

SmartCrop Advisor: AI-Based Crop Prediction and Contract Farming Platform

Narendra Kolte¹, Pranav Pawar², Mohit Suradkar³, Sahil Wadafale⁴, Prof. S. H. Thengil

¹Department of Information Technology, Sinhgad College of Engineering, Pune- 41

²Department of Information Technology, Sinhgad College of Engineering, Pune- 41

³Department of Information Technology, Sinhgad College of Engineering, Pune- 41

⁴Department of Information Technology, Sinhgad College of Engineering, Pune- 41

Abstract : The Smart Farming Assistant is an Artificial Intelligence (AI)-driven platform designed to empower small and marginal farmers by offering intelligent crop advisory, contract farming opportunities, and real-time farm management support. The system utilizes soil testing reports and AI-based analysis, handled by the **Crop Prediction Module**, to recommend the most suitable crops and generate personalized farm schedules covering all stages from sowing to harvesting. A crucial element is the **Contract Farming Module**, which enables farmers to view and apply for contracts published by agro-based companies, ensuring assured markets and fair pricing. The platform also integrates the **Government Scheme Information Module**, real-time market intelligence, and provides an offline mode for users in low-connectivity rural areas. By focusing on digital intelligence, market access, and structured financial mechanisms, the Smart Farming Assistant bridges the gap between traditional farming and modern digital agriculture, enhancing profitability, efficiency, and sustainability for farmers

Key Words: AI, Contract Farming, Crop Advisory, Smart Farming, Small Farmers; Sustainability; Broiler Chicken; Agent-based simulation; Agricultural supply chain; Household income; Rice cultivation; High ecological value standard.

1. INTRODUCTION

Agriculture is one of the most important sectors contributing to the economic development of many countries and serves as the primary source of livelihood for a large population. Farmers often face challenges in selecting suitable crops due to variations in soil conditions, climate changes, rainfall patterns, and market uncertainties. Improper crop selection can lead to reduced productivity, financial losses, and inefficient utilization of agricultural resources.

With the advancement of Artificial Intelligence (AI) and Machine Learning (ML), data-driven solutions have emerged as effective tools for improving agricultural decision-making. Machine learning algorithms can analyze agricultural parameters such as soil nutrients, temperature, humidity, pH value, and rainfall to predict the most suitable crops for cultivation. Such intelligent systems help farmers make informed decisions and improve overall farm productivity.

In addition to crop selection challenges, farmers often encounter difficulties in accessing reliable markets and obtaining fair prices for their produce. Contract farming has emerged as a promising approach that establishes agreements between farmers and companies, ensuring market access,

price stability, and reduced financial risk. However, the lack of a centralized digital platform often limits effective communication and coordination between stakeholders.

To address these challenges, this paper proposes **SmartCrop Advisor: AI-Based Crop Prediction and Contract Farming Platform**, an integrated solution that combines machine learning-based crop prediction with a contract farming management system. The platform enables farmers to receive crop recommendations based on environmental and soil conditions while also connecting them with companies offering contract farming opportunities.

The proposed system is developed using modern web technologies including React.js, Node.js, Express.js, MongoDB, and Python-based machine learning models. By integrating intelligent crop prediction and contract farming services into a single platform, SmartCrop Advisor aims to improve agricultural productivity, support sustainable farming practices, and enhance the economic well-being of farmers.

2. LITERATURE SURVEY

The application of Artificial Intelligence (AI) and Machine Learning (ML) in agriculture has gained significant attention in recent years. Researchers have developed various intelligent systems to assist farmers in crop selection, yield prediction, disease detection, and resource management. These technologies help improve agricultural productivity by enabling data-driven decision-making and reducing uncertainty in farming operations.

Several studies have explored the use of machine learning algorithms such as Random Forest, Decision Tree, Support Vector Machine (SVM), and Artificial Neural Networks for crop prediction. These models analyze agricultural parameters including soil nutrients, temperature, humidity, rainfall, and pH levels to recommend suitable crops for cultivation. Among these techniques, Random Forest has demonstrated high prediction accuracy and robustness due to its ensemble learning approach.

Contract farming has also emerged as an important agricultural practice that establishes agreements between farmers and companies. Research studies indicate that contract farming helps farmers secure market access, reduce price fluctuations, and receive technical support from agribusiness organizations. It also enables companies to ensure a stable supply of agricultural produce while maintaining quality standards. However, traditional contract farming processes often suffer from limited transparency, inefficient communication, and lack of digital management systems.

Recent advancements in web technologies have enabled the development of digital agriculture platforms that connect farmers with various stakeholders. These platforms provide

services such as weather forecasting, market price information, crop advisory, and farm management. However, many existing systems focus on a single functionality and do not provide an integrated solution combining crop prediction and contract farming services.

The review of existing literature reveals a gap in developing a unified platform that offers both intelligent crop recommendation and contract farming management. The proposed SmartCrop Advisor system addresses this limitation by integrating machine learning-based crop prediction with a contract farming platform. This approach enables farmers to make informed cultivation decisions while simultaneously accessing reliable market opportunities through a single digital ecosystem.

Trust, Breach, and Risk

Trust plays a crucial role in agricultural and contract farming systems. Farmers and companies must rely on each other to fulfill contractual obligations, maintain product quality, and ensure timely payments. However, breaches of contract, market uncertainties, and information asymmetry often create risks for both parties. Research studies indicate that transparent communication, digital record management, and monitoring systems can significantly reduce disputes and improve trust among stakeholders. Integrating digital technologies into contract farming platforms helps enhance accountability, minimize risks, and strengthen long-term business relationships.

Technology Adoption and Sustainability

The adoption of modern technologies such as Artificial Intelligence, Machine Learning, Internet of Things (IoT), and digital farming platforms has transformed the agricultural sector. These technologies enable farmers to make informed decisions regarding crop selection, resource utilization, and market opportunities. Sustainable agriculture requires efficient use of natural resources while maintaining long-term productivity and environmental balance. Studies have shown that technology-driven agricultural solutions improve crop yield, reduce resource wastage, and support sustainable farming practices. Therefore, integrating intelligent technologies with agricultural management systems can contribute significantly to sustainable agricultural development and farmer welfare.

3. SYSTEM ARCHITECTURE AND DESIGN

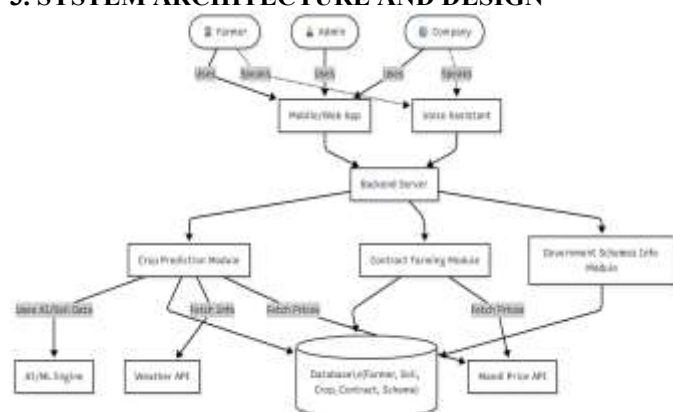


Figure 3.1: System Architecture Diagram

The proposed **SmartCrop Advisor: AI-Based Crop Prediction and Contract Farming Platform** is designed

using a multi-tier architecture that ensures scalability, reliability, and efficient data management. The system consists of four major layers: the Presentation Layer, Application Layer, Machine Learning Layer, and Database Layer. Each layer is responsible for specific functionalities and collectively enables seamless interaction among farmers, companies, and administrators.

The **Presentation Layer** is developed using React.js and provides a responsive and user-friendly interface. It serves as the interaction point for farmers, companies, and administrators. Farmers can access crop prediction services, weather information, and contract farming opportunities, while companies can create and manage contracts. Administrators are provided with tools for user management, company verification, and system monitoring.

The **Application Layer** is implemented using Node.js and Express.js. This layer handles business logic, user authentication, authorization, request processing, and communication between the frontend and backend services. Secure login and role-based access control mechanisms ensure that users can access only the functionalities relevant to their roles.

The **Machine Learning Layer** is developed using Python and Scikit-learn. This component processes agricultural data such as Nitrogen (N), Phosphorus (P), Potassium (K), temperature, humidity, pH value, and rainfall. The trained Random Forest model analyzes these parameters and predicts the most suitable crop for cultivation. The prediction results are returned to the application layer through REST APIs.

The **Database Layer** uses MongoDB to store user information, crop datasets, contract farming records, company details, and system logs. The database ensures efficient data retrieval and management while supporting future scalability requirements.

The contract farming module acts as a bridge between farmers and companies. Companies can publish farming contracts with crop requirements, pricing details, and terms of agreement. Farmers can browse available contracts and apply directly through the platform. This digital process improves transparency, reduces communication barriers, and enhances market accessibility. From a design perspective, the system follows a modular approach that allows independent development and maintenance of individual components. The architecture supports future enhancements such as real-time weather forecasting, crop disease detection, fertilizer recommendation, and mobile application integration without significant structural modifications.

Overall, the proposed architecture provides a secure, scalable, and intelligent platform that combines machine learning-based crop prediction with contract farming services, enabling data-driven agricultural decision-making and improved farmer-company collaboration.

4. METHODOLOGY

The proposed **SmartCrop Advisor: AI-Based Crop Prediction and Contract Farming Platform** is developed to provide farmers with intelligent crop recommendations and

direct access to contract farming opportunities through a single digital platform. The methodology adopted in this work integrates machine learning techniques, web technologies, and database management systems to create an efficient decision-support system for modern agriculture. The system is designed to assist farmers in selecting suitable crops based on environmental and soil conditions while simultaneously connecting them with companies seeking agricultural produce through contract farming agreements.

The first stage of the methodology involves the collection of agricultural data from publicly available and verified datasets. The dataset consists of several important parameters that directly influence crop growth and productivity, including Nitrogen (N), Phosphorus (P), Potassium (K), temperature, humidity, pH value, and rainfall. These parameters are widely recognized as critical factors in determining the suitability of crops for a particular agricultural environment. The collected dataset serves as the foundation for training and evaluating the machine learning model used in the crop prediction process.

After data collection, the dataset undergoes a preprocessing phase to improve its quality and reliability. Raw agricultural datasets often contain missing values, duplicate records, inconsistencies, or irrelevant information that may negatively affect model performance. Therefore, data cleaning techniques are applied to remove errors and ensure consistency. The preprocessing stage also includes data validation and feature selection, which help identify the most relevant attributes for crop prediction. By preparing the data carefully, the system improves the accuracy and reliability of the generated recommendations.

Once the dataset is prepared, the machine learning model is developed and trained. The Random Forest algorithm is selected for crop prediction because of its high classification accuracy, robustness, and ability to handle large agricultural datasets effectively. Random Forest works by constructing multiple decision trees and combining their outputs to generate a final prediction. This ensemble learning approach reduces overfitting and improves predictive performance. During the training process, the dataset is divided into training and testing subsets. The training data is used to build the model, while the testing data is used to evaluate its accuracy and effectiveness. The trained model is then saved and integrated into the application for real-time crop prediction.

The crop prediction process begins when a farmer enters agricultural parameters through the user interface. The system collects information such as soil nutrient values, temperature, humidity, rainfall, and pH level. These inputs are validated and forwarded to the machine learning prediction module. The trained Random Forest model analyzes the input parameters and predicts the most suitable crop that can be cultivated under the given environmental conditions. The prediction result is then displayed to the farmer through the application interface. This functionality helps farmers make informed cultivation decisions and reduces the risk associated with inappropriate crop selection.

In addition to crop prediction, the system incorporates a contract farming module that bridges the gap between farmers and agricultural companies. The contract farming component allows registered companies to publish farming contracts that

specify crop requirements, pricing details, quality standards, and contract duration. Farmers can browse available contracts, review their details, and apply for opportunities that match their agricultural capabilities. This digital approach simplifies the contract farming process and provides greater transparency, efficiency, and accessibility for all stakeholders involved.



Figure 5.1 Farmer Dashboard

Farmer dashboard provides quick access to crop prediction, contract farming opportunities, weather updates, mandi prices, and farm analytics.

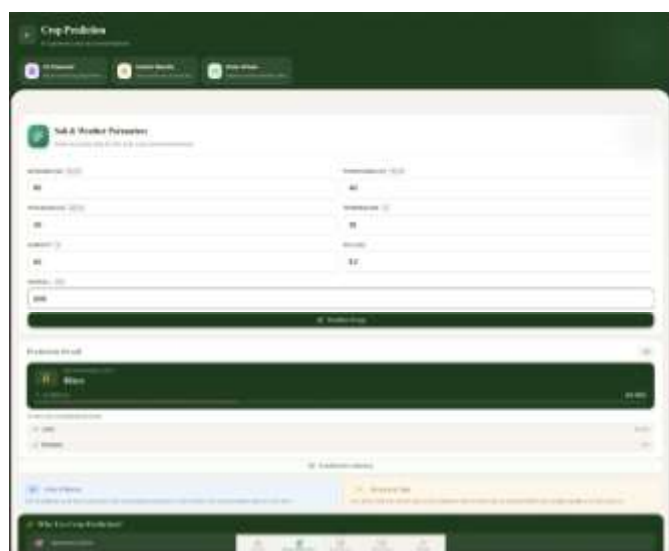


Figure 5.2 Crop Prediction Output

The Crop Prediction page allows farmers to enter soil parameters such as Nitrogen, Phosphorus, Potassium, temperature, humidity, and rainfall. recommends the most suitable crop for cultivation.



Figure 5.3 Contract Farming Page

The Contract Page displays available contract farming opportunities offered by companies. Farmers can view contract details, eligibility criteria, and apply directly through the platform. This feature helps improve market connectivity and income stability.



Figure 5.4 Admin Dashboard

The Admin Management Page includes modules for Company Verification, User Management, and Contract Management. It enables administrators to approve registrations, manage user accounts, and oversee contract-related activities to maintain platform integrity.

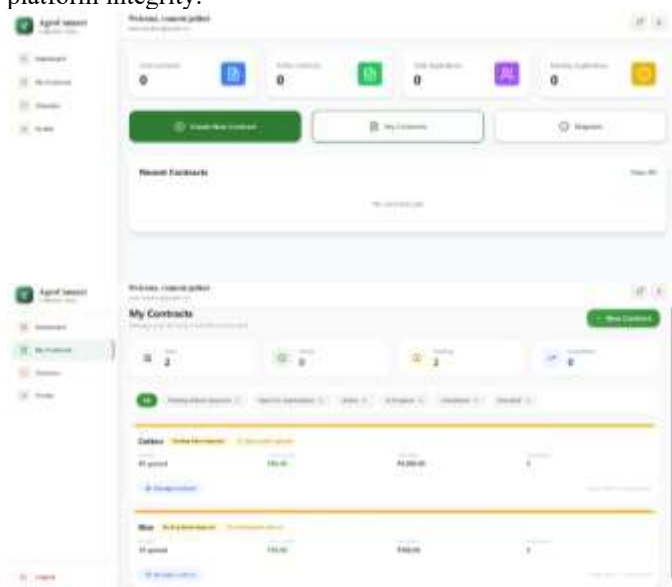


Figure 5.5 Company Dashboard

The Company Dashboard enables companies to manage farming contracts and interact with registered farmers. It

provides tools for posting new contracts, reviewing applications, and monitoring ongoing agreements efficiently.

The platform follows a role-based architecture consisting of three major user categories: Farmers, Companies, and Administrators. Farmers can access crop prediction services, explore contract opportunities, and manage their profiles. Companies can create and manage contracts, review farmer applications, and monitor contractual activities. Administrators are responsible for verifying company registrations, managing users, overseeing contract activities, and maintaining the overall integrity of the system. Role-based authentication and authorization mechanisms ensure that users can only access functionalities relevant to their responsibilities.

The frontend of the application is developed using React.js, HTML5, CSS3, and Tailwind CSS. These technologies provide a responsive and interactive user interface that can be accessed through modern web browsers. The backend is implemented using Node.js and Express.js, which handle user requests, authentication, business logic, and communication with the machine learning module. MongoDB serves as the primary database management system, storing user information, crop prediction records, contract details, and administrative data. The machine learning module is developed using Python and Scikit-learn and is integrated with the backend through RESTful APIs.

To ensure smooth communication among different system components, the application follows a client-server architecture. The frontend sends requests to the backend server whenever users interact with the system. The backend processes these requests, retrieves or updates information in the database, communicates with the machine learning module when necessary, and returns the appropriate response to the user. This architecture provides scalability, maintainability, and efficient resource utilization.

Security and data integrity are also important considerations in the proposed methodology. User authentication mechanisms are implemented to protect sensitive information and prevent unauthorized access. Company verification procedures are included to ensure that only legitimate organizations can participate in contract farming activities. Furthermore, the system maintains records of user interactions and contract transactions to support transparency and accountability within the platform.

The overall workflow of the SmartCrop Advisor system begins with user registration and authentication. Farmers can then access the crop prediction module by entering agricultural parameters and receiving crop recommendations. Simultaneously, companies can publish contract opportunities, which become available to eligible farmers through the platform. Administrators continuously monitor platform activities, manage users, and ensure the smooth operation of all services. The integration of crop prediction and contract farming into a unified platform enables data-driven agricultural decision-making and improves collaboration among stakeholders.

The proposed methodology provides an effective solution for addressing agricultural challenges related to crop selection and market accessibility. By leveraging machine learning

algorithms, modern web technologies, and digital contract farming mechanisms, the system contributes to improved productivity, reduced farming risks, enhanced transparency, and sustainable agricultural development. The methodology serves as the foundation for implementing an intelligent agricultural ecosystem that benefits farmers, companies, and administrators alike.

6. RESULTS AND EVALUATION

The SmartCrop Advisor system was successfully developed and tested to evaluate its effectiveness in crop prediction and contract farming management. The platform integrates machine learning techniques with a web-based application to provide intelligent agricultural recommendations and improve communication between farmers and companies. The evaluation of the system was carried out by testing its major functional modules, including user authentication, crop prediction, contract farming, company management, and administrative operations.

The crop prediction module serves as the core component of the system. Farmers are required to enter agricultural parameters such as Nitrogen (N), Phosphorus (P), Potassium (K), temperature, humidity, pH value, and rainfall. These inputs are processed by the trained Random Forest machine learning model, which analyzes the data and predicts the most suitable crop for cultivation. The generated recommendations assist farmers in selecting crops that are compatible with their environmental and soil conditions, thereby improving productivity and reducing the risk of crop failure.

The user authentication module was tested to verify the registration and login functionalities for different user roles. The system successfully authenticated Farmers, Companies, and Administrators using role-based access control mechanisms. Authorized users were able to access their respective dashboards and functionalities without any security issues. The login process ensured secure access to sensitive information and prevented unauthorized system usage.

The Farmer Dashboard was evaluated for usability and accessibility. Farmers were able to view crop prediction services, explore contract farming opportunities, and manage their profile information efficiently. The dashboard provided a user-friendly interface that simplified navigation and reduced the complexity of accessing agricultural services. The system responded effectively to user inputs and displayed prediction results within a short period.

The contract farming module was tested by creating multiple farming contracts through company accounts and submitting applications through farmer accounts. Companies were able to publish contract details such as crop requirements, pricing information, contract duration, and terms of agreement. Farmers successfully viewed available contracts and applied for opportunities that matched their agricultural capabilities. The module demonstrated smooth interaction between stakeholders and improved transparency throughout the contract farming process.

The Company Dashboard was evaluated to ensure efficient contract management. Companies were able to create new contracts, monitor farmer applications, and manage existing

agreements through a centralized interface. The dashboard streamlined contract administration and reduced the effort required for manual coordination between companies and farmers.

The administrative module was tested to evaluate its ability to manage platform activities. Administrators successfully verified company registrations, monitored user activities, and managed contracts within the system. The Company Verification module ensured that only authorized organizations could participate in contract farming activities. The User Management and Contract Management modules provided complete control over platform operations and contributed to maintaining system integrity and security.

The performance of the crop prediction model was evaluated using testing data that was not included during the training phase. The Random Forest algorithm demonstrated reliable prediction performance and generated accurate crop recommendations based on the provided agricultural parameters. The model effectively handled different combinations of input values and consistently produced meaningful results. This confirms the suitability of machine learning techniques for agricultural decision support systems. The overall system performance was assessed in terms of functionality, responsiveness, usability, and reliability. The web application operated smoothly across modern browsers and provided consistent results during testing. Database operations such as user registration, contract creation, data retrieval, and prediction history management were executed efficiently through MongoDB. The integration between the frontend, backend, and machine learning modules functioned without significant delays or errors.

The output screens generated during testing further validate the successful implementation of the system. Screens such as the Login Page, Farmer Dashboard, Crop Prediction Page, Contract Farming Page, Company Dashboard, Admin Dashboard, Company Verification Page, User Management Page, and Contract Management Page demonstrate the practical functionality of the proposed solution. These outputs confirm that the system successfully achieves its objectives of intelligent crop prediction and digital contract farming management.

The evaluation results indicate that SmartCrop Advisor provides an effective and user-friendly platform for modern agricultural support. By combining machine learning-based crop prediction with contract farming services, the system enhances agricultural decision-making, improves market accessibility, and promotes sustainable farming practices. The successful implementation and testing of all modules demonstrate the feasibility and practical applicability of the proposed solution in real-world agricultural environments.

7. CONCLUSION

Agriculture continues to play a vital role in economic growth and food security, making it essential to adopt modern technologies that support farmers in making informed decisions. The proposed **SmartCrop Advisor: AI-Based Crop Prediction and Contract Farming Platform** successfully integrates machine learning techniques with web-

based technologies to address two major agricultural challenges: crop selection and market accessibility.

The developed system utilizes a Random Forest machine learning model to analyze important agricultural parameters such as soil nutrients, temperature, humidity, rainfall, and pH values, and provides accurate crop recommendations to farmers. This helps reduce uncertainty in crop selection and enables farmers to improve productivity through data-driven decision-making. The contract farming module further enhances the platform by creating a digital bridge between farmers and companies, allowing transparent communication, efficient contract management, and better market opportunities.

The implementation of role-based access for Farmers, Companies, and Administrators ensures secure and efficient management of platform activities. The system successfully provides functionalities such as crop prediction, contract creation, company verification, user management, and administrative monitoring through an intuitive and user-friendly interface. The integration of React.js, Node.js, Express.js, MongoDB, and Python-based machine learning technologies results in a scalable and reliable agricultural support platform.

The evaluation of the system demonstrates that SmartCrop Advisor effectively assists farmers in selecting suitable crops and accessing contract farming opportunities. The platform improves transparency, enhances collaboration among stakeholders, and contributes to sustainable agricultural development. By combining intelligent crop prediction with digital contract farming services, the proposed solution offers a practical and efficient approach to modernizing agricultural practices.

In conclusion, SmartCrop Advisor provides an innovative and technology-driven solution that empowers farmers, strengthens farmer-company relationships, and promotes efficient resource utilization. The successful implementation of the system highlights the potential of Artificial Intelligence and Machine Learning in transforming the agricultural sector and supporting the development of a smarter and more sustainable farming ecosystem.

8. FUTURE WORK

The proposed SmartCrop Advisor system provides an effective solution for crop prediction and contract farming management. However, there are several opportunities for future enhancements that can further improve the functionality, accuracy, and usability of the platform. With the continuous advancement of Artificial Intelligence, Machine Learning, and Smart Agriculture technologies, the system can be extended to support additional intelligent services for farmers and agricultural organizations.

One potential enhancement is the integration of real-time weather forecasting services. By incorporating live weather data from meteorological APIs, the system can provide farmers with accurate weather predictions and generate crop recommendations that consider current and future climatic conditions. This feature would help farmers make better

cultivation decisions and reduce risks associated with unpredictable weather patterns.

Another important improvement is the implementation of crop disease detection using computer vision and deep learning techniques. Farmers could upload images of crops affected by pests or diseases, and the system would automatically identify the problem and recommend suitable preventive measures. Such a feature would enable early detection of diseases and help minimize crop losses.

The platform can also be enhanced by introducing an intelligent fertilizer recommendation module. Based on soil nutrient levels and crop requirements, the system could suggest the appropriate type and quantity of fertilizers needed to improve crop growth and productivity. This would support precision agriculture practices and promote efficient resource utilization.

To increase accessibility and user adoption, a dedicated mobile application can be developed for Android and iOS devices. A mobile platform would allow farmers to access crop predictions, contract farming opportunities, and agricultural information anytime and anywhere. Mobile notifications could also be used to provide timely updates regarding contracts, weather alerts, and farming recommendations.

Future versions of the system may incorporate multilingual support to accommodate farmers from different linguistic backgrounds. Providing regional language options would improve user experience and make the platform more accessible to farmers in rural areas who may not be comfortable using English-based interfaces.

The integration of government agricultural schemes and subsidy information is another promising enhancement. The platform could provide personalized recommendations about relevant government programs, financial assistance, insurance schemes, and agricultural subsidies based on the farmer's profile and farming activities. Furthermore, advanced analytics and data visualization tools can be implemented to help farmers analyze historical crop performance, market trends, and contract outcomes. These insights would support long-term agricultural planning and strategic decision-making.

In the future, SmartCrop Advisor can evolve into a comprehensive digital agriculture ecosystem by integrating Artificial Intelligence, Internet of Things (IoT) devices, remote sensing technologies, and blockchain-based contract management systems. Such developments would further improve transparency, efficiency, and sustainability in modern agricultural practices.

REFERENCES

1. Baldonado, M., Chang, C.-C.K., Gravano, L., Paepcke, A.: The Stanford Digital Library Metadata Architecture. *Int. J. Digit. Libr.* 1 (1997) 108–121.
2. Bruce, K.B., Cardelli, L., Pierce, B.C.: Comparing Object Encodings. In: Abadi, M., Ito, T. (eds.) *Theoretical Aspects of Computer Software. Lecture Notes in Computer Science*, Vol. 1281. Springer-Verlag, Berlin Heidelberg New York (1997) 415–438.

3. van Leeuwen, J. (ed.): Computer Science Today. Recent Trends and Developments. Lecture Notes in Computer Science, Vol. 1000. Springer-Verlag, Berlin Heidelberg New York (1995).
4. Veldwisch, G. J., & Woodhouse, P. (2022). Formal and informal contract farming in Mozambique: Socially embedded relations of agricultural intensification. *Journal of Agrarian Change*, 22(1), 162–178.
5. Susanty, A., Puspitasari, N. B., Purwaningsih, R., & Siregar, A. R. R. Sustainability Assessment of Contract Farming Broiler Chicken Supply Chain Using Rap-Poultry.
6. Nguyen Khanh, H., Chiong, R., Chica, M., Middleton, R. H. Agent-Based Simulation of Contract Rice Farming in the Mekong Delta, Vietnam.
7. Ruml, A., Ragasa, C., & Qaim, M. (2022). Contract farming, contract design and smallholder livelihoods. *Australian Journal of Agricultural and Resource Economics*, 66, pp. 24–43.
8. Chen, J., & Zhou, H. (2023). The Role of Contract Farming in Green Smart Agricultural Technology. *Sustainability*, 15, 10600.
9. Holt, C.A.; Laury, S.K. Risk aversion and incentive effects. *Am. Econ. Rev.* 2002, 92, 1644–1655.
10. Wen, Z.; Fan, X.; Ye, B.; Chen, Y. Characteristics of an effect size and appropriateness of mediation effect size measures revisited. *Acta Psychol. Sin.* 2016, 48, 435.
11. Poulton, C., Dorward, A., & Kydd, J. (1998). The revival of smallholder cash crops in Africa: Public and private roles in the provision of finance. *Journal of International Development*, 10(1), 85–103.
12. White, B., Borras, S. M. Jr., Hall, R., Scoones, I., & Wolford, W. (2012). The new enclosures: Critical perspectives on corporate land deals. *Journal of Peasant Studies*, 39, 619–647.
13. Oya, C. (2012). Contract farming in sub-Saharan Africa: A survey of approaches, debates and issues. *Journal of Agrarian Change*, 12, 1–33.