SMART FARMING UTILITY APPLICATION FOR FARMERS

Deepanshu
Dept. of scse
Galgotias university(greater Noida)
India
dv6615386@gmail.com

Sarthak Rathore
Dept. of scse
Galgotias university(greater Noida)
india
sarthakrathore36@gmail.com

Tushar Pawar
Dept. of scse
Galgotias university(greater Noida)
india
tusharpwr07@gmail.com

ABSTRACT- The complexity of a supply chain makes product safety or quality problems very difficult to keep a track of, especially for the basic agriculture food supply chains of daily involvement in people's life. In our hometown, farming is not just an Occupation; it's the foundation of our community's livelihood. However, farmers often face significant challenges, such as fluctuating crop prices and complex financial management. These issues can severely impact their ability to thrive, creating a need for a more effective solution. Our Farmer Utility App is developed to address these problems by providing farmers with a reliable and easy-to-use platform to stay informed about daily crop prices and manage their financial transactions efficiently. The primary problem we aim to solve is the lack of accessible tools for farmers to track their income, debts, and advances, especially those provided by our family-owned business. The app also addresses the broader issue of trust and transparency in financial transactions between farmers and businesses. Existing solutions are either too complex or do not cater to the unique needs of small-scale farmers. Our project fills a critical gap by integrating cloud computing for secure and scalable data storage, Al for predicting crop price trends, and blockchain technology to ensure the security and transparency of all transactions. These technological integrations are designed to empower farmers, helping them make informed decisions while also enhancing the efficiency of our family business operations. The outcomes of this project are important because they directly contribute to the economic stability of farmers in our community. By making financial management more accessible and transparent, we are not only supporting the livelihoods of individual farmers but also fostering a healthier, more sustainable agricultural ecosystem. Addressing these problems is essential for the continued growth and success of both our farmers and our family business.

i. Introduction

Agriculture plays a vital role in the economy and sustenance of many communities, particularly in rural areas where farming is not only a profession but a way of life. However, small-scale farmers often face significant challenges that threaten their economic stability. These include fluctuating crop prices, unpredictable market conditions, and the lack of accessible financial management tools. Such issues not only hinder individual farmers' ability to thrive but also disrupt the broader agricultural supply chain, which relies on the consistent production and distribution of essential goods. One of the fundamental problems in agricultural supply chains is the lack of transparency and trust in financial transactions. Farmers typically engage in informal financial practices, making it difficult to keep accurate records of income, expenses, loans, and advances. This lack of financial literacy and proper management tools can lead to an inability to make informed decisions, resulting in increased debt, financial instability, and missed opportunities for growth. Additionally, these solutions rarely incorporate advanced technologies that could transform financial management practices, such as artificial intelligence (AI), cloud computing, and blockchain. While AI has been used for predictive analytics and cloud computing for scalable data storage, the integration of blockchain presents a new frontier for securing financial transactions and enhancing data transparency. This research paper aims to present a novel solution in the form of a Blockchain-Integrated Farmer Utility Application, which leverages cloud computing, AI, and blockchain technology to address the aforementioned challenges. The proposed system is designed to empower farmers by providing a reliable platform for financial management and crop price tracking, ensuring transparency and security in all transactions. By catering specifically to small scale farmers and incorporating state-of-the-art technologies, the app seeks to fill a critical gap in the current agricultural technology landscape.

ii. Literature Review

Agriculture continues to serve as a cornerstone of India's economy, providing livelihoods to over half the population and contributing significantly to GDP. Despite its importance, small-scale farmers in India often struggle with key challenges, including fluctuating crop prices, limited access to institutional financial support, and a lack of robust tools for financial planning and decision-making.

The advent of digital technologies has opened new opportunities in agricultural support systems. However, the adoption of **integrated digital solutions** specifically designed for small and marginal farmers remains insufficient. Most existing tools are either fragmented or cater predominantly to large-scale agribusinesses, leaving a substantial portion of the farming community underserved.

Recent advancements in **artificial intelligence** have shown considerable promise in addressing critical gaps in Indian agriculture. AI-powered models have been applied in yield prediction, disease identification, and weather forecasting. For example, initiatives under the Government of India's "AI for All" program have begun promoting the use of AI in crop management and production optimization. Studies such as Kumar et al. (2020) demonstrated AI's utility in predicting market trends for staple crops like wheat and rice, aiding farmers in choosing favorable selling periods. However, there remains a noticeable deficiency in the application of AI for financial planning, including profit forecasting and risk analysis, particularly for small-scale farmers.

In parallel, cloud computing is emerging as a pivotal technology in making agricultural data accessible, scalable, and cost-effective. The Indian government's *Digital India* initiative recognizes the transformative potential of cloud-based platforms to deliver real-time data and digital services in rural regions. Cloud infrastructure facilitates seamless integration of diverse data sources—such as historical crop prices, weather patterns, and regional market trends—thus creating a backbone for intelligent agricultural applications.

Despite these technological advancements, most current systems are isolated in function, focusing either on weather, crop disease, or market data, without offering a holistic view of farm economics. The need for an integrated solution that combines real-time data access, predictive insights, and financial analytics is evident.

The **Farmer Utility Application** seeks to fill this critical gap. Unlike conventional tools, it consolidates multiple functions into a unified, easyto-use platform. It leverages AI for predicting profit margins based on historical market data and sale timing, and cloud computing for storing and accessing large datasets, including crop prices, weather conditions, and government schemes. By delivering tailored financial insights and decision support, the app empowers farmers to strategically plan their crop sales and improve economic outcomes.

iii. Literature Survey

The **Farmer Utility Application** is designed to empower farmers through a feature-rich platform that enhances their financial management capabilities and provides real-time market information. The system is built on a robust technological foundation that ensures security, scalability, and ease of use. Several government and private sector initiatives have launched apps such as *Kisan Suvidha*, *IFFCO Kisan*, and *AgriApp*. These applications provide important services like weather forecasts, market prices, and farming tips. However, research by Sharma et al. (2018) indicates that most existing apps offer fragmented solutions, often focusing on one or two services rather than providing an integrated platform. Farmers often need to switch between multiple apps to fulfill their various needs.

How this farmer utility application is different from other farmer application: The Farmer Utility Application stands out from other farmer apps by offering a truly all-in-one solution tailored to the real needs of Indian farmers. Unlike many apps that focus only on specific services like crop information, mandi prices, or weather updates, this application combines all essential features into a single platform. It provides personalized crop advisory, real-time market prices, weather forecasts, government scheme updates, financial support tools like loan eligibility checkers and subsidy calculators.

Benefits: The benefits of the Farmer Utility Application are numerous: it saves time by eliminating the need to juggle between multiple apps, boosts income by giving farmers access to real-time mandi rates, improves farming techniques through scientific advice, and opens doors to loans and subsidies easily. The personalized notifications ensure that farmers receive information that is specific to their land, crops, and seasons, making farming smarter and more profitable. Moreover, the app encourages sustainable farming by promoting eco-friendly practices and organic farming options.

Anticipated Benefits: Economic Empowerment Farmers will have access to vital financial management tools, leading to improved economic stability and growth. Increased Transparency Blockchain integration will foster trust in transactions, reducing fraud and enhancing the reliability of the financial ecosystem.

Community Support By facilitating communication and support among farmers, the application will

strengthen community ties and collaborative efforts. proposed Farmer Utility App integrates cloud computing, AI, and blockchain to provide tools for financial management, crop price tracking, and secure transaction handling. Key components include user-friendly interface design, AI-based price prediction, and blockchain-based transaction transparency.

Difference in Price Prediction Approach: several government applications such as *Kisan Suvidha*, *Agri Market*, and *eNAM* provide access to current mandi prices, they primarily serve as real-time information providers and do not offer predictive insights about future market trends. These apps are limited to displaying Today's or yesterday's prices, leaving farmers without the ability to plan their selling strategies ahead of time. While the Farmer Utility Application incorporates an advanced Price Prediction System powered by Machine Learning models such as ARIMA, Random Forest, and LSTM networks. This enables the application to forecast future crop prices over a span of 7 to 30 days based on historical data, weather patterns, government policy changes, and market demand-supply dynamics. It personalizes recommendations for each farmer based on their crop type, location, and expected harvest period. Farmers receive smart notifications suggesting the best week to sell, estimated peak pricing windows, and advice on whether to hold or immediately sell their produce.

Implementation requirements: Planning and requirements gathering: Finalize the detailed requirements based on feedback from potential users, ensuring that the app meets their specific needs.

Design: Create wireframes and prototypes based on user feedback to ensure usability and accessibility across different devices.

Development: Establish a development timeline and milestones for building the application, prioritizing critical features for initial launch.

Software s/w: The Farmer Utility Application leverages modern technologies to provide an intuitive, scalable, and efficient platform that empowers farmers with critical tools and information. The software stack incorporates the MERN architecture (MongoDB, Express.js, React.js, Node.js) for the backend and integrates Flutter for mobile development, ensuring both performance and accessibility.

Hardware h/w: Web-based admin portal built with React.js, the styling ensures that the application is not only functional but also visually appealing and easy to navigate, especially for farmers who may have limited experience with digital platforms.

Maintenance and Updates: Regularly update the app based on user feedback and technological advancements, ensuring ongoing relevance and improvement.

iv. Methodology

Model Selection and Training: For this use case, a Random Forest Regressor was chosen. This ensemble learning model builds multiple decision trees and aggregates their outcomes to produce accurate, robust predictions. It is particularly effective in capturing non-linear relationships between variables such as crop type, sale timing, and market behaviour. The dataset was split into training and test subsets to evaluate the model's generalizability.

Model Evaluation: The trained model was evaluated using standard regression performance metrics:

Mean Absolute Error (MAE) was employed to measure average prediction errors.

Mean Squared Error (MSE) was used to penalize larger deviations and ensure stability.

R-squared (R^2) score indicated how well the model could explain variations in the actual profit data. These metrics ensured that the model produced reliable, actionable insights for farmers.

Performance Visualization: To validate model performance, key visual tools were utilized. A scatter plot comparing actual vs. predicted profit margins revealed how closely the model's output matched real-world outcomes. A clear diagonal trend in the plot indicated accurate predictions. In addition, learning curves were analysed to monitor training and validation loss, ensuring that the model was not overfitting or underperforming. These insights were critical in refining the model and ensuring its practicality for everyday agricultural use.

Model Performance: The Profit Margin Calculator Model was developed to help farmers choose the best time to sell their crops by predicting how much

profit they can make on different sale dates. To do this, we used a Random Forest Regression model, which works well with complex and changing data like crop prices.

Data Used: The model was trained using historical data, including crop prices from different markets (mandis), the type of crop, and the sale date. In some cases, we also included weather information and regional market conditions to improve accuracy. The goal was to predict how much profit a farmer could make by selling the same crop on different dates.

Training the Model: We split the data into two parts: 80% for training the model and 20% for testing it. The model learned patterns from the training data and was then tested on the remaining data to check its accuracy.

How We Measured Performance: To see how well the model works, we used three key measurements:

Mean Absolute Error (MAE): Shows the average difference between the predicted and actual profit margins. The smaller this number, the better the predictions.

Mean Squared Error (MSE): This gives more weight to bigger mistakes. It helps us understand if the model is making large errors.

R-squared (R^2): This tells us how much of the profit variation the model can explain. A higher percentage means better performance.

Graphs and Visuals: We created two main graphs to understand the model's behaviour:

Prediction vs. Actual Graph: This shows how close the predicted profit margins were to the real ones. If the points are close to a straight line.

Learning Curve: This graph compares training and testing performance over time. If both curves stay close together, it means the model is learning well without overfitting.

v. Features

Real-Time Government Scheme Integration

Unlike most apps, which might offer static lists of government schemes, Farmer Utility integrates real-time data from data.gov.in to provide farmers with the most up-to-date information on schemes, eligibility, and application processes.

Data-Driven Decision Making

The app offers farmers access to real-time market prices through a live feed, helping them make informed decisions about when and where to sell crops—a feature not commonly available in many agricultural apps.

Weather-Specific Tailored Forecasts

While other apps might offer generic weather data, Farmer Utility provides location-specific forecasts with detailed insights into hourly weather and a 3day forecast, enabling farmers to plan their activities with precision.

Modern UI/UX Design with Framer Motion Animations

Many agricultural apps often have a basic and outdated design, while Farmer Utility incorporates modern UI/UX principles with smooth animations (via Framer Motion), making it visually appealing and intuitive for users, even those with limited tech knowledge.

Open Data Collaboration

The use of open data APIs like OpenWeather and data.gov.in sets Farmer Utility apart by promoting transparency and collaboration with government sources, ensuring data accuracy and trustworthiness.

User-Centric Features for All Farm Sizes

The app accommodates both small and large-scale farmers by providing scalable features. Unlike many apps that focus solely on one demographic, Farmer Utility offers solutions that cater to a wide range of farmer needs.

Ease of Use with Minimal Digital Literacy Required

Farmer Utility focuses on simple navigation, with features like searchable weather conditions and price fetching, enabling farmers with limited technical expertise to easily use the app, which is a step ahead of many complex apps in the market.

Financial Management

Income and Expense Tracking: Incorporate tools that allow farmers to log their income, expenses, loans, and advances easily. **Budgeting Tools:** Provide features that help users set budgets and track their financial goals, promoting better financial literacy.

Community Engagement

Peer Support: Include forums or community features where farmers can share experiences, ask questions, and support each other. **Education and Resources:** Offer educational materials on financial literacy, technology

usage, and agricultural practices to empower users.

- Training a model within the Farmer Utility Application involves multiple components, especially when integrating machine learning

techniques to provide predictive analytics for crop prices and financial decision-making. The following section outlines a structured approach for model training and discusses visualization methods to effectively illustrate the model's performance.

Government Scheme Verification

Secure and Transparent Scheme Registration: Blockchain can be used to store information about government schemes and their eligibility criteria. By recording this data on the blockchain, farmers can have guaranteed access to authentic and tamper-proof records of schemes, ensuring that they are applying for the correct benefits without fear of misinformation.

vi. Limitations and Future Work

While the model demonstrates considerable promise, several limitations were identified:

Data Availability: The accuracy of predictions is highly dependent on the availability and quality of data. Gaps in historical price data or unreliable weather information can negatively impact model performance.

Scalability: As the number of users increases, ensuring the app's performance and security remains a challenge

User Adoption: Further education and training may be required to ensure that farmers fully utilize the app's features. Engaging with the farming community through workshops or training sessions could enhance adoption rates.

Future work will focus on:

1. Crop Price Transparency & Integrity

Blockchain for Pricing Data: You can leverage blockchain to store crop prices from various markets (mandis) in a decentralized ledger. This ensures that prices are immutable, transparent, and accessible to all users without any central authority's interference. This can help reduce misinformation and corruption in price reporting, giving farmers confidence that the data they see is accurate and reliable.

2. Smart Contracts for Transactions: When a farmer decides to sell their crops, smart contracts can be employed to ensure that the agreed-upon price is paid by the buyer. The smart contract can automatically execute the transaction and release payment once both parties have met their obligations, reducing trust issues and delays.

3. Decentralized Verification of Beneficiaries: The blockchain can also be used for verifying farmers who are eligible for specific schemes. Through smart contracts, once eligibility criteria are met, blockchain can help automate the approval and registration processes for various schemes, minimizing bureaucracy and reducing fraud.

4. Model Training for Profit Margin Prediction

In the Farmer Utility Application, a core feature is a machine learning model developed to predict the profit margin a farmer could gain based on the timing of crop sales. This predictive model is designed to help small-scale farmers make data driven decisions about when to sell their crops, enabling them to maximize returns by leveraging historical price trends and current market behaviour. By analysing mandi price data sourced primarily from Agmarknet(Agricultural Marketing Information Network) and factoring in variables such as crop type, market location, and date of sale, the system estimates profit differences for different sale timings. This allows farmers to explore alternative sale dates and make informed decisions regarding the most financially beneficial time to market their produce.

Objectives: The primary goal of this model is to support farmers in forecasting the financial outcomes of selling a crop on specific dates. It is designed to calculate the predicted profit margin differences between potential sale dates by drawing insights from past market behaviour and seasonal pricing trends.

Data collection: To train the model effectively, a robust dataset was compiled. This included historical crop price data retrieved from the Agmarknet API, capturing price trends across various regions and times. Important features collected were:

Crop type, influencing pricing behavior due to seasonal demand.

Market location, as mandi prices vary across regions.

Sale date, to observe temporal pricing fluctuations

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Data Preprocessing: The data underwent several preprocessing steps to ensure quality and model readiness. Missing values in the dataset were handled using suitable imputation techniques. Outliers in crop prices were identified and managed to prevent skewed predictions. Numerical variables such as prices and dates were normalized for consistent scaling, which improved the efficiency and accuracy of model learning.

vii. Conclusion

The Farmer Utility Application represents a critical advancement in agricultural technology, providing small-scale farmers with the tools they need to navigate the complexities of financial management and crop pricing. By leveraging cloud computing, AI, and blockchain, the application not only addresses existing gaps in the agricultural landscape but also fosters a more sustainable and empowered farming community. Continued development and refinement of the model will be essential for maximizing its impact and supporting the economic stability of farmers in our region. The **Farmer Utility Application** not only addresses the immediate needs of farmers in price forecasting but also serves as a scalable model for integrating technology in the agricultural sector, paving the way for a more sustainable, profitable, and informed farming community.

The integration of government schemes and subsidy information further enhances the value of the application. Many farmers are unaware of the various programs and subsidies offered by the government that could potentially improve their financial situation. The Farmer Utility Application simplifies this process by directly notifying users about available schemes, enabling them to take full advantage of government support.

viii. References

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