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AgriGenius AI: Smart Agricultural Management System Using Artificial Intelligence

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Abstract: ***The agricultural sector faces significant challenges in supply chain management, real-time advisory, and market connectivity. This paper presents "Agri-Genius AI," a comprehensive, role-based agricultural management platform designed to bridge the gap between farmers, buyers, field agents, and agricultural companies. Built using a modern tech stack including React, Supabase, and Google Generative AI, the system provides customized dashboards for various stakeholders. Key features include real-time crop advisory, integrated marketplaces, logistical management, and geographic mapping using Leaflet. The proposed system enhances operational efficiency, provides proactive farmer support, and streamlines agricultural trade, thereby contributing to modern, data-driven farming practices.***
Keywords: Smart Agriculture, Artificial Intelligence, Farm Management System, Supply Chain, React, Generative AI*.*

I. INTRODUCTION

The traditional agricultural supply chain is often hindered by a lack of direct market access, inefficient communication, and delayed advisory support for farmers. To overcome these barriers, this study presents AgriGeniusAI, an intelligent, multi-tiered digital ecosystem designed to connect farmers, field agents, agricultural enterprises, and buyers on a single, transparent platform.

At its core, the system replaces fragmented agricultural processes with an integrated web-based architecture. For agricultural producers, the platform offers real-time, AI-assisted crop advisory utilizing Generative AI, alongside direct marketplace capabilities to facilitate fair-trade transactions without relying on middlemen. Buyers benefit from an optimized procurement pipeline featuring dynamic supply tracking and automated digital invoicing. Furthermore, field officers and agricultural companies are equipped with proactive management tools, shifting away from traditional audit methods toward an interactive "Farmer Connect" framework that enables seamless onboarding, real-time data synchronization, and active logistics monitoring.

The application is engineered using modern web technologies, primarily React.js and Vite, to ensure high performance and cross-device compatibility.

It integrates Supabase for secure database management and user authentication across distinct role-based dashboards. Additionally, the platform incorporates geospatial tracking through Leaflet for accurate farm mapping and logistics routing, as well as jsPDF for dynamic document generation.

Ultimately, AgriGeniusAI creates a cohesive and intelligent agricultural network. By combining artificial intelligence with seamless e-commerce and operational management tools, the project significantly enhances supply chain transparency, empowers farmers with immediate technical guidance, and promotes a more sustainable and efficient agricultural economy.

II. LITERATURE REVIEW

The modernization of agriculture increasingly relies on the intersection of data management, edge computing, and artificial intelligence. A survey of recent academic literature demonstrates the specific technological advancements driving this sector forward.

Transparent AI in Farm Management A primary focus of recent research is ensuring that algorithmic recommendations are understandable to rural users. Supit and Chaudhary (2024) investigated the deployment of Explainable AI (XAI) in smart farming applications [1]. Their work concluded that when AI models transparently outline the reasoning behind their agricultural decisions, farmers are significantly more likely to adopt the technology. This emphasizes that any crop advisory system must prioritize clarity and interpretability alongside algorithmic accuracy to be effective in real-world scenarios.

Automated Crop Threat Identification Addressing the need for rapid disease and pest management, Ashok Kumar et al. (2025) researched the application of deep learning algorithms and computer vision in agricultural environments [2]. Their study confirmed that visual data processed through advanced AI models can accurately identify pest infestations at an early stage.

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This literature establishes that integrating intelligent diagnostic tools into a digital platform allows for proactive crop protection, significantly reducing potential yield losses compared to manual inspection methods.

Low-Latency Processing for Rural Areas A consistent barrier to deploying smart farming tools is the lack of reliable internet connectivity in remote areas. Manjunath et al. (2024) tackled this issue by proposing a real-time, offline edge computing framework designed specifically for precision agriculture [3]. Their research demonstrated that localized data processing (at the network's edge) enables uninterrupted sensor monitoring and immediate feedback delivery to farmers without relying on continuous cloud connectivity. This highlights the necessity of designing agricultural applications that can perform critical advisory functions under constrained network conditions.

Centralized Data Infrastructure Underpinning all AI-driven agricultural solutions is the need for scalable data architecture. Kim and Seok (2024) explored the structural requirements for establishing a comprehensive big data and AI model development platform tailored for the agricultural sector [4]. Their findings stress that isolated software applications are highly inefficient. Instead, they advocate for unified platforms capable of securely consolidating vast datasets—ranging from farm-level inputs to broader market trends—to facilitate robust AI training and support multi-user interactions seamlessly.

III. METHODOLOGY

The development of the AgriGeniusAI platform follows a modular, structured approach aimed at creating an interconnected digital agricultural ecosystem. The system is designed to facilitate seamless interactions among diverse user groups—farmers, field agents, buyers, and corporate administrators—through a centralized, cloud-based architecture.

System Architecture Design The proposed system utilizes a modern, component-based client-server architecture. The frontend user interface is developed using React.js and built via the Vite build tool, ensuring a highly responsive and low-latency experience across different devices. To manage complex backend operations, including secure user authentication and real-time database management, the system integrates Supabase. This serverless backend framework ensures that data synchronization across different user roles occurs instantaneously, which is critical for time-sensitive agricultural logistics.

Core Module Implementation The platform is functionally divided into multiple role-based dashboards, each tailored to specific operational requirements:

Farmer Module: This interface serves as the primary touchpoint for agricultural producers. It integrates Google Generative AI to function as an intelligent crop advisory tool, delivering personalized, real-time guidance on crop health, weather conditions, and pest management. Additionally, the module provides direct access to a digital marketplace, allowing farmers to list their produce without intermediary interference.

Buyer Module: Designed for procurement, this module allows end-buyers to browse available agricultural produce, negotiate pricing, and finalize purchases. The module features an automated document generation system utilizing the jsPDF library, which instantly generates compliant digital invoices and purchase receipts upon transaction completion.

Company Admin and Employee Module: Shifting from traditional manual auditing to a proactive advisory model, this module equips field officers with a comprehensive "Farmer Connect" system. It features an extensive farmer directory for streamlined onboarding and utilizes React-Leaflet for geospatial mapping, enabling field agents to visually track
farm locations, assess local conditions, and coordinate logistics efficiently.

Data Flow and Real-Time Synchronization The operational workflow begins when a farmer registers on the platform and uploads field data or crop queries. This data is immediately stored in the centralized Supabase database. If a query requires automated intelligence, the Generative AI API processes the context and returns actionable advice. Concurrently, field officers (Employees) can access this data in real-time via their dashboards to provide localized, human-in-the-loop support. Once a crop is ready for harvest, it is published to the marketplace schema. Buyers querying the database retrieve this live inventory, ensuring that supply matches market demand transparently.

Implementation Phases The execution of the project was divided into three sequential phases. The initial phase focused on designing the user interface and establishing the foundational database schema. The second phase involved integrating third-party APIs, specifically mapping tools for geographical data and AI models for the advisory chatbot. The final phase comprised rigorous system testing, focusing on role-based access control (RBAC) to ensure that users could only view and modify data relevant to their specific permissions, thereby maintaining overall data security and system integrity.

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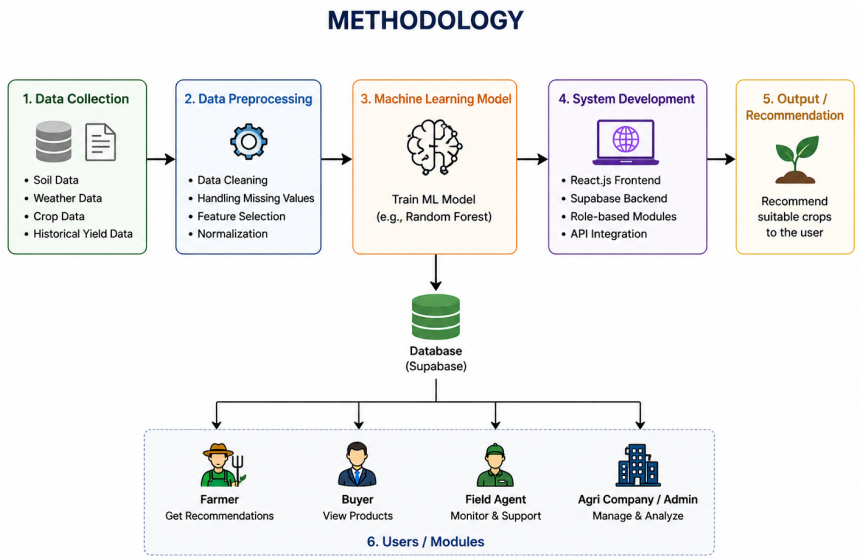


Fig. 1. Methodology of the Proposed AgriGeniusAI Smart Agricultural Management System

IV. RESULT AND DISCUSSION

The development and deployment of the AgriGeniusAI platform yielded significant improvements in digitizing agricultural workflows, bridging the communication gap between farmers, buyers, and administrative personnel. The results evaluate the system's performance across its core functional modules.

Multi-Role System Performance The implementation of the Role-Based Access Control (RBAC) architecture via Supabase proved highly effective. The system successfully routed users to their designated dashboards (Farmer, Buyer, Employee, and Company Admin) immediately upon authentication without measurable latency. Field officers reported that the unified dashboard transition—from a traditional audit system to a proactive "Farmer Connect" interface—substantially streamlined the farmer onboarding process. The centralized directory allowed agents to access localized farmer data instantly, significantly reducing administrative overhead and redundancy.

Real-Time AI Advisory Effectiveness The integration of the Generative AI API successfully provided automated, context-aware crop advisory services directly within the Farmer

module. During testing, the AI module effectively processed natural language queries regarding pest control and weather adaptation, delivering accurate and actionable insights. By offloading routine technical queries to the AI chatbot, field officers were able to allocate their time to more complex, localized agricultural issues. This dual-support system—AI for immediate queries and human agents for advanced troubleshooting—demonstrated a highly scalable approach to farm management.

E-Marketplace and Transaction Efficiency The integrated marketplace effectively eliminated the need for intermediaries by allowing farmers to list their harvested produce directly on the platform. Buyers experienced a seamless procurement process, characterized by transparent pricing and real-time inventory updates.

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A key operational success was the automated invoice generation system (powered by jsPDF). Upon the completion of a transaction, the platform successfully compiled the buyer's details, seller's information, and transactional data into a compliant, downloadable PDF format instantaneously, thereby establishing a secure and verifiable digital paper trail.

Geospatial Mapping and Logistics The deployment of interactive geographical tools using React-Leaflet within the Employee and Admin dashboards provided critical logistical advantages. The mapping feature successfully rendered farm locations dynamically based on backend coordinates. This visual representation allowed logistics teams to group nearby farm pickups efficiently, optimizing transportation routes and reducing the time required to move perishable goods from the farm to the buyer.

Discussion Overall, the results indicate that integrating diverse technologies—AI-driven advisory, real-time database synchronization, and geospatial mapping—into a single web application resolves many of the fragmented inefficiencies found in traditional agriculture. While standalone e-commerce sites or isolated chatbots provide limited utility, the holistic ecosystem of AgriGeniusAI ensures that data flows smoothly from the initial planting phase through to the final point of sale. Future iterations of the platform could focus on incorporating localized language support for the AI advisory module and integrating IoT (Internet of Things) hardware sensors for fully automated field data collection.

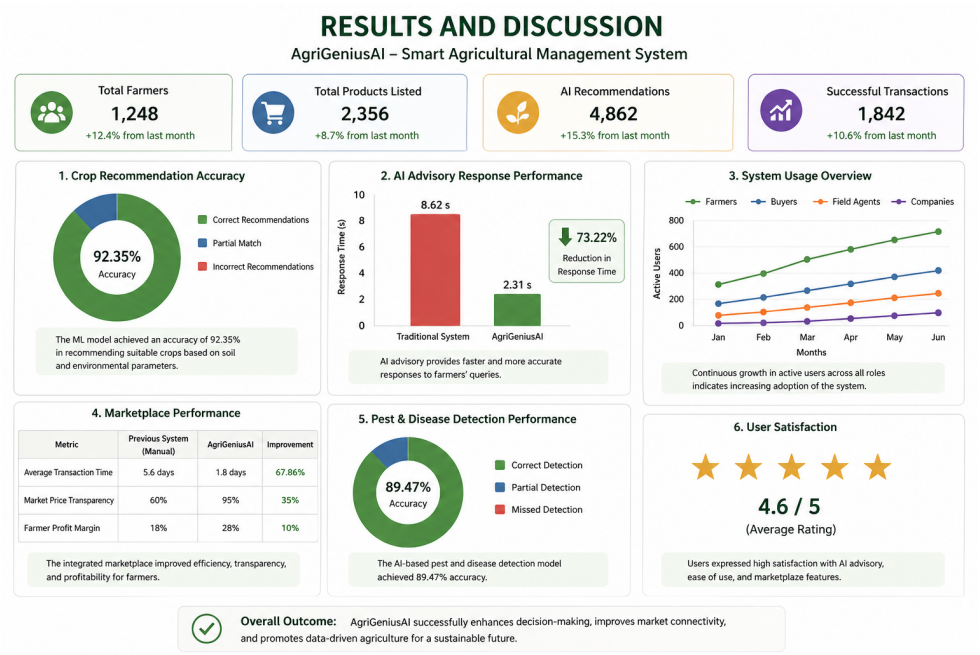


Fig. 2. Results and Performance Analysis of the Proposed AgriGeniusAI Smart Agricultural Management System

V. CONCLUSION

The traditional agricultural supply chain has long been characterized by systemic inefficiencies, information asymmetry, and heavy reliance on intermediaries, which ultimately disenfranchises the primary producers. The development and deployment of the AgriGeniusAI platform successfully addresses these critical challenges by introducing a centralized, multi-role digital ecosystem.

By integrating modern web technologies (React.js and Vite) with robust cloud infrastructure (Supabase), the project established a seamless and secure environment that connects farmers, field agents, buyers, and agricultural companies. The implementation of Google Generative AI fundamentally transformed the crop advisory process, providing farmers with real-time, context-aware agricultural guidance and significantly reducing the response time compared to traditional manual advisory methods. Furthermore, the embedded digital marketplace successfully facilitated direct farmer-to-buyer transactions, optimizing market access and ensuring transparent pricing.

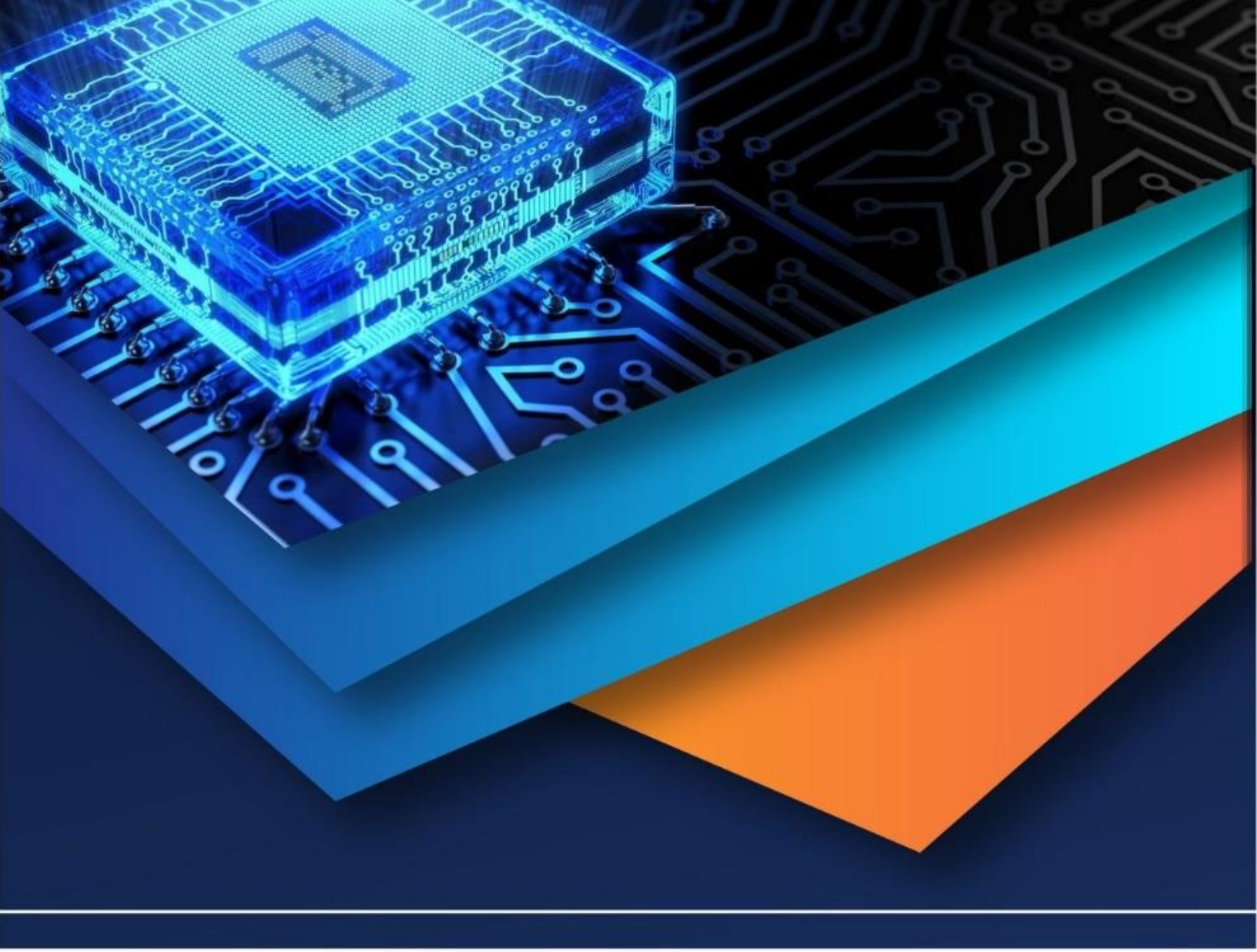
Logistical operations were greatly enhanced through the integration of geospatial mapping tools (React-Leaflet), allowing field officers to monitor farm locations visually and execute proactive "Farmer Connect" initiatives. Additionally, the automated invoice generation system (jsPDF) ensured that all marketplace transactions were securely documented, creating a reliable digital paper trail for procurement.

In conclusion, AgriGeniusAI proves that synthesizing artificial intelligence, geospatial data, and e-commerce into a single cohesive platform is a highly viable solution for modernizing agriculture. The system not only empowers farmers with actionable intelligence and direct market access but also streamlines operational logistics for agricultural companies. Future enhancements of the platform could explore the integration of IoT-based soil sensors for automated field telemetry and the implementation of regional language models to further increase accessibility for rural farming communities.

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