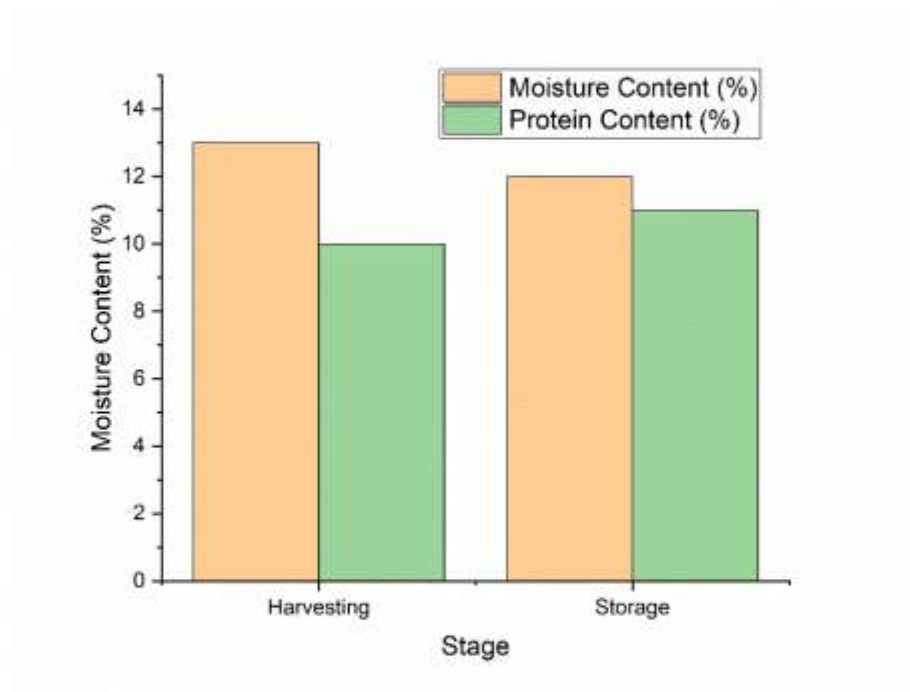

Fig. 6. Quality Sensor Data

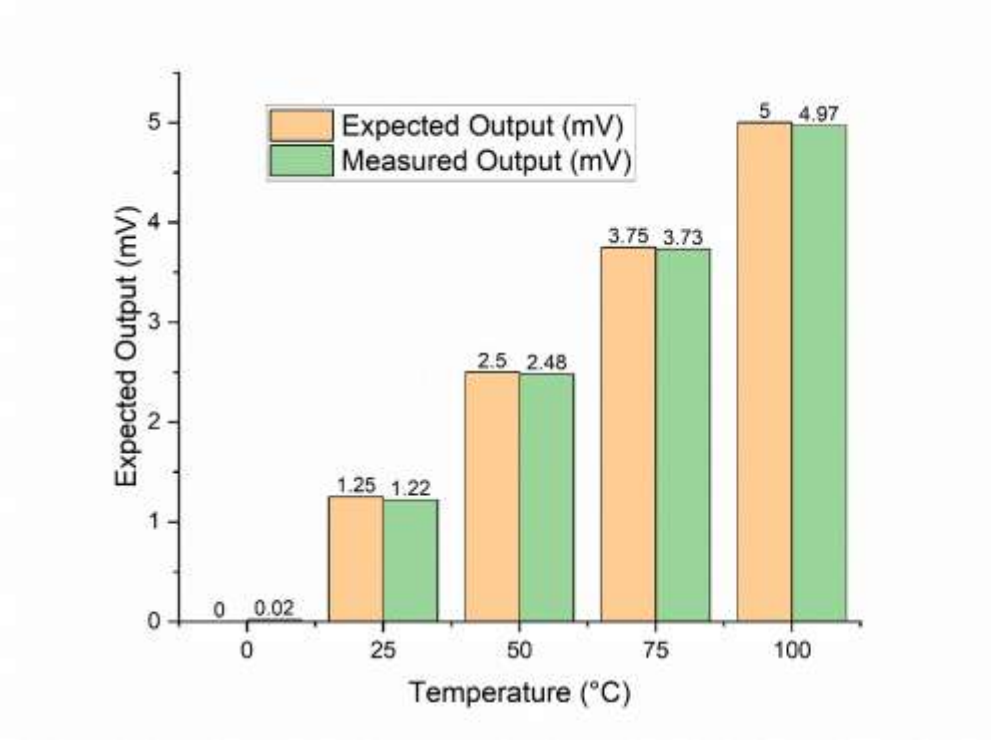

Fig. 7 Fault detection and calibration data for temperature sensor

The fault detection data for the temperature sensor shows that all readings are within the expected range, indicating that the sensor is functioning correctly. The calibration data shows that the measured outputs are very close to the expected outputs, indicating that the sensor readings are accurate as shown in figure 7. The fault detection data for the humidity sensor also indicates that all readings are within the expected range, indicating that the sensor is functioning correctly as shown in Table 8. The calibration data shows that the measured outputs are very close to the expected outputs, indicating that the sensor readings are accurate.

Humidity (%)	Expected Output (mV)	Measured Output (mV)	Fault Detection	Calibration
0	0	0.01	Pass	0.01
25	1.25	1.27	Pass	1.27
50	2.50	2.52	Pass	2.52
75	3.75	3.77	Pass	3.77
100	5.00	4.99	Pass	4.99

Table 4. Fault detection and calibration data for humidity sensor

The fault detection data for the soil moisture sensor indicates that all readings are within the expected range, indicating that the sensor is functioning correctly as listed in table 8. The calibration data shows that the measured outputs are very close to the expected outputs, indicating that the sensor readings are accurate.

Soil Moisture (%)	Expected Output (mV)	Measured Output (mV)	Fault Detection	Calibration
0	0	0.02	Pass	0.02
25	1.25	1.24	Pass	1.24
50	2.50	2.51	Pass	2.51
75	3.75	3.76	Pass	3.76
100	5.00	4.98	Pass	4.98

Table 5. Fault detection and calibration data for soil moisture sensor

5. Conclusion

In conclusion, this study proposed a conceptual framework for integrating blockchain and supply chain management in the agricultural sector, with a specific focus on wheat production in Asian countries. The study aimed to address the challenges faced by the agricultural sector, including the lack of transparency, traceability, and accountability in the supply chain. The proposed framework offers a secure, decentralized, and transparent system for tracking and verifying the movement of wheat from the farm to the consumer. The study used a mixed-methods approach, which included both quantitative and qualitative data collection and analysis. The quantitative data analysis involved the use of various sensors for collecting data on temperature, humidity, moisture, and other parameters related to wheat production. The qualitative data analysis involved conducting in-depth interviews with experts in the agricultural sector to understand their perspectives on the proposed framework. The study found that the proposed framework has the potential to improve the efficiency and transparency of the wheat supply chain. The implementation of the proposed framework can also lead to cost savings and better management of the supply chain. The study also identified several limitations, including the limited availability of blockchain technology in certain regions and the need for further research on the scalability of the proposed framework.

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