Smart Contract Farming Using AWS Cloud

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Abstract - Contract farming has become a widely accepted method for promoting vertical coordination in agriculture in developing countries. However, there is a lack of agreement regarding its capacity to facilitate structural transformation in rural economies. The results of a field experiment on contract farming for crop production in India are presented. We have observed that the most basic contract has nearly as significant an impact as contracts with additional attributes, despite the fact that all contracts have positive effects on welfare and productivity measures. This implies that producers are capable of addressing other constraints independently once price risk is resolved through the provision of a fixed-price contract. To resolve this matter, the proposed system creates a model that extracts the requirements of both the farmer and the customer, allowing for a bidirectional analysis to establish a contract between the two parties through the use of the AWS cloud platform.

Key Words: Vertical Coordinates, Rural Economies, Fixed-Price Contract, Attribute, Price risk

1.INTRODUCTION

In order to alleviate poverty and food insecurity experienced by the millions of households dependent on agriculture, structural reform must be prioritized as a critical component of economic development efforts. There is a wealth of literature that details the many obstacles that prevent rural farms from moving from subsistence to commercial output. Uncertainty over prices, difficulty obtaining financing, and inadequate technical expertise are all factors to consider. Constraints like these keep things the same on the farm by influencing things like input demand, yields, sales, and profits. The rural economy may be able to undergo structural transformation with the help of vertical coordination. One common strategy to promote this kind of vertical coordination is contract farming, which has grown in popularity in recent years. Through the utilization of farm production contracts, larger processors and medium-sized farming households can transfer the risk and initial capital requirements to themselves. In exchange, businesses get a steady supply of high-quality raw materials. Although not everyone shares the belief that contract farming may promote structural change in rural areas and boost local economies, many do see it that way. Past research has relied solely on observational data, with many studies being limited to cross-sectional data, which contributes to the lack of agreement over the effects of contract farming in developing nations.

The first field experiment including contract farming in a poor nation context was presented here.2 We employ a randomized control experiment (RCT) in collaboration with a Beninese rice processing company, wherein we provide a subset of smallholder farmers at random with contracts to produce rice. Scale, productivity, and commercial orientation are three indicators of rural change that are positively and significantly affected by contract farming. Contract farming households significantly outperform the control group in several key areas: area planted to rice increases by 23%, yields by 29%, market share more than doubles, and per capita income increases by 50%.

In light of these conclusions, it is critical to identify the characteristics of the contract that are responsible for the outcomes in terms of both productivity and household income. Further randomization into one of three production contract types is used to achieve this goal. The first kind of contract is the fixed-price contract, where the processor promises the farmers a certain amount for their rice. The second one is a contract for production management in which the processor ships out extension agents three or five times during the growing season to provide farmers lessons and advice. Thirdly, there's the input supply contract, where the processor uses harvest as a means to deduct the cost of inputs like seed and fertilizer. Given the limited resources of our implementing partner, we randomly assign one of three outcomes to the major experiment: 1) a price guarantee, 2) extension training combined with the price guarantee, or 3) input loans on top of the price guarantee and extension training.

Based on the characteristics of the contract, we discover that the treatment's impact on rice planting area and market share differs substantially. Nevertheless, we do not observe any notable variations in the treatment's impact on rice yields or income per capita according to contract attributes. The statistical differences between the more complicated and expensive contracts that offer input loans and/or extension training and the fixed-price contract on treatment impacts on planted area, yield, and income per capita are often very small. If farmers are able to alleviate price risk, they will be free to tackle technological efficiency and capital restrictions independently.

Primarily, our research adds to the existing body of empirical literature on contracts for agricultural production and their motivations. A large body of empirical research from underdeveloped nations examines factors that may influence a person's choice to engage in contract farming. Contracts and contract at ties have been the subject of an increasing amount of research into their effects on output and revenue, although this work could be skewed due to the inherent subjectivity of contract selection. Our research is the first of its kind to examine the effects of contract farming on a developing nation through experimental means. In addition, we analyze how various contract features affect production decisions and the cash flow realization on farms. Our research shows that various indicators of agricultural income and production are positively affected by contract farming. Additionally, we zero in on contract farming of a staple crop as our experimental focus. Specialty and high-value crops have dominated the writings on contract farming. The margins and incentives for cultivating staple crops are limited compared to specialized crops. This means that our findings can be applied to other basic crops as well as serve as a starting point for estimating the potential effects of contract farming on specialty crops with higher value and margins.

[1] Qiliang Zhu et al. presented a fairness-aware APP recommendation method for the purpose of taking into account the fairness between high visibility and low visibility APPs. In this method, APP candidates are divided into high visibility APPs and low visibility APPs, and implement recommendation algorithms, respectively. The main study emphasizes on the fairness of low visibility APP during recommendation process. For low visibility APPs, author continuously adjust fairness factor for everyone according to the latest users' feedback, and do recommendation based on the roulette-wheel algorithm. For high visibility APPs, author employ the fuzzy analytic hierarchy process to implement recommendation. According to the experiments based on real datasets, the proposed method shows good performance in terms of fairness, which can discover excellent APPs among low visibility APPs rapidly, and improve user satisfaction. Our proposed method is a pioneer attempt for fairness aware APP recommendation.

[2] Quang Nhat Tran et al, describe as blockchain has found its way to be a useful tool in real life thanks to its decentralized manner and robustness against data manipulation, the privacy of the involved parties as well as data transparency is still an open question. In order to fully leverage the power of blockchain technology without compromising the security, techniques to ensure the privacy ought to be implemented. In this survey, author have discussed the current challenges in privacy protection when applying Blockchain in different fields. Based on that, author have provided two layers of categorization for privacy-preserving blockchain applications by first reviewing some key advances in different block chain's applicability areas, then categorized the types of privacy accordingly. Importantly, author proposed PPSAF, a novel Privacy-Preserving Smart Agriculture Framework based on blockchain to further explore this technology's potential in smart farming and smart agriculture.

[3] Lin Xie et al. proposed as digital agriculture technology is more friendly to large-scale farms, the digital transformation of small-scale farms in developing countries has encountered significant challenges. This research discussed how small farmers might be involved in digitalization from mechanization. By analyzing the case study presented by Changzhou County, Sichuan province in China, small farmers obtained a relatively large farmland scale by forming cooperatives. Then they outsourced agricultural production to service providers, who provided mechanized agricultural services to cooperatives. Some service providers have developed trading platforms and digitized them to create an integrated digital agricultural service platform. This platform integrates farm management systems, precision planting systems, digital operation systems, and quality control traceability systems.

An examination of earlier research that was deemed a Litereature Survey is presented in the second part of this publication. Section 3, labeled "Proposed methodology," provides a comprehensive description of the proposed approach. Section 4 delves into the experimental evaluation, Section 5 examines possible modifications, and Section 6 concludes the essay with a conclusion on the present plan.

2. LITERATURE SURVEY

[4] Janet Molina-Maturano et al. extended the commonly used UTAUT framework to reveal the main behavioral aspects of Mexican farmers' intention to adopt agricultural apps, including understudied farmers' intrinsic motivations. Performance expectancy was found to be the strongest predictor of farmers' intention to adopt an app to provide agricultural information. This highlights the importance of understanding the benefits perceived by farmers. Thus, managers of agricultural projects aiming to deploy mobile-phone apps need to ensure that their use for data collection offers benefits to farmers, such as mobile credit compensations. Mastery-approach goals (MAG) were found to be significant, and revealed a baseline of farmers' intrinsic motivation (why they are motivated to use it in the first place) independently of the content of the application. This is of special interest in the initial decision to adopt, with their readiness to learn and master the use of an app providing agricultural innovation.

[5] Muhammad Shoaib Farooq et al. narrate the current status of the research has indicated that it was feasible to remotely monitor the greenhouse parameters such as CO2, PH, moisture content, humidity, temperature, and irrigation by using IoT sensors and devices. In this survey, author have discussed emerging technologies of IoT and provided a rigorous discussion on IoT-based greenhouse farming patterns. Furthermore, various traditional and developed cultivation techniques are discussed which can help the growers to understand the technological structure of a greenhouse. In addition, author have also discussed the IoT-enabled greenhouse network structure based on cloud and big data analysis, which act as an IoT backbone and help farmers to increase crop productivity. Moreover, this survey provides a state-of-the-art overview of IoT-based greenhouse farming applications, sensors/devices, communication protocols, and technologies. Furthermore, several important dimensions of IoT-greenhouse farming, top technology firm's trends, and success stories performance metrics have been discussed to succor the stakeholders.

[6] Malni Kumarathunga et al. presents a novel approach to establish trust progressively that facilitates three modes of exchanges: deliver material to receive money on the spot, deliver material early to receive money later, and receive money early to deliver material later, facilitating online trust between farmers and buyers to evolve gradually. It is developed integrating several notions: community trust, social capital, aggregated marketing, and futures contracts. It mitigates market risks and financial risks encountered by the farmers while engendering future possibilities of alleviating production risks as well. The approach is demonstrated as the Smart Agricultural Commodity Market platform, integrating a blockchain network to create a blockchain-based community, record all transactions and execute the smart contracts.

[7] Manik Rakhra et al. research polled 562 Punjabi farmers. The poll revealed many critical findings, including why farmers are not harvesting more. The difficulties confronting agriculture were examined in terms of farmer education, land ownership, awareness, mobile phone use, debt burden, loan source, and interest in renting equipment. The research found that farmers lack awareness of current technology, which is extensively used in agricultural operations worldwide. Another barrier is the financial status of farmers, especially small and marginal farms. Farm management loans from commission agents or private firms progressively enslave the farmers. Landlords continue to adopt traditional manufacturing methods despite their ignorance of current production methods. This project developed smart tillage, a platform that enables farmers to rent and lease equipment.

[8] Randhir Kumar et al. designed a DL and SC-assisted secure data sharing framework for IoT-based IA. Specifically, a novel DL module was designed that combined CSAE with GRU, MLPs, and softmax classifier to detect intrusion in the network. In SC module, first authentication, key management scheme was proposed. The, normal transactions received from DLbased IDS were mined by CS using SC-based PoA (aura algorithm) consensus technique. The validated transactions were added to the IPFS-based storage layer and returned cryptographic hash was stored on blockchain ledger. Experimental analysis of DL and SC module proves the effectiveness of the proposed framework.

[9] Yinsheng Li et al. it is found that the participants in the metaverserelated agricultural applications are designed as users rather than residents. There is another critical setback for the metaverse to be a fusion cyber-physical space, as the cyber space is

subject to different values principles from the physical space. Based on the observation, a Cyber-Farm of trigram metaverse is proposed to be developed a values-driven and whole-profits-oriented crowd dispatching. The Cyber-Farm is constructed on a unified trigram space through the fusion of cyber, physical, and values spaces. Based on a trusted blockchain infrastructure, the values space is a parallel and superstructure to the cyber and physical spaces. Further, the values space enables both the cyber space and physical space to follow the same values principles, and operate in a fair, efficient, and equal rules through a values-driven governance system. What make differences of this work is to identify and provide solutions to the critical issues of metaverse development, namely, a methodology of constructing a metaverse and fusion space with heterogeneous principles.

[10] Gouranga Das et al. propose a main conclusion is that CF is pro-growth but anti equity. Further, since, by its very definition, CF solves the problem of any food deficiency in a country through food import financed by the export of the CF good, there is no scope for any concern on the possible deterioration of the trade balance. Since these results are not context-dependent and will happen in any competitive economy with some restrictions on the factor intensities of the CF and non-CF sectors, it contributes to clarifying the confusion on the overall desirability of CF.

[11] ABDUS SALAM et al. describe several transfer learning models, including modified MobileNetV3Small, were trained and tested for mulberry leaf disease detection. Modified MobileNetV3Small showed superior accuracy, albeit with higher performance variability. VGG19 proved to be a robust option with slightly lower accuracy, while ResNet50 offered a compelling balance of accuracy and consistency, characterized by its notably low standard deviation. The selection of the model was based on performance and model size, with MobileNetV3Small having the smallest size in megabytes, making it suitable for building Android applications. The app size remained below 100MB, which is optimal for mobile applications running machine learning models. Although the study results demonstrate the promising nature of the proposed framework, further research is warranted.

[12] Hong-Danh Thai et al. aims to automate the classification process using computer vision and artificial intelligence techniques. Image processing and data augmentation methodologies are employed, and a model is trained using YOLOv8. Additionally, a software application has been developed to enable the real-time identification of coffee beans through video and image streaming. Web Socket is utilized for communication purposes. The implemented technology has demonstrated the capability to detect and distinguish nine different types of coffee beans, even in cases involving mold or insect damage. As a result, the system’s efficiency has significantly improved, with the required identification time reduced to 1 to 3 seconds. Its cost-effective and scalable infrastructure, achieved through a cloud-based solution paired with a low-cost primary server, further enhances its accessibility, allowing for easy scaling of operations without substantial hardware investments.

Future Scope/Limitations: Future work can be defined as improving model accuracy, which can be achieved by incorporating more advanced deep learning architectures, fine-tuning hyper parameters, and leveraging larger, more diverse datasets. Next, expanding the range of detectable defects includes identifying a broader spectrum of defects, such as moisture content irregularities or internal damage.

[13] Hayfaa Subhi Malallah et al. propose the marketing of agricultural goods is a significant business that is increasing at a rate comparable to that of other industries. This web-based tool is used to aid with database upkeep. It has a hospitable environment that stimulates consumer interaction. As a consequence, it simplifies the procedure by saving us time and effort. It will assist the management in controlling and managing the system's operations effectively and efficiently. Another feasible modification is the integration of the system with bigger organizations, such as agricultural information centers, in order to better serve them. After analyzing various sorts of research, it has been feasible to reach the conclusion that the web-based systems that have been implemented have been advantageous to the organizations. However, there were also variances across the trials, since each used the system in a unique manner. Several methods were demonstrated to be more or less advantageous for each study assignment in terms of efficiency, time efficiency, performance, and job task facilitation.

[14] Eman-Yaser Daraghmi et al. presents a fully-functional Blockchain-based prototype, namely Agro Chain that is designed to manage the Agricultural Supply Chain (ASC) process for any digital agricultural record. The prototype undergoes validation through the

specification of three architectural designs (multi-blockchain, centralized, and distributed) and the delineation of several principles integrated into the prototype. The proposed smart contracts are developed under Quorum, an Ethereum variant tailored for providing private business environments.

[15] Ik- Ugwoezuonu Lilian et al. narrate the correlation analysis conducted in this research provides valuable insights into the dynamics of mobile app-based extension services in agriculture. The findings underscore the significance of mobile technologies in agricultural extension, revealing patterns of usage, perceived usefulness, impact on farmers' outcomes, and challenges faced in implementation. The strong positive correlation between the usage patterns of mobile apps among farmers and extension agents indicates a convergence in their adoption behaviors. This suggests a promising trend towards the widespread adoption of mobile technologies for accessing agricultural extension services. Moreover, the moderate to strong positive correlations between perceived usefulness, ease of use, and satisfaction with mobile app-based extension services highlight the importance of user-centric design principles in enhancing user experience and satisfaction. This emphasizes the need for continued efforts in developing intuitive and valuable mobile applications tailored to the needs of farmers and extension agents.

3. METHODOLOGY

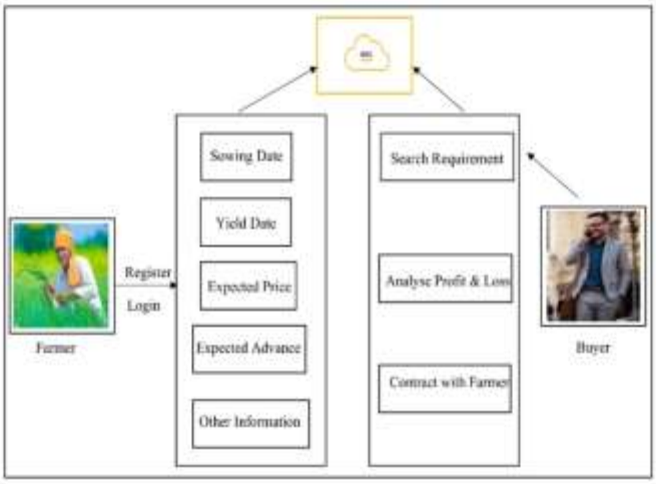

Figure 1 System Overview

Contract farming is an agricultural production system in which farmers and buyers enter into an agreement before cultivation begins. This system establishes predefined conditions regarding production methods, quantity, quality, and price of the produce. It serves as a structured arrangement that benefits both parties, ensuring a stable market for farmers while providing buyers with a consistent supply of agricultural products.

Step 1. Initial Login Screen:

Upon launching the application, users are presented with two distinct options, clearly delineated for ease of access:

Login as Farmer: Selecting this option directs the user to the dedicated farmer login interface, providing a secure entry point for registered farmers.

Login as Buyer: This option leads to the buyer login process, which will be detailed later in this guide, ensuring a streamlined experience for both user types.

Step 2. Farmer Login/Registration:

The farmer login interface presents two primary options for accessing the platform:

Registration: New farmer users must first register their details within the system. Clicking this button opens the farmer registration form, prompting users to provide essential information such as name, contact details, farm location, and other relevant data. Upon completion, users click "Submit" to finalize the registration process and create their account.

Login: After successful registration, returning farmers can log in using their established credentials (username and password). This secure login process grants access to the platform's functionalities.

Step 3. Farmer Operations Frame:

Successful login directs farmers to the main operations frame, a central hub offering four key functionalities:

Manage Profile: This section allows farmers to update and edit their registered information, ensuring accuracy and relevance of their profile data. Farmers can modify contact details, farm size, and other pertinent information as needed.

Crop Details: This section provides comprehensive tools for managing crop information, featuring two sub-menus:

Add: Farmers can input detailed crop information, including: Crop ID (a unique identifier for each crop); Crop Name (the common or scientific name of the crop); Sowing Date (the date the crop was planted); Harvesting Date (the projected or actual harvest date); Expected Rate (the anticipated price per unit); Expected Quantity (in quintals, a standard unit of weight); Expected Advance (any upfront payment requested); Farm Location (determined using an integrated map feature that fetches the user's current location via GPS and allows for precise selection of latitude and longitude coordinates); Price Confirmation (indicating whether the crop price is fixed or negotiable); Other Information (a free-text field for additional details such as crop variety, fertilizer usage, and specific site address). Upon completing all fields, the farmer clicks "Submit" to record the crop information.

View: This sub-menu allows farmers to review and manage previously entered crop data. Farmers can search for specific crops using various criteria, such as crop name or sowing date. The "View" functionality displays detailed information for each selected crop, allowing farmers to monitor progress and track key metrics. Furthermore, this section allows for editing and updating existing crop data, providing flexibility and ensuring accuracy throughout the growing season. Farmers can modify any of the previously entered fields, reflecting changes in expected yield, harvest date, or other relevant factors.

Smart Contract: This section facilitates the creation and management of sales agreements between farmers and buyers, featuring two sub-views:

View Interest: This sub-view displays details of buyers who have expressed interest in purchasing the farmer's crops. The information provided includes the buyer's name, contact details, and the specific crops they are interested in. This allows farmers to assess potential buyers and initiate contact.

View Contract: This sub-view displays the status of existing contracts with buyers. Farmers can see which contracts have been accepted, rejected, or are still pending. This provides a clear overview of on-going sales agreements and facilitates communication between parties.

Exit: This option securely logs the farmer out of the system, protecting their data and ensuring privacy.

Buyer Operations

Choosing "Login as Buyer" on the initial screen initiates the buyer login process, providing access to the platform's functionalities for purchasing crops.

Step 1. Buyer Login/Registration:

Similar to the farmer registration process, new buyers must register by providing their details and creating an account. Existing buyers can log in using their established credentials.

Step 2. Buyer Operations Frame:

After successful login, buyers access the following options:

Manage Profile: This section allows buyers to update and edit their registered information, ensuring accuracy and relevance of their profile data. Buyers can modify contact details, business information, and other pertinent information as needed.

Crop Details: This section provides tools for viewing and interacting with crop listings, featuring two sub-menus:

View Crops: This sub-menu allows buyers to browse available crops based on various criteria, such as crop type, location, and expected harvest date. Detailed information about each crop, including price and quantity, is displayed, enabling buyers to make informed purchasing decisions. Click on "Show Interest" opens a frame where users confirm conditions, quantity, and advance before click on "Contract Farm." This adds details to the farmer's smart contract menu for buyer contact.

Check Status: It opens a frame displaying requested crop statuses. Selecting and click on "View Details" shows all records. Here in this menu the buyer can check the status regarding the contract send to the farmer to buy the crop. Here he can see the farmer's acceptance for the contract.

Logout: This option securely logs the buyer out of the system.

Contract farming plays a crucial role in modern agriculture by bridging the gap between farmers and buyers. It enhances productivity, ensures fair pricing, and reduces market risks. However, challenges such as contract enforcement, price fluctuations, and dependency on buyers must be addressed to create a more sustainable and mutually beneficial system. Proper regulation and support can further strengthen contract farming as a viable solution for agricultural growth and food security.

4. RESULT AND DISCUSSION

The proposed method makes use of cloud-based technologies and blockchain integration to develop a reliable Smart Contract Farming System using AWS Cloud. The system is implemented using modern programming frameworks along with cloud services provided by Amazon Web Services (AWS). The development and deployment were carried out on a system with Windows OS, an Intel Core i5 processor, 8 GB RAM, and 500 GB storage capacity.

AWS services such as cloud storage, computing resources, and database management are utilized to handle smart contracts and farming-related transactions efficiently. The system ensures secure, transparent, and automated execution of agreements between farmers, buyers, and stakeholders. The effectiveness of the proposed method has been evaluated under various operational conditions, and the experimental findings are discussed below.

Scalability Analysis of Cloud Transactions

The scalability of the proposed system is analyzed by evaluating the performance of cloud-based transactions executed through smart contracts. The system supports multiple users, including farmers, buyers, and administrators, each having separate login access. All transaction data, such as crop details, agreements, and payments, are securely stored and processed using AWS cloud infrastructure.

The density and processing time of cloud transactions are analyzed and presented in the table below. This includes various operations such as contract creation, validation, execution, and data retrieval.

S. No	No. of Database Transactions	Time Taken (in Seconds)
1	256	0.48
2	541	0.95
3	801	1.62
4	965	1.88
5	1299	2.05

Table 1: Smart Contract Transaction Time Estimation

Graphical Analysis of Transactions

The data from the table is further used to generate a graphical representation, as shown in Figure 2. The graph clearly illustrates the relationship between different smart contract operations and the time required to execute them on the AWS cloud platform.

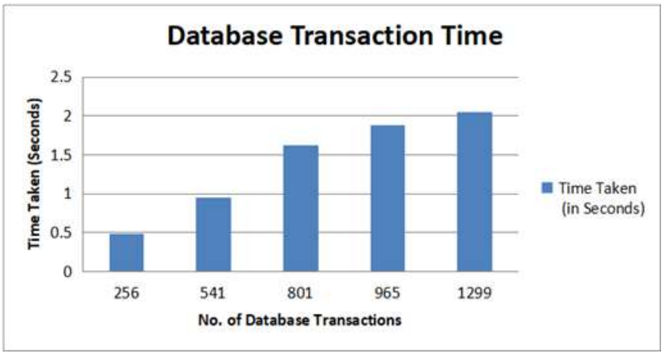

Figure 2: Smart Contract Transactions Graph

The graphical analysis shows that the execution time increases gradually with the complexity of operations, but remains within acceptable limits. This demonstrates the scalability and efficiency of the AWS cloud infrastructure in handling large volumes of farming-related transactions.

The results confirm that cloud-based smart contracts significantly improve transparency, reduce manual intervention, and enhance the reliability of agricultural transactions. The system ensures secure data handling and faster execution compared to traditional methods.

Overall, the proposed system demonstrates high scalability, efficient transaction processing, and improved reliability, making it suitable for real-world agricultural applications. The integration of AWS cloud with smart contracts enhances system performance and ensures better resource utilization.

5. CONCLUSIONS

An increasing number of developing countries are turning to contract farming as a means of promoting vertical coordination in their agricultural sectors. This trend is expected to continue. On the other hand, there are a variety of perspectives regarding whether or not it can stimulate fundamental changes in rural economies. We demonstrate how contract farming can lead to increased agricultural yields by using data that was collected from an experiment that was conducted in India. It has come to our attention that even the most fundamental contract has a nearly identical positive impact on welfare and productivity indicators as more complicated contracts that contain a greater number of benefits. As a result, it would appear that farmers are able to handle additional limits on their own after a fixed-price contract has eliminated the possibility of price risk.

As the future scope of this research, this can be enhanced to work in real time cloud and work as web service and mobile application to help formers and buyers.

REFERENCES

[1] Q. Zhu, Q. Sun, Z. Li and S. Wang, "FARM: A Fairness-Aware Recommendation Method for High Visibility and Low Visibility Mobile APPs," in IEEE Access, vol. 8, pp. 122747-122756, 2020, doi: 10.1109/ACCESS.2020.3007617.

[2] Q. N. Tran, B. P. Turnbull, H. -T. Wu, A. J. S. de Silva, K. Kormusheva and J. Hu, "A Survey on Privacy-Preserving Blockchain Systems (PPBS) and a Novel PPBS-Based Framework for Smart Agriculture," in

IEEE Open Journal of the Computer Society, vol. 2, pp. 72-84, 2021, doi: 10.1109/OJCS.2021.3053032.

[3] Lin Xie, Biliang Luo and Wenjing Zhong, "How Are Smallholder Farmers Involved in Digital Agriculture in Developing Countries: A Case Study from China", a. Land 2021, 10, 245. https://doi.org/10.3390/land10030245

[4] Janet Molina-Maturano, Nele Verhulst, Juan Tur-Cardona, David T. Güereña, Andrea Gardeazábal-Monsalve, Bram Govaerts and Stijn Speelman, "Understanding Smallholder Farmers' Intention to Adopt Agricultural Apps: The Role of Mastery Approach and Innovation Hubs in Mexico", Agronomy 2021, 11, 194. https://doi.org/10.3390/ agronomy11020194

[5] M. S. Farooq, S. Riaz, M. A. Helou, F. S. Khan, A. Abid and A. Alvi, "Internet of Things in Greenhouse Agriculture: A Survey on Enabling Technologies, Applications, and Protocols," in IEEE Access, vol. 10, pp. 53374-53397, 2022, doi: 10.1109/ACCESS.2022.3166634.

[6] Malni Kumarathunga, Rodrigo N. Calheiros and Athula Ginige, "Smart Agricultural Futures Market: Blockchain Technology as a Trust Enabler between Smallholder Farmers and Buyers", . Sustainability 2022, 14, 2916. https://doi.org/ 10.3390/su14052916

[7] Manik Rakhra, Sumaya Sanober, Noorulhasan Naveed Quadri, Neha Verma, Samrat Ray, and Evans Asenso, "Implementing Machine Learning for Smart Farming to Forecast Farmers' Interest in Hiring Equipment", Hindawi Journal of Food Quality Volume 2022, Article ID 4721547, 17 pages https://doi.org/10.1155/2022/4721547.

[8] R. Kumar, P. Kumar, A. Aljuhani, A. K. M. N. Islam, A. Jolfaei and S. Garg, "Deep Learning and Smart Contract-Assisted Secure Data Sharing for IoT-Based Intelligent Agriculture," in IEEE Intelligent Systems, vol. 38, no. 4, pp. 42-51, July-Aug. 2023, doi: 10.1109/MIS.2022.3201553.

[9] Yinsheng Li, "A Values-Driven Cyber-Farm of Trigram Metaverse Based on Autonomic Crowd-Dispatching", International Journal of Crowd Science, https://doi.org/10.26599/IJCS.2023.9100027

[10] Gouranga Das, Ranajoy Bhattacharyya and Sugata Marjit, "Contract Farming and Food Insecurity in an Open Competitive Economy: Growth, Distribution, and Government Policy", y. Journal of Risk and Financial Management 16: 249. https://doi.org/10.3390/ jrfm16040249

[11] A. Salam, M. Naznine, N. Jahan, E. Nahid, M. Nahiduzzaman and M. E. H. Chowdhury, "Mulberry Leaf Disease Detection Using CNN-Based Smart Android Application," in IEEE Access, vol. 12, pp. 83575-83588, 2024, doi: 10.1109/ACCESS.2024.3407153.

[12] H. -D. Thai, H. -J. Ko and J. -H. Huh, "Coffee Bean Defects Automatic Classification Realtime Application Adopting Deep Learning," in IEEE Access, vol. 12, pp. 126503-126517, 2024, doi: 10.1109/ACCESS.2024.3452552.

[13] Hayfaa Subhi Malallah, Maiwan Bahjat Abdulrazzaq, "Web-Based Agricultural Management Products for Marketing System: Survey", Academic Journal of Nawroz University (AJNU), Vol.12, No.2, 2023, Copyright ©2017. e-ISSN: 2520-789X https://doi.org/10.25007/ajnu.v12n2a1532

[14] E. -Y. Daraghmi, S. Jayousi, Y. -A. Daraghmi, R. S. M. Daraghma and H. Fouchal, "Smart Contracts for Managing the Agricultural Supply Chain: A Practical Case Study," in IEEE Access, vol. 12, pp. 125462-125479, 2024, doi: 10.1109/ACCESS.2024.3439412.

[15] Ik- Ugwoezuonu Lilian, Ezike Chimezie C., "ASSESSING THE EFFECTIVENESS OF MOBILE APPS IN ENHANCING AGRICULTURAL EXTENSION SERVICES DELIVERY IN NIGERIA", African Journal of Sustainable Agricultural Development | ISSN: 2714-4402 Vol. 5, Number 2 (April-June, 2024) | www.ijaar.org/ajsad.