Farmer Relief – Smart Crop Insurance and Risk Solution

Ayush Gaonkar[1], Ganesh V Bhandari[2], Gautam Kumar Gandhani[3], Gursimranjeet Singh[4], and Dr. Pallavi GB[5]
[1–5]BMS College of Engineering, Department of Computer Science and Engineering, Bangalore, India
Email: { ayush.cs22, ganesh.cs22, gautam.cs22, gursimranjeet.cs22, pallavi.cse } @bmsce.ac.in

***Abstract*—India's agricultural sector is frequently affected by natural disasters and economic instability, which severely impact small and marginal farmers. Traditional crop insurance systems are plagued by inefficiencies such as delayed claim processing, lack of transparency, and high operational costs. Blockchain, with its decentralized and immutable ledger system, presents an innovative solution to these problems. This survey analyzes two research papers that propose Ethereum-based crop insurance platforms. The goal is to evaluate how blockchain and smart contracts can revolutionize the agricultural insurance ecosystem in India by ensuring faster claim settlements, fraud prevention, and increased farmer trust. Through detailed analysis of architecture, algorithms, performance metrics, and real-world testing, this paper outlines the current capabilities and future scope of blockchain-powered crop insurance systems.**

***Index Terms*—Blockchain, Crop Insurance, Ethereum, Smart Contracts, Agriculture, Decentralization, Weather Analysis, Machine Learning**

I. INTRODUCTION

Although a sizable section of India's population is directly or indirectly supported by agriculture, the sector continues to face numerous obstacles like weather unpredictability, natural disasters, and market volatility, which put farmers—especially smallholders—at serious financial risk. Farmers have a general mistrust of traditional crop insurance programs because of their complicated, manual claim procedures, slow payouts, and lack of transparency [2], [3], [5]. Crop Cutting Experiments (CCEs), one of the labor-intensive and error-prone methods used in the current system for claim assessment, introduce biases and delays and make claim verification difficult and vulnerable to fraud [5]. With decentralized, immutable ledgers and self-executing smart contracts that automate claim processing based on real-time, verifiable data triggers like rainfall or drought conditions, blockchain technology has emerged as a game-changing solution. This eliminates middlemen and saves time and money [1], [2], [4]. With smart contracts that automatically trigger payouts when predetermined conditions are met and all transactions recorded on an immutable ledger, recent blockchain-based crop insurance models—such as those utilizing Ethereum and decentralized oracle networks—have shown the potential for faster, more effective claims processing and increased transparency[2], [4], [6]. Due to these systems' increased transaction throughput, decreased latency, and encouraging results from pilot studies, crop insurance is now more accessible, affordable, and reliable for smallholder farmers [2], [6], [7]. But for blockchain-based crop insurance to be widely adopted and effective in India's agricultural ecosystem, issues like scalability, real-time data integration, gas fee optimization, and user-friendly interfaces for rural populations still need to be resolved [4], [5].

II. BLOCKCHAIN

Blockchain technology is becoming more widely acknowledged as a strong remedy for the enduring problems in crop insurance systems, especially those pertaining to operational efficiency, transparency, trust, and data integrity. Manual, error-prone workflows, slow claim settlements, and a lack of transparency are common problems with traditional crop insurance procedures, which undermine farmer confidence and lower insurance uptake. By offering a decentralized, unchangeable ledger where all transactions—including the issuance of policies, premium payments, and claim settlements—are safely documented and available to authorized stakeholders, blockchain solves these problems. This improves trust between farmers, insurers, and regulators by doing away with the need for middlemen, cutting down on administrative burden, and guaranteeing that data cannot be altered [1] ,[2] , [6].

The application of smart contracts—self-executing agreements encoded onto the blockchain—is a crucial component of blockchain in crop insurance. As evidenced by blockchain-based parametric insurance pilots in Kenya and India, these contracts automatically initiate claim settlements when predetermined conditions—like weather thresholds or yield data—are fulfilled [1], [2] , [13]. Smart contracts significantly cut settlement times from months to days and reduce the possibility of fraud or disputes by automating payouts and eliminating arbitrary, manual interventions. All parties can also audit the process in real time thanks to blockchain's transparency, which guarantees that payouts and claim conditions are transparent, consistent, and unchangeable. This is especially crucial in settings where there is a high level of mistrust toward insurers and where earlier systems were vulnerable to data manipulation or denial of

legitimate claims [6], [7], [8].

Peer-to-peer and decentralized risk pools, new insurance product types, and wider participation—including for smallholder farmers in developing nations—are some of the ways that blockchain can democratize crop insurance, according to the literature [1], [2], [13]. Blockchain simplifies verification and underwriting, further lowering expenses and administrative burdens by securely storing and sharing vital data, including land records, crop histories, and claim events. The accuracy and promptness of risk assessment and claim processing are improved by integration with real-time data sources, such as satellite imagery and Internet of Things devices, allowing for more accurate and responsive insurance coverage [9], [12].

The integrity of the insurance process is preserved while privacy and security are guaranteed by recent innovations like the AgriInsureDON framework, which uses decentralized oracles to aggregate reliable risk data from various sources [12]. Furthermore, mobile applications and user-friendly interfaces have been created to encourage farmer participation, making it simpler for even those who are not tech-savvy to register, submit claims, and get paid [2], [8]. These developments encourage wider adoption among formerly underserved farming communities in addition to increasing crop insurance's effectiveness and accessibility.

Blockchain-based crop insurance systems can provide faster, more dependable, and more inclusive insurance services, despite ongoing challenges like digital literacy, regulatory adaptation, and the need for trustworthy data sources [3], [6], [8]. Blockchain has the potential to change crop insurance into a more robust and farmer-friendly safety net by tackling the fundamental problems of trust, efficiency, and transparency. This would ultimately support the sustainability and resilience of agricultural systems around the world [2], [3], [7].

III. MACHINE LEARNING

According to recent studies and initiatives [2], [3], [4], machine learning (ML) is becoming more and more important in modernizing India's crop insurance systems. ML models are being used to improve and digitize yield estimation, risk underwriting, and claims settlement, among other phases of the insurance process. ML algorithms can precisely evaluate crop health and forecast yields by combining data from a variety of sources, including satellite imagery, vegetation indices, real-time weather and rain gauge station data, soil and crop data, and time-series videos of crop growth. By lowering the manual errors and biases that have historically hampered the process, this makes it possible for Crop Cutting Experiments (CCEs), which are crucial for evaluating insurance claims, to be conducted more successfully and efficiently [1], [8], [11].

AI-driven sampling techniques are used by ML-powered platforms, like those created by Cropin and other agtech companies, to optimize the selection of field plots for CCEs. This greatly reduces the number of samples needed and saves a significant amount of time and money for insurers and the government [8], [11]. Additionally, these platforms make it easier to gather and analyze data in real time, which raises the precision and openness of yield estimates and claim evaluations. For instance, AI and ML have been combined in the Pradhan Mantri Fasal Bima Yojana (PMFBY) to expedite the CCE procedure, which has led to quicker and more dependable claim settlements for millions of farmers in several states [8], [11].

Moreover, differences between the area sown and the area insured are addressed using machine learning techniques. Machine learning (ML) can be used to detect instances of excess or double insurance, verify that only legitimate claims are processed, and find discrepancies between reported and actual cropped areas by examining geo-coded digital land records and village shapefiles [6]. These initiatives are further supported by the digitization of land records as part of the Digital India Land Records Modernization Program, which offers precise, current spatial data that can be compared with insurance applications [6].

In order to determine the risk profile of particular regions or plots, ML models evaluate both historical and current satellite data for underwriting. This enables insurers to more accurately and fairly determine premiums [3], [9]. In order to create thorough risk profiles and automate underwriting decisions in real time, advanced machine learning techniques like Extreme Machine Learning (ELM) and ensemble methods integrate a variety of datasets, such as historical weather patterns, soil quality indicators, crop yield records, market trends, and socioeconomic factors [3]. Robust testing and scenario analysis are used to validate these models, guaranteeing their adaptability and resilience to shifting market and environmental conditions [3].

ML analytics-powered real-time integration of insurer data with weather and satellite data providers expedites the settlement process by automating the transfer of claim amounts straight to farmers' accounts and streamlining claim notification [6], [10]. AI-based crop insurance systems, for example, have been implemented in districts affected by hailstorms, such as Akola and Yavatmal in Maharashtra. Automated tools, including satellite imagery, remote sensing, and mobile-uploaded photographic evidence, are used to verify damage and speed up payments, eliminating the need for manual field inspections and minimizing delays [4].

Additionally, ML plays a key role in preventing and detecting fraud. The integrity of the insurance system is maintained by ML algorithms that identify anomalies and possible fraudulent activity by examining trends in yield

data, claim frequencies, and crop health indices [7], [9]. These capabilities are further enhanced by the combination of GIS and ML, which gives insurers the ability to track crop health, map and monitor agricultural fields, and identify irregularities with previously unheard-of accuracy [7].

IV. USE CASES FROM INDIA

Significant digital advancements have been made in India's crop insurance market, especially with the incorporation of blockchain technology to address enduring issues with efficiency, transparency, and trust. Launched in 2016, the government-backed Pradhan Mantri Fasal Bima Yojana (PMFBY) is a flagship program that aims to expand insurance coverage by utilizing cutting-edge technologies for risk assessment, claim settlement, and operational efficiency [1], [2], [12]. It replaced earlier yield-based insurance programs. Insurers and government organizations are investigating blockchain-based solutions under PMFBY and related programs to improve insurance workflows, lower manual error rates, and guarantee data integrity for all parties involved [1], [2].

The implementation of blockchain-based smart contracts to automate the settlement of crop insurance claims is one noteworthy use case. All participants in this model—banks, farmers, regulators, and insurers—function as nodes on a permissioned blockchain network. Based on reliable data inputs from governmental organizations or weather stations, smart contracts are set up to initiate automatic payouts when predetermined criteria (like yield data or weather thresholds) are satisfied. With this method, manual intervention is eliminated, settlement times are shortened from months to days, and each transaction has an unchangeable audit trail [1], [2], [4]. The ability of insurance regulators, insurers, banks, and meteorological departments to all upload pertinent data (policy details, premium payments, weather events, and claim notifications) straight to the blockchain has been shown by experimental frameworks utilizing platforms such as Hyperledger Fabric. All authorized stakeholders can monitor the status of claims in real time, and the system guarantees transparency and guards against data manipulation. According to pilot results, blockchain networks can process thousands of transactions in a matter of minutes, significantly increasing the speed at which claims settlements can be completed in comparison to conventional systems [4].

Blockchain has also been suggested as a solution to problems like fraud in Indian crop insurance, area disparities, and double insurance. A shared blockchain that incorporates geo-coded digital land records and crop data allows stakeholders to confirm the legitimacy of insurance applications, identify fraudulent claims, and guarantee that only legitimate losses are compensated [1] , [12]. Mobile applications that let farmers submit claim data and get updates—all of which are stored on the blockchain for complete traceability—help to further support this digitization effort [1]. In addition to improving operational effectiveness, these innovations aid in restoring confidence among farmers, who have historically been leery of insurance scheme delays and nonpayment. The incorporation of blockchain technology is anticipated to enhance the precision and dependability of crop insurance procedures in India as digital land records and satellite imagery become more accessible [1], [12].

V. PERFORMANCE EVALUATION

Blockchain-based crop insurance systems' performance evaluation shows notable gains in speed, transparency, and data integrity over conventional procedures. For instance, a prototype implementation of calamity-based crop insurance using Hyperledger Fabric demonstrated that networks enabled by smart contracts could process 10,000 transactions at the insurance company node in less than twenty minutes, with query execution times of less than 47 seconds and ledger update (invoke) times of approximately 61 seconds for the same batch of transactions [4]. Compared to traditional manual claim settlement procedures, which can take more than six months to finish, this represents a significant reduction.

By guaranteeing that all transactions are visible and available to authorized stakeholders, including banks, regulators, insurers, and farmers, blockchain's transparency significantly improves trust and collaboration [4], [7]. Blockchain records' immutability guards against fraud and data manipulation, guaranteeing that vital information like weather data, crop cutting experiment outcomes, and insurance policies are always correct and verifiable [4], [7]. Blockchain lessens paperwork and bureaucratic burdens by automating and simplifying administrative tasks, which increases user satisfaction and trust [7].

VI. RESEARCH GAPS

When compared to conventional models, blockchain-based crop insurance systems have shown notable gains in data integrity, efficiency, and transparency. But before these solutions can be widely implemented and expanded throughout India's varied agricultural landscape, a number of important research gaps need to be filled. It is uncertain how well current implementations will work when they are made available to millions of farmers in different climates because they are frequently only tested in small or simulated settings. Due to their high transaction costs and low throughput, public blockchains like Ethereum may be unaffordable for smallholder farmers, raising serious concerns about scalability [2], [4] ,[5]. Most prototypes still rely on static or manually uploaded data, which limits automation and may

introduce errors or manipulation. This makes it difficult to integrate real-time, trustworthy environmental data, such as weather and soil metrics [5]. Adoption is further hampered by rural farmers' low levels of digital literacy and technology access, as well as the intricacy of blockchain interfaces and digital wallets [1], [2]. Although blockchain technology is safe, endpoints (like wallets and oracles) are susceptible to cyberattacks, and integration is challenging due to a lack of interoperability standards among governments, insurers, and blockchain platforms [2], [5]. Lastly, the regulatory ambiguity surrounding blockchain and cryptocurrency use in insurance makes widespread adoption even more challenging [2]. A comprehensive strategy involving technological innovation, user-friendly design, and reliable data will be needed to close these gaps.

VII. PROPOSED SOLUTION

Crop insurance is starting to take shape with a strong, scalable, and farmer-focused framework that combines blockchain technology with real-time data and machine learning. By using Ethereum smart contracts, this system automates the issuance of policies, the collection of premiums, and the settlement of claims. Verified real-time weather data from satellite-based sources or APIs like the Indian Meteorological Department (IMD) is linked to insurance triggers [3], [5]. A multilingual mobile or web portal that is accessible to even those with low levels of digital literacy is used by farmers to register and manage their policies. Machine learning models evaluate risk profiles and forecast weather impacts, and policy terms are safely stored on-chain, improving the precision and equity of insurance coverage [4]. The system can use fiat-pegged stablecoins or ERC-20 tokens for smooth and effective payouts. The problem of high transaction costs and storage constraints is resolved by moving to more scalable blockchains like Polygon or integrating with decentralized storage solutions like IPFS [3]. Automating claim triggers and preventing fraud depend on the dependable and impenetrable integration of off-chain data, which is ensured by Oracle networks, such as Chainlink, or privacy-preserving decentralized oracles, like the AgriInsureDON framework [5]. This strategy is backed by data from pilot projects in Kenya and India, where blockchain-based insurance platforms have shown notable gains in speed, transparency, and trust. Payouts are processed in minutes rather than months and are automatically triggered by weather events. In order to guarantee that even the smallest farmers receive prompt, equitable, and transparent coverage, the suggested framework seeks to establish a completely decentralized, safe, and easily accessible insurance ecosystem [1], [3], [5].

VIII. CONCLUSION

In conclusion, decentralized ledgers and automated smart contracts that initiate timely payouts based on vali--dated data make blockchain-based crop insurance systems a game-changer for the agriculture industry by greatly enhancing transparency, efficiency, and trust. As evidenced by pilot projects that have seen faster processing, lower premiums, and greater farmer confidence, these systems lower administrative costs, minimize fraud, and make insurance more accessible and affordable for smallholder farmers. A more robust and inclusive agricultural ecosystem can be fostered by ongoing innovation and cooperation among technologists, insurers, and policymakers, even though issues like scalability, real-time data integration, and user accessibility still exist.

REFERENCES

[1] *Javaid, M., Haleem, A., Singh, R.P., Khan, S. and Suman, R., 2021. Blockchain technology applications for Industry 4.0: A literature-based review. Blockchain: Research and Applications, 2(4), p.100027.*

[2] *Yadav, V.S. and Singh, A.R., 2019, July. A systematic literature review of blockchain technology in agriculture. In Proceedings of the international conference on industrial engineering and operations management (pp. 973-981). Southfield, MI, USA: IEOM Society International.*

[3] *Ghosh, R.K., Gupta, S., Singh, V. and Ward, P.S., 2021. Demand for crop insurance in developing countries: new evidence from India. Journal of agricultural economics, 72(1), pp.293-320.*

[4] *Biswal, D. and Bahinipati, C.S., 2022. Why are farmers not insuring crops against risks in India? A Review. Progress in Disaster Science, 15, p.100241.*

[5] *Alam, S., Shuaib, M., Khan, W.Z., Garg, S., Kaddoum, G., Hossain, M.S. and Zikria, Y.B., 2021. Blockchain-based initiatives: current state and challenges. Computer Networks, 198, p.108395.*

[6] *Schwarze, R. and Sushchenko, O., 2022. Climate insurance for agriculture in europe: on the merits of smart contracts and distributed ledger technologies. Journal of Risk and Financial Management, 15(5), p.211.*

[7] *Bolt, J., Berende, M. and Sampao, P., 2019. The opportunities of blockchain technology for crop insurance in Kenya.*

[8] *Bhusal, C.S., 2021. Blockchain technology in agriculture: a case study of blockchain start-up companies. International Journal of Computer Science & Information Technology (IJCSIT) Vol, 13.*

[9] *Vivek T A,M Kashif,M S Nikhil,U Sohini Sahukar, July 2020 IJCRT2007510, Agricultural Insurance on Blockchain.*

[10] *Kamilaris, A., Cole, I.R. and Prenafeta-Boldú, F.X., 2021*. *Blockchain in agriculture. In Food* Technology Disruptions (pp. 247-284). Academic Press..

[11] Omar, I.A., Jayaraman, R., Salah, K., Hasan, H.R., Antony, J., Omar, M.A., 2023. Blockchain-Based Approach for Crop Index Insurance in Agricultural Supply Chain. *IEEE Access*, vol. 11, pp. 118660–118675.

[12] Dayana, D.S. and Kalpana, G., 2023. A Secured Blockchain Based Approach for Decentralized Agri-Insurance for Food Crops Supply Chain. *Journal of Theoretical and Applied Information Technology*, vol. 101, no. 9, pp. 3547–3558.

[13] Manukumari, M.S. and Veena Kumari, B.K., 2024. Evaluating the Efficacy and Acceptance of Blockchain for Crop Insurance in India. *Journal of Emerging Technologies and Innovative Research (JETIR)*, vol. 11, no. 12, pp. h423–h424.

[14] Antony, J., Srinivasan, S., et al., 2024. Blockchain Oracles for Decentralized Agricultural Insurance Using Decentralized Oracle Networks. *Frontiers in Blockchain*, vol. 7.

[15] Climate Finance Lab, *Blockchain Climate Risk Crop Insurance*. Climate Finance Lab, 2019.