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AI-Based Smart Crop Insurance with Blockchain Claim Automation

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ABSTRACT

Weather-driven crop losses expose farmers to serious financial risk, and the claim procedures attached to conventional crop insurance often depend on paper forms, manual checks and long waiting periods. This paper describes a prototype crop insurance platform that pairs machine-learning risk screening with blockchain-backed claim recording. A Random Forest classifier assigns an environmental risk class from rainfall, temperature and soil-moisture readings. A Streamlit application maintains farmer profiles and policy records, confirms that a policy was in force on the reported loss date, and computes an indicative payout from the affected area, the coverage per acre and the percentage of crop lost. Validated claims and later status changes are written as transactions to a Solidity smart contract running on a local Ganache network and accessed through Web3.py. On a prepared dataset of 1,200 records, the classifier reached 98.75% accuracy, 92.50% precision, 100% recall and a 96.10% F1-score. The prototype is an academic implementation; it is not linked to insurer or government systems, and its model results have not been checked against real field data.

Keywords— Crop Insurance, Machine Learning, Random Forest, Blockchain, Smart Contract, Claim Automation, Risk Assessment.

I. INTRODUCTION

Farming remains a primary livelihood for a large share of the Indian population, and its output depends heavily on the weather. Irregular rainfall, temperature swings and shifts in soil moisture can cut yields within a single season and leave small farmers with little financial cushion. Crop insurance is intended to absorb part of that shock by compensating eligible losses.

In practice, the claim process can itself become a burden. A farmer has to assemble documents, the policy has to be matched against the loss event, and the relevant records are often held in separate systems that the farmer cannot inspect. These steps add delay and make it hard to see why a claim sits at a particular stage.

A blockchain is a shared ledger in which confirmed entries are difficult to alter [1]. Platforms that support smart contracts extend the idea by allowing program code to execute on the ledger and to record its outcomes [2]. Several researchers have therefore proposed such platforms as a way to make insurance workflows more transparent and traceable [3]–[5].

This paper presents a working prototype that combines three elements. First, a Random Forest classifier supplies an environmental risk indication. Second, a web application manages farmers, policies and claims and applies date and status checks. Third, a Solidity contract stores claim submissions and status updates as blockchain transactions. The remainder of the paper reviews related work, describes the method and architecture, reports results and limitations, and closes with directions for future work.

II. RELATED WORK

Blockchain-based insurance has been examined from several angles. Omar et al. [3] propose a blockchain approach to crop index insurance within the agricultural supply chain, in which payouts follow an index instead of individually assessed losses. A case study on calamity-based crop insurance [4] looks at how blockchain-enabled Internet of Things (IoT) can support claims after natural calamities. More recent work on blockchain oracles [5] addresses how trusted IoT data can reach decentralized agricultural insurance contracts, a central difficulty because a contract cannot observe the physical world on its own.

These studies indicate that distributed ledgers can improve transparency, traceability and automation. The present work differs in scope. Instead of concentrating on one mechanism, such as index payouts or oracle design, it brings record management, policy validation, a risk classifier and claim recording together in one small application that can be run and tested locally. It also keeps the classifier separate from the claim decision and treats its output only as a supporting indicator. No official insurer or government data are used.

III. PROPOSED METHOD

A. Overview

The system is organized around four functions: record keeping, environmental risk classification, claim validation and estimation, and blockchain recording. Each is described below.

B. Farmer and Policy Records

The application stores each farmer's details together with the policy held, including the policy number, insured crop, coverage amount, validity period and current status. These records are the reference against which every claim is checked.

C. Environmental Risk Classification

The environmental risk class is predicted by a Random Forest, an ensemble method that grows many decision trees on resampled data and combines their outputs by voting [6]. The model takes rainfall, temperature and soil moisture as inputs and was developed with scikit-learn [7] on a dataset of 1,200 records with 12 attributes. Averaging over many trees lowers the tendency of a single tree to overfit, which suits tabular inputs of this kind. The predicted class is displayed as a supporting risk indicator. It is not a verified assessment of crop damage and does not decide any claim.

D. Claim Capture and Validation

When a farmer reports a loss, the application records the loss date, the cause, the affected area, the percentage of crop lost and a free-text description. A claim moves forward only if the associated policy has an active status and the reported loss date falls inside its validity period.

E. Claim Estimation

For a validated claim, an indicative amount is computed as

$$C_{est} = A \times R \times L / 100 \quad (1)$$

where C_{est} is the estimated claim, A is the affected area in acres, R is the coverage per acre and L is the loss percentage. In practice, final settlement depends on the insurer's rules and the policy terms, so the result should be read as an estimate.

F. Blockchain Recording

Validated claims are sent through Web3.py to a Solidity smart contract deployed on a local Ganache network. Both the submission and later status updates are stored as transactions, and the transaction details are returned to the interface so that the user can see the record. Ganache provides a private test chain, so no real assets are involved.

IV. SYSTEM ARCHITECTURE

Fig. 1 shows the overall structure. The Streamlit interface passes farmer, policy and claim details to the application layer. This layer checks policy dates and status, calculates the estimate, and reads and writes the comma-separated values (CSV) files that hold farmer, policy and claim records. Environmental readings are sent to the Random Forest model, whose output returns to the application layer. Claims that pass validation are forwarded to the blockchain layer, and the resulting transaction information is displayed in the interface.

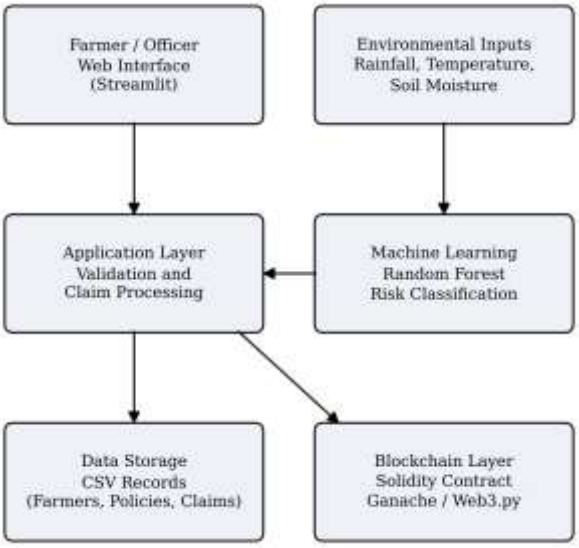


Fig. 1. System architecture of the proposed smart crop insurance application.

Fig. 2 summarizes the claim workflow. A claim that fails the policy check is rejected, and only validated claims are estimated and submitted to the smart contract.

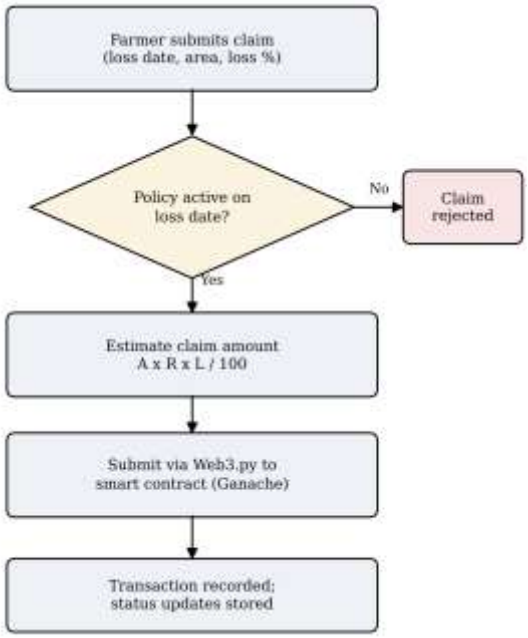


Fig. 2. Claim processing workflow.

V. IMPLEMENTATION AND RESULTS

A. Implementation Environment

The prototype was written in Python. Streamlit supplies the interface, Pandas handles the tabular records, scikit-learn trains the classifier, and Solidity, Web3.py and Ganache form the blockchain layer.

B. Model Evaluation

The classifier was developed on a prepared dataset of 1,200 records with 12 attributes. Table I lists the reported metrics.

TABLE I
MODEL EVALUATION RESULTS ON THE PREPARED DATASET

Metric	Result
Accuracy	98.75%
Precision	92.50%
Recall	100%
F1-score	96.10%

The model reached an accuracy of 98.75% and an F1-score of 96.10%. A recall of 100% means that no positive-class case in the evaluation data was missed, while a precision of 92.50% shows that a small share of predicted positives were false alarms. For a screening indicator, missing genuine at-risk cases is usually more costly than raising an extra alert, so this balance is reasonable for a supporting role.

C. Functional Testing

Functional tests covered farmer registration, environmental risk prediction, policy validation, claim calculation, blockchain submission, status updates and the persistence of records. After the application was restarted, the stored records were still available.

D. Limitations

The reported figures come from a prepared dataset and have not been independently validated on real-world field data, so they should not be read as evidence of field performance. The system runs on a local Ganache chain, has no connection to insurer or government databases, and relies on loss details entered by the user without field-level verification.

VI. CONCLUSION AND FUTURE WORK

This paper described a prototype that joins machine-learning risk screening with blockchain-based claim recording for crop insurance. The classifier gives a supporting environmental risk indication, while the application validates policies, estimates claim amounts and keeps centralized records, and the smart contract stores claim submissions and status updates as transactions. Future work includes integration with authorized insurer databases, the use of real-time weather services, field-level verification of crop damage and deployment on a production blockchain.

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