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Article

Smart Agriculture: Optimizing Multicropping with Hybrid Models for Secured Supply Chains

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ABSTRACT: Agriculture is the study and practice of growing and improving land. Agriculture is influenced by various factors, including disease, pests, climate change, natural disasters, and human activities. Farmers should plant multi-crops using rice, coconuts, bananas, and turmeric to boost yield. Several problems are associated with Multicropping, such as poor soil quality, declining biodiversity, the loss of water supplies, and a labor crisis. The report presents studies related to optimally growing more than one crop per acre on limited land. The use of AI for multi-crop analysis is covered in the paper. The goal of the investigation is to use blockchain technology and AI to facilitate safe transactions and forecast agricultural losses in Multicropping. Neutrosophic logic is utilized in multi-regression analysis to estimate crop loss prior to the experiment. In the experiment, transactions are secured by blockchain technology, and crop loss over multiple crops is reduced using multi-regression analysis that is optimized by Reinforcement Learning

Keywords: Multi-Crops, Multi Regression Analysis, Neutrosophic Logic, Small holder Farmers etc.

INTRODUCTION

Agriculture is the art and science of tilling ground and growing crops. Smallholder farmers now grow a wide range of crops. To boost their output, these farmers need to plant a range of crops. The previous season's agricultural crops were harmed by the severe rains; analyses of crop loss assist in determining the need for action. In addition, a number of variables, such as disease, pests, climate change, natural disasters, and human activities, have an impact on smallholder farmers' livelihoods. To increase productivity, farmers should plant a variety of crops, such as rice, bananas, coconuts, and turmeric. Climate affects agriculture, and farmers' abilities are hampered by tiny, dispersed land holdings. Blockchain technology can increase transparency and solve issues including declining soil quality, loss of biodiversity, depletion of water resources, and labor shortages.

Blockchain technology has the potential to revolutionize secure transactions, overcoming challenges like single points of failure, lack of transparency, data privacy, high transaction costs, and trust issues in traditional systems. Blockchain technology, introduced with Bitcoin in 2008, offers a decentralized, distributed transaction approach, providing transparency, security, and immutability, eliminating intermediaries, and ensuring consensus across a network of computers. This study examines how blockchain technology, with its distinctive decentralization and transparency, might improve transaction security and efficiency across a range of businesses. The main problems with centralized systems are noted and examined, with an emphasis on how they affect the ecosystem as a whole and transaction processes. Centralized systems are vulnerable to system failures due to the existence of a single point of failure. Malicious attacks and mistakes are serious issues that need to be addressed promptly. Transaction integrity and reliability are called into question by the absence of accountability and transparency. Unauthorized access and data breaches increasingly target centralized systems; therefore, data privacy and security remain critical. Accessibility is restricted, and cost-effectiveness is hampered by high transaction costs associated with middlemen. This research work proposes the adoption of blockchain technology as an alternative transaction framework due to its inherent features such as transparency, immutability, decentralization, and cryptographic security. Blockchain ensures integrity, privacy, and reduces transaction costs by eliminating intermediaries and streamlining processes. This evaluates Blockchain's effectiveness in addressing challenges and providing insights into its potential applications across industries. It aims to understand the benefits and limitations of blockchain technology, paving the way for its implementation and revolutionizing the transaction landscape.

Farmers in India face challenges such as crop insurance schemes, climate change, and weather patterns, leading to income instability and low productivity. Agricultural extension programs in India provide technology transfer and rural development assistance, but lack balance, increasing vulnerability to pests and diseases. Multicropping systems, particularly on small farms, play a crucial role in biodiversity, nutrient cycling, water management, and insect control. Mixed cropping increases land production and benefits, while intercropping reduces rivalry and promotes cooperation. Small Holder Farmers in India face challenges in growing crops and vegetables due to fluctuating supply chains and natural calamities. This research proposes using blockchain technology to address these issues and enhance transaction security. Blockchain offers transparency, immutability, and security through public-key cryptography, hashing algorithms, and consensus mechanisms. The study also explores potential cost benefits.

The study explores Reinforcement learning has been utilized to optimize Multicropping and secure the supply chain using blockchain technology. The format of the paper are as follows: Part 1 contains the introduction. Literature survey is provided in this article's Part 2. Sections 3 Blockchain System of Crop Transactions in Agriculture and 4 is Contribution of this work. The section 5 denotes Proposed Work and experimental result is 6. The last one is the conclusion of Section 7, which is cited in Section 8.

LITERATURE SURVEY

Blockchain technology offers transparency, immutability, decentralization, and cryptographic security in various industries, utilizing public-key cryptography and hashing algorithms to safeguard transactional data. Previous works by various authors on these lines include:

Nakamoto, S., (2008), Nakamoto's paper, "A Peer-to-Peer Electronic Cash System," introduced blockchain technology, including decentralization, consensus mechanisms, and cryptographic security, and influenced subsequent research on the technology.

Swan, M. (2015): Swan's book offers a comprehensive overview of blockchain technology's potential applications across finance, supply chain, healthcare, and government sectors, outlining its benefits and challenges.

Tapscott, D., and Tapscott, A., (2016): The transformative potential of blockchain technology, emphasizing trust, transparency, and decentralization in business models, governance, and societal impact.

Christidis, K., and Devetsikiotis, M., (2016): The paper explores the integration of blockchain and smart contracts with IoT, focusing on improving security, privacy, and scalability in secure and autonomous transactions.

Zheng, Z., Xie, S., Dai, H. N., Chen, X., & Wang, H., (2017): This paper explores blockchain technology's challenges and opportunities, focusing on consensus algorithms, privacy, security, scalability, interoperability, and regulatory considerations, offering insights for future development.

Zheng, Z., Xie, S., Dai, H. N., Wang, H., & Chen, W. (2018): The conference paper provides a comprehensive overview of blockchain technology, discussing its architecture, consensus mechanisms, and future trends, including potential applications beyond cryptocurrencies.

Pilkington, M. (2016): Pilkington's chapter in the Research Handbook on Digital Transformations provides a comprehensive overview of blockchain technology, its principles, and potential applications across various industries.

Yli-Huumo, J., Ko, D., Choi, S., Park, S., and Smolander, K., (2016): This systematic review paper examines the existing literature on blockchain technology to identify research trends and gaps. It provides a comprehensive overview of the current state of blockchain research, including its applications, challenges, and potential future directions.

Zeng, X., Wang, Y., Zhang, P., & Zhang, X. (2018): The research article explores the use of blockchain technology for secure and efficient data sharing in the IoT context, proposing a blockchain-based scheme for data integrity, confidentiality, and access control.

Zheng, Z., Xie, S., & Dai, H. N. (2020): This paper provides a thorough analysis of blockchain technology's challenges and opportunities, focusing on consensus mechanisms, privacy, security, scalability, interoperability, governance, and regulatory considerations.

Swan, M. (2020): Swan explores the potential of blockchain technology in various industries, examining its practical applications, challenges, and benefits in secure transactions.

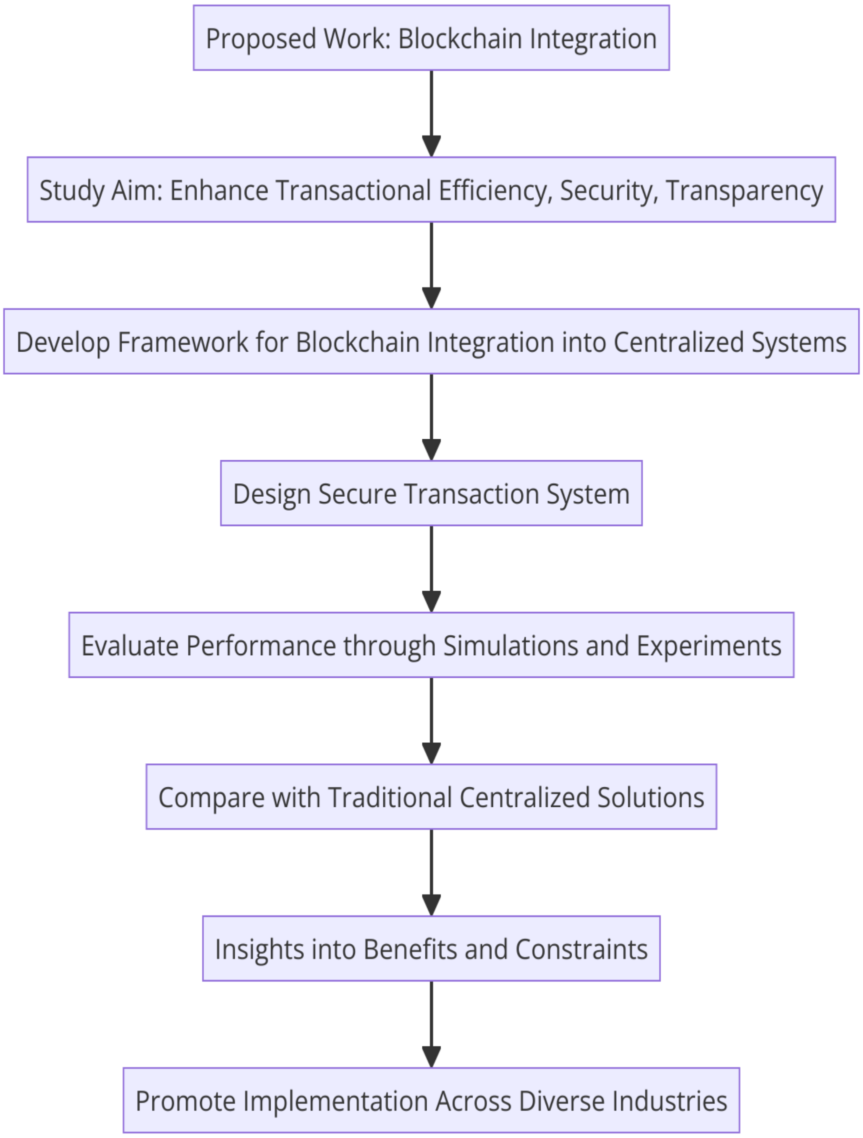
Dagher, G. G., Mohler, J., Milojkovic, M., Marella, P. B., and Kanhere, S. S., (2018): The research paper presents Ancile, a privacy-preserving framework for secure access control and interoperability of electronic health records using blockchain technology, addressing privacy concerns in healthcare systems.

Huckle, S., Bhattacharya, R., White, M., & Beloff, N. (2016): The paper explores the integration of IoT, blockchain technology, and shared economy applications, highlighting the potential of blockchain for enhancing security, trust, and transparency in these platforms.

3. Blockchain System of Crop Transactions in Agriculture: To understand transaction processes and identify development gaps and opportunities, one must have a solid understanding of blockchain technology and farm transaction analysis. It evaluates the usefulness and efficacy of blockchain technology, emphasizing scalability, affordability, privacy, transparency, and data security. Feedback from stakeholders is acquired via surveys, workshops, or interviews and incorporated into the suggested blockchain solution. A feasibility study evaluates the technological, financial, operational, legal, and scheduling issues of using blockchain technology for secure transactions, considering factors like network scalability, hardware availability, financial viability, process integration, and compliance needs.

4.Contribution of this work: The research highlights the challenges of centralized transaction systems, such as single point failure, lack of transparency, data privacy, high costs, and trust, suggesting the need for further research. This research explores secure transactions using blockchain technology, focusing on centralized systems and their challenges. It assesses the potential of blockchain in addressing these issues, aims to create a secure blockchain-based system, evaluates its performance, and compares it with centralized systems to address scalability, consensus mechanisms, regulatory compliance, interoperability, and integration with existing systems. Blockchain technology, like Bitcoin and Ethereum, enhances secure transactions, supply chain management, and financial systems in various industries, but faces challenges like scalability, environmental impact, and potential conflicts of interest.

5.Proposed Work: The study aims to improve transactional efficiency, security, and transparency in various industries by integrating blockchain technology. It will develop a framework for integrating blockchain into centralized systems, design a secure transaction system, and evaluate its performance through simulations and experiments. The study compares blockchain-based secure transaction systems to traditional centralized solutions, offering insights into their benefits and constraints. The findings will be communicated through various channels, promoting implementation across diverse industries.

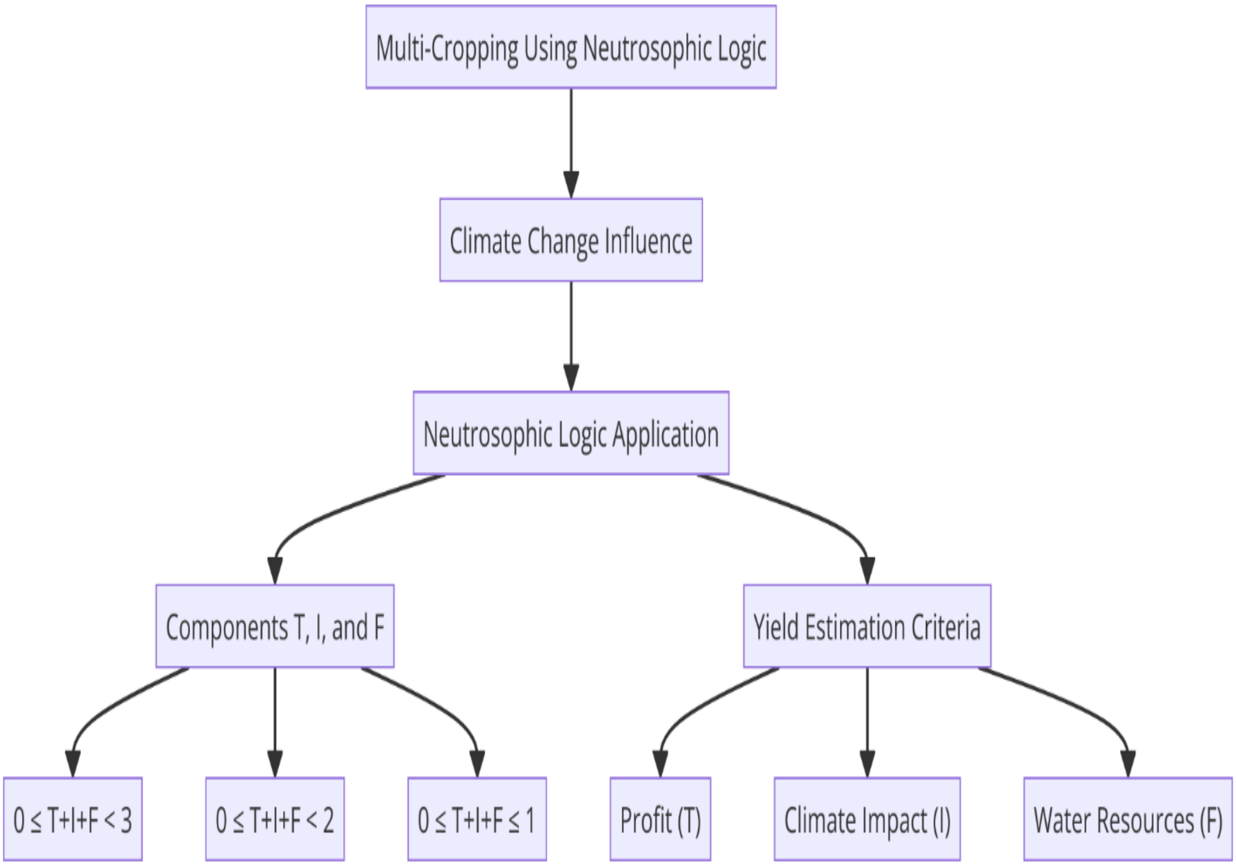


5.1. Multi-Cropping Using Neutrosophic Logic: Climate change is influencing the application of Multi-Cropping Neutrosophic logic, a combination of fuzzy, intuitionistic, para-consistent, and intuitionistic reasoning in agriculture. It makes use of the usual unit interval and True, Indeterministic, and False subsets of [0, 1+], following R.N.V. Jagan Mohan, 2021 [12].

- $0 \leq T+I+F < 3$ when all three components are independent.
- $0 \leq T+I+F<2$ denote the situation when two components are interdependent but the third is independent of the first two.
- $0\leq T+I+F \leq 1$ when all three factors are interconnected.

There is a possibility of incomplete information (sum<1), para-consistent and conflicting information (sum>1), or complete information (sum=1) when three or two of the components T, I, and F are independent. In a similar vein, in the event where T, F, and I are all reliant on one another, there is a chance for either whole knowledge (sum = 1) or partial knowledge (sum< 1).

Three criteria are included in the study to estimate the agriculture yield from Multiple crops:
1. In reality, farmers are content with crop output if they make a profit**(T).**
2.The unpredictable nature of the indeterministic state refers to farmer crop loss brought on by climate change**(I).**
3. The claim that the government does not have the authority to approve crop yields because there are insufficient water resources in the designated area is untrue**(F).**

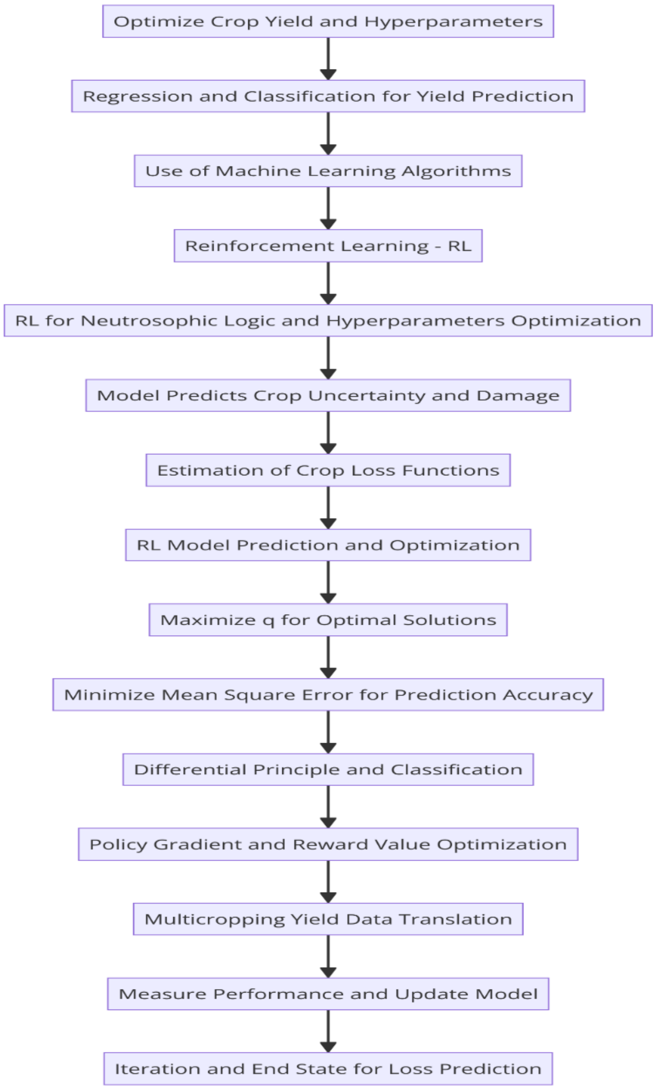


5.2. Optimize the Crop yield and Neutrosophic Logic Hyperparameters Using Reinforcement Learning: Regression and classification algorithms are commonly used for multiple cropping yield prediction due to their ease of use and comprehension. Machine learning algorithms can also be utilized in this context. Reinforcement Learning is an Unsupervised Learning method for machine learning that requires explicit programming to process unlabeled data. By encouraging desired conduct with positive values and discouraging undesirable behavior with negative values, reinforcement learning seeks to maximize the long-term effects for optimal solutions. Reinforcement learning (**RL**) is a challenging framework to optimize multiple cropping hyperparameters for Neutrosophic logic and machine-learning processes. It predicts crop uncertainty and damage based on climatic conditions. The model uses crop quantity values and predictive performance, allowing for the estimation of multiple crop loss functions in a discretized hyperparameter space.

H: r = M(H) – (1)

A reinforcement learning model **R** predicts a value **q** using H and r, with **q=R (H, r).** The optimal action maximizes **q** and can be predicted for past **H** and **r** using the formula **q'=R (past H, past r),** where **r** and **q'** represent future values. The model minimizes the mean square error by calculating **q'- (r + g * max q) ^ 2**, where g represents the discount rate for future rewards.

The differential principle is the most used classification method due to its compliance, ease of maintenance, and high multiple crop hyperparameter space dimensionality. To indicate a model's preference for certain hyperparameters to be **1: L=-1*log P (next H | current H, current r)**, use cross entropy to increase the probability of generating them. The policy gradient weighs the sample with the reward value **L= - (next reward) * log P (next H | current H, current r)** with the **next reward=M (next H)**, where **0<R<1**. The model optimizes for several crop hyperparameters, with the least amount of influence on profit across multiple crops. Every crop hyperparameter has a classification excellent of its own. Reinforcement learning has been utilized to enhance the efficiency of Multicropping. The figure 1 shows Reinforcement Learning model utilizes Multicropping yield data to optimize loss prediction by measuring performance and updating iterations and end states. The follows steps are following are



Step:1. Multicropping yield data translate to Reinforcement Learning: The system utilizes imagery, extensive soil and climate databases, and plant history to generate accurate forecasts, comparing the performance of Reinforcement Learning. Crop yield, which is frequently used to refer to grain, is the average agricultural production per unit of land area. It is typically mentioned in acres.

Step:2. Measure performance and update model the Multicropping yield: Crop yield is a crucial measure of agricultural performance, influencing discussions on growth, technological advancements, climate change, farmer performance, and food security. Accurate crop yield analysis is crucial for agronomists, economists, and policymakers. Intercropping and mixed cropping, which grow multiple crops, can complicate measuring output per unit of area. The study revealed a significant difference in yields between cultivated and harvested areas in smallholder rice growers, due to irregular plots, obstructions, crop loss, or poor germination.

Step:3. Multicropping yield iteration and end state that maximize model performance for loss prediction: Reinforcement learning is a type of machine learning that generates computer models to predict or make inferences about unidentified facts. It can be extended to various cropping yield data translation tasks by identifying loss, generating translations based on comparable proofs, and improving translation yield accuracy by forecasting errors.

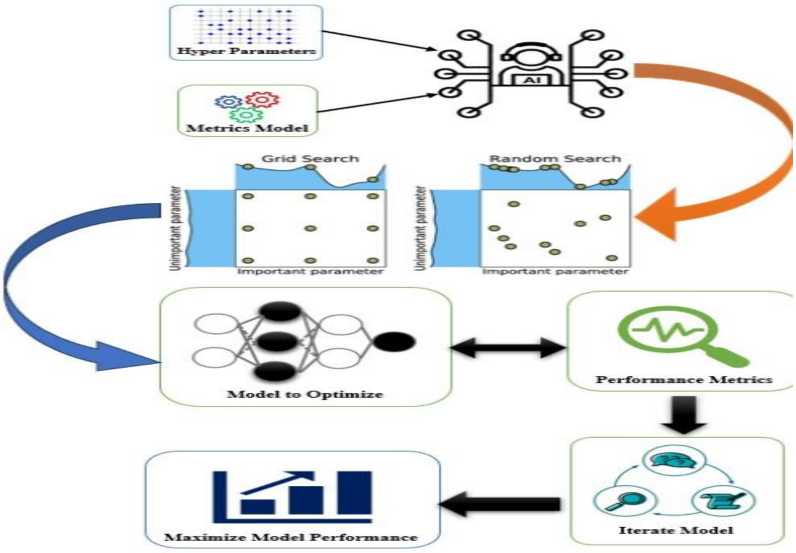
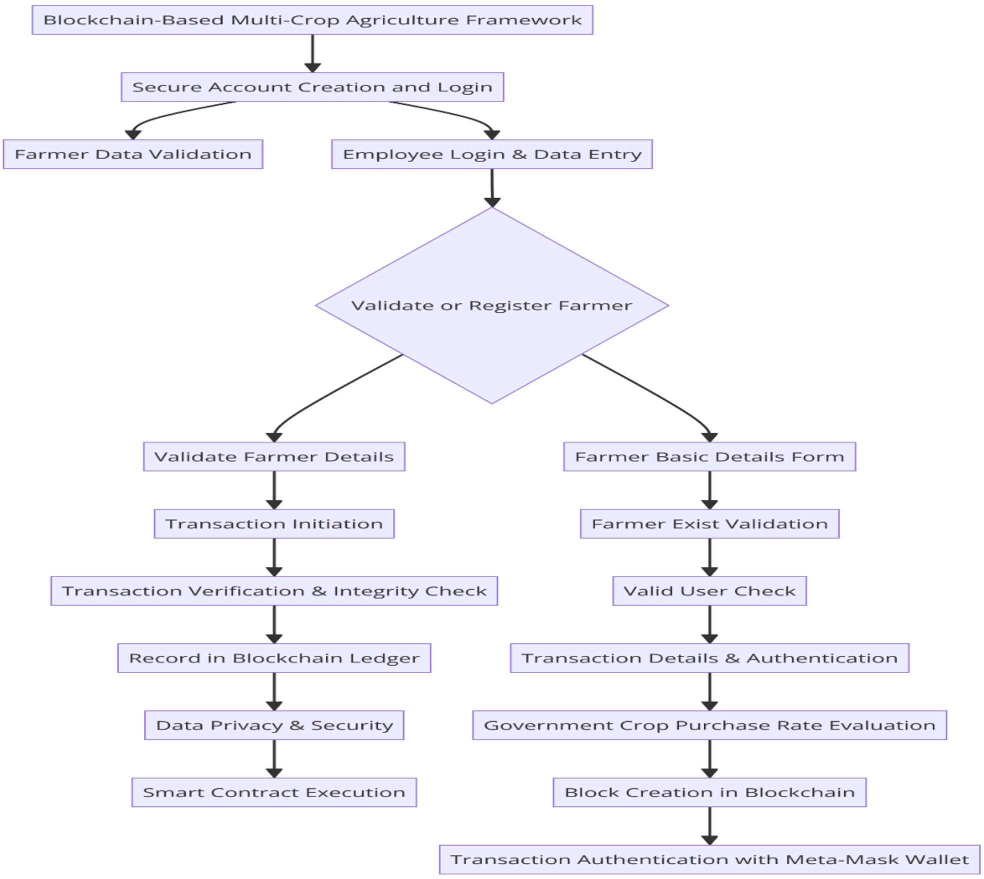


Figure-1: Multiple Crops Optimize Hyperparameters Conditions with Reinforcement Learning

5.3 Blockchain-Based Multi-Crop Agriculture Framework: The Blockchain system should enable farmers to securely create and register accounts, while employees can log in using their credentials. The system's Farmer Data Validation should be capable of validating the farmer data. Users can initiate transactions with transaction details, and the system should verify their authenticity and integrity using cryptographic techniques and consensus mechanisms. All transactions should be recorded in the blockchain ledger to ensure immutability and transparency. The Blockchain system should ensure data privacy and security by utilizing robust encryption and access control mechanisms to protect transactional data. The Blockchain system should facilitate the execution of smart contracts, automating the enforcement of predefined rules and conditions in transactions, if applicable.



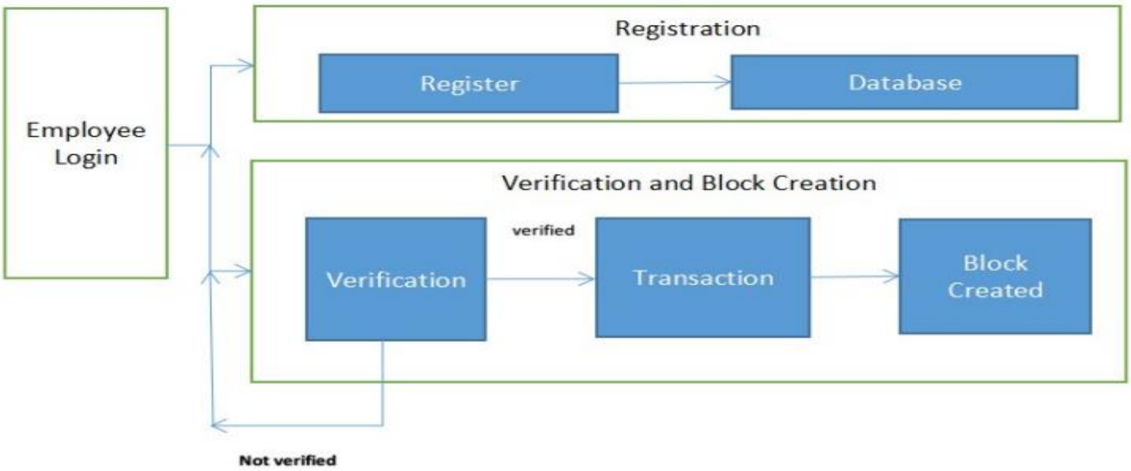
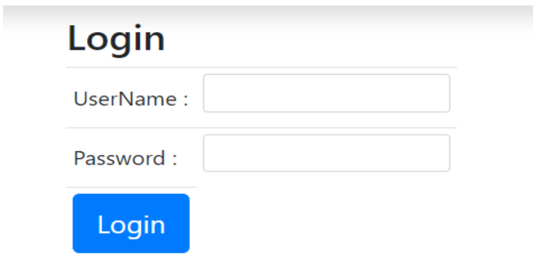
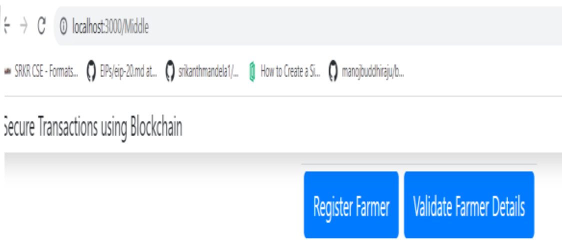


Figure-2: Crop Agriculture Framework Process Using Blockchain

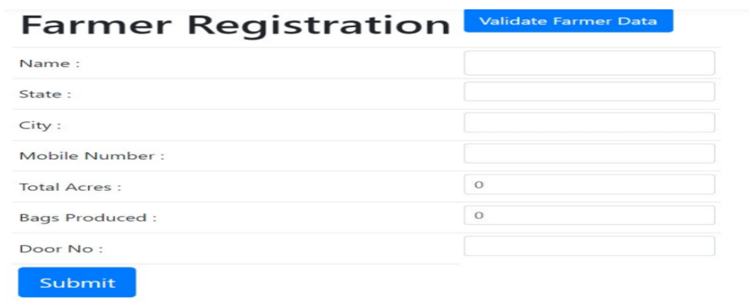
1). In the Step-1, Employee login into the application and redirected to form with two buttons. One allows user to verify details and other button is for farmer basic details like Name, Mobile Number, State, City/Village, and Total Acres of land he owns, Door Number and No. of Bags produced by him will be submitted.





First the employee enters the username and password. Once the details were verified, then they will be asked to either Register Farmer or Validate Farmer Details.

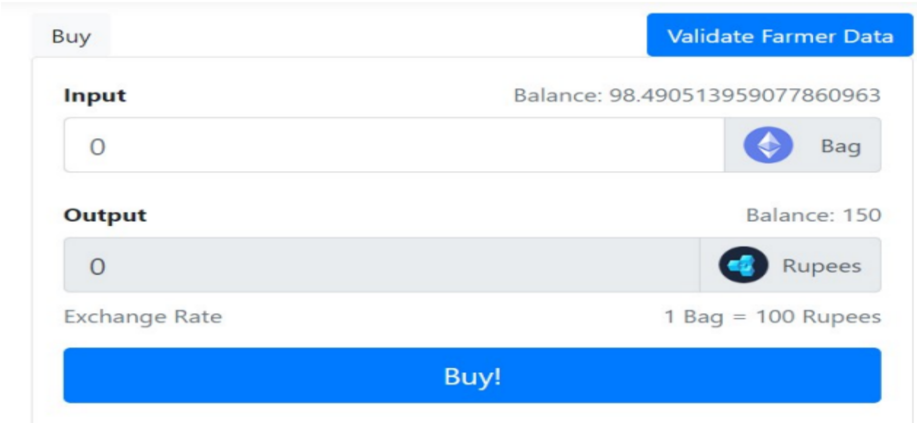
2). In Step-2, It is redirected to validate the data of the farmer using his Name, City/Village and Mobile Number. Once farmer is valid, Page is redirected to Transaction.



First the farmer data is being inserted with required details like Name, State, City, Mobile Number, Total Acres, and Bags Produced by the farmer and Door Number. If already existed, pop-up will be shown saying Farmer Exist.

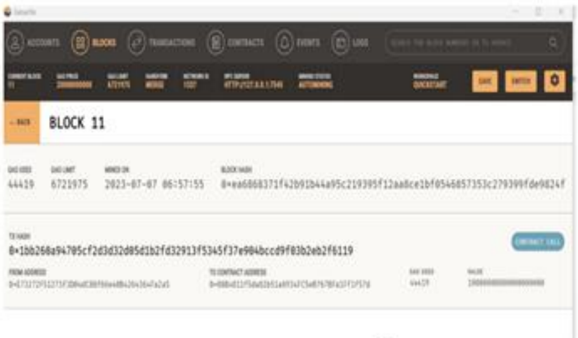
3) If the farmer details were not valid, Pop-up appears saying not a valid user and redirect back to farmer details submit page in Step-2.

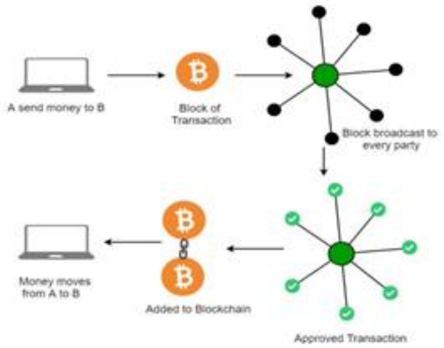
Validate the farmer's name, city and mobile number for authentication purpose. Employee will be redirected to performed transaction in the next page only if the farmer is valid. Pop-up will shown saying to register the farmer.
4) In Step-4. As per the standard rate provided by government, the bags produced will be evaluated and accordingly the crop will be purchased. Block will be created in blockchain.



Government pays the farmer according to the market rate for the crop produced. Here we used Ethereum as the blockchain framework and here there will be additional layer of protection with Meta-Mask wallet and it can be used as layer for authentication of transaction.

Block creation in blockchain networks involves date time and hash values, with Ganache used to validate these creations and transaction details.





The system must efficiently handle high transaction volumes, use robust measures like encryption, and be user-friendly, reliable, and compatible with various platforms. It should integrate with existing systems, smallholder farmers databases, and third-party services, and be developed within budget and timeframe.

6. Experimental Result: Farmers are advised to produce a range of crops, including rice, bananas, coconuts, turmeric, and other crops, as this can increase productivity and yield of use outcomes. Heavy rains caused damage(y) to agriculture harvesting in 2023, with weight(x_1), investment amount(x_2), and crop received amount(x_3) as independent variables. By comparing agricultural yields from damaged and healthy crops, crop loss evaluations, a type of conventional analysis, assist farmers in determining the need for intervention. A number of factors, including disease, pests, climate change, natural catastrophes, and human activities, affect the economy and the livelihoods of farmers when crops are lost. With multi-regression analysis, the goal is to estimate crop loss in Table 1: Multi-Crops of Agriculture.

S.No.	Crops Names	Damage (y)	Crop Weight (100kgs)/Quintal (x_1)	Invest Amount (x_2)	Received (x_3)
1	Rice	15000	25	10000	15000
2	Banana	12000	50	30000	18000
3	Turmeric	15000	50	10000	14000
4	Kandha	13000	60	33000	22000
5	Coconut	14000	10	11000	24000
6	Coco	12000	30	10500	15000
Total		81,000	220	1,04,500	1,08,000

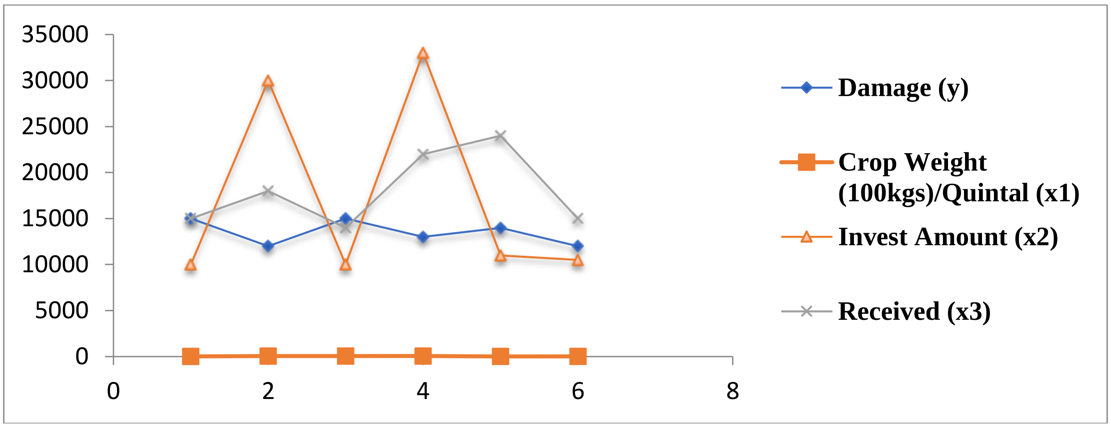


Figure-3: Multi-Crops of Agriculture

In this case, n=6. Replace the data from table 1 with the harvesting information in the standard equations:

$\sum y = N b_0 + b_1\sum x_1 + b_2\sum x_2 + b3\sum x_3$

$\sum x_1 y = b_0\sum x_1 + b_1 \sum x_1{}^2 + b_2 \sum x_1 x_2 + b_3 \sum x_1 x_3$

$\sum x_2 y = b_0 \sum x_2 + b_1 \sum x_1 x_2 + b_2\sum x_{2i}{}^2 + b_3\sum x_2 x_3$

$\sum x_3 y = b_0\sum x_3 + b_1 \sum x_3 x_1 + b_2 \sum x_2 x_3 + b_3 \sum x_{3i}{}^2$

So that,

$81,000 = 6b_0 + 220 b_1 + 104500 b_2 + 108000 b_3$

$3005000 = 220 b_0 + 10,225 b_1 + 4655000 b_2 + 3985000 b_3$

$1369000000 = 104500b_0 + 4655000b_1 + 2420250000 b_2 + 1977500000 b_3$

$1425000000 = 108000b_0 + 3985000b_1 + 1977500000b_2 + 2030000000b_3$

When we solve, we

$b_0 = 18211.882$

$b_1 = 60.3507262$

$b_2 = -0.10716$

$b_3 = -0.281017$

Consequently, the necessary regression plane is

$\mathbf{y=18211.882+60.3507262x_1+(-0.10716)x_2}$

Estimation of Each Harvesting:

1. For a Rice Crop damage of per acre (x_1=25) and x_2=10000, the damage incurred in rupees is y(x_1=25, x_2=10000) = 18211.882+60.3507262*25+(-0.10716)*10000=19718.5-1071.6.

The Rice Crop damage of per acre y=18646.9.

2. For a Banana Crop damage of per acre (x_1=50) and x_2=30000, the damage incurred in rupees is y(x_1=50, x_2=30000) = 18211.882+60.3507262*50 + (-0.10716)*30000 = 21229.42 – 3214.80.

The Banana Crop damage of per acre y=18014.62.

7. Conclusion and Future Perspective: The investigation aims to predict the losses on multiple crops and when to supply products using blockchain technology to support secure transactions. Before going to the experiment, multi-regression analysis is used to estimate crop loss with the help of Neutrosophic logic. In the experiment, blockchain technology is used to protect transactions, and multi-regression analysis is used to estimate crop loss across several crops using Reinforcement Learning. The aimed to address the challenges in the agriculture sector, including single point of failure, lack of transparency, data privacy, security concerns, high transaction costs, and trust. By leveraging blockchain features like transparency, immutability, decentralization, and cryptographic security, the project demonstrated how these issues can be mitigated. The implementation of a secure transaction system offers benefits such as enhanced transparency, trust, reduced risk of single point of failure, and improved efficiency. Future research could focus on scalability, interoperability, and privacy-enhancing techniques.

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