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RAITHANET: A FARMER-CENTRIC DECISION SUPPORT SYSTEM FOR CROP ADVISORY, FERTILIZER GUIDANCE, DISEASE DIAGNOSIS, AND SUBSIDY–MARKET LINKAGE USING EXPLAINABLE AI AND MICROSERVICES

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ABSTRACT: Farmers often face critical challenges in making timely, informed decisions related to crop selection, fertilizer application, disease prevention, and accessing profitable markets. RaithaNet addresses these challenges by providing an integrated, farmer-centric decision support system that unites practical agricultural expertise with modern artificial intelligence. Leveraging soil composition, climatic conditions, and geospatial data, the system delivers context-specific crop and fertilizer recommendations. Its plant disease detection module, powered by deep learning, enables rapid diagnosis from a single mobile image, accompanied by clear treatment guidelines, medicine images, and proper usage instructions. In addition, RaithaNet offers personalized subsidy recommendations by linking farmers to relevant government schemes,

while its marketplace integration facilitates direct connections with buyers, reducing middlemen costs. Built on a modular microservices architecture and underpinned by explainable AI, the platform ensures transparency, scalability, and adaptability to diverse regional needs. By combining data-driven insights with local agricultural knowledge, RaithaNet aims to enhance productivity, minimize losses, and promote sustainable income growth for farming communities.

KEYWORDS: RaithaNet, Decision Support System, Explainable AI, Microservices, Crop Advisory, Fertilizer Guidance, Disease Diagnosis, and Subsidy-Market Linkage.

I. INTRODUCTION

Agriculture remains a cornerstone of livelihoods across the globe, yet farmers frequently encounter critical decision-making challenges. Determining the optimal crop, estimating the right fertilizer dosage, identifying diseases at an early stage, and securing fair market value are often constrained by limited access to timely, reliable, and contextual information. In many rural regions, farmers depend primarily on inherited knowledge or intuition, which, while valuable, may result in reduced yields, inefficient resource usage, and diminished profitability.

The rapid growth of artificial intelligence (AI) and data-driven decision systems offers transformative potential to address these challenges. By leveraging data on soil composition, climate patterns, and geolocation, AI models can generate tailored recommendations for individual farms. However, existing digital solutions often focus on isolated aspects of farming or present outputs without sufficient transparency, leading to hesitation in adoption.

To bridge this gap, the proposed system—RaithaNet—offers an integrated, user-friendly decision support platform for farmers. It unifies crop recommendation, fertilizer guidance, disease detection via image-based analysis, subsidy information access, and direct farmer-to-market linkage within a single ecosystem. The platform combines advanced AI algorithms with localized agricultural expertise, ensuring that insights are both technically robust and easily

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comprehensible. By enabling informed decisions, RaithaNet aims to enhance productivity, reduce input costs, and strengthen the economic resilience of farming communities.

II. LITERATURE SURVEY

Machine learning has transformed traditional agriculture by enabling data-driven crop recommendations. Smith et al. [1] demonstrated how models analyzing soil and environmental data can suggest the best crops, helping farmers optimize yields.

Deep learning techniques now allow for accurate plant disease detection through mobile images. Verma and Singh [2] developed a real-time diagnostic system that empowers farmers with easy and timely disease identification.

Integrating government subsidy information into agricultural platforms enhances farmers' financial decisions. Das and Patil [3] proposed ways to embed subsidy data, bridging gaps between resources and users.

Role-based access control is essential for managing permissions among farmers, dealers, and administrators. Thomas [4] emphasized this approach to secure and customize agricultural digital platforms.

Cloud services like Google Cloud [5] and Cloudinary [6] provide scalable infrastructure and efficient media management, supporting large-scale agricultural data handling.

Explainable AI builds trust by making AI recommendations transparent. Lee [7] reviewed methods that clarify AI decision-making, encouraging farmer adoption.

Modern frameworks such as FastAPI [8] and React [9] enable modular, responsive, and user-friendly platforms, ensuring smooth development and interaction.

Collectively, these advances shape integrated systems combining crop advisory, disease detection, subsidy access, secure roles, explainable AI, and cloud infrastructure to effectively support farmers.

CURRENT SYSTEM

Nowadays, farmers have access to a range of tools that help with different parts of farming, such as apps for choosing the right crops, diagnosing plant diseases from photos, checking government subsidies, and finding buyers through online marketplaces. But most of these tools work separately and don't offer a smooth, all-in-one experience.

Many systems don't explain their advice clearly, which makes it harder for farmers to trust and act on it. Plus, challenges like poor internet access and limited tech skills can make it difficult for some farmers to benefit fully. It's also uncommon to find a single easy-to-use platform that combines crop advice, subsidy information, and market connections—all tailored to local farming conditions.

RaithaNet is designed to fill this gap by bringing these essential services together in one transparent, flexible system. It's simple to use, adapts to different farming situations, and uses explainable AI to ensure farmers understand and trust the guidance they receive.

PROPOSED SYSTEM

RaithaNet is built to address the challenges farmers face by uniting key agricultural services into a single, easy-to-use platform. It provides personalized crop and fertilizer recommendations by analyzing soil, weather, and location data specific to each farm. The system's disease detection feature enables quick identification of crop illnesses from simple photos and offers clear treatment instructions, including images and usage guidelines for medicines.

Additionally, RaithaNet guides farmers to the right government subsidies, simplifying access to financial aid tailored to their needs. It also bridges the gap between farmers and buyers by facilitating direct market connections, helping farmers receive fair prices without intermediaries.

A defining feature of RaithaNet is its use of explainable AI, which not only delivers accurate recommendations but also

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explains the reasoning behind them in accessible language. This transparency builds trust and encourages informed decision-making. The platform's modular microservices architecture ensures it is scalable and adaptable, ready to incorporate new features as agricultural needs evolve. Designed with usability in mind, RaithaNet makes advanced agricultural technology accessible to farmers of varying technical backgrounds, fostering sustainable productivity and improved livelihoods.

III. SYSTEM ARCHITECTURE

RaithaNet adopts a modular, scalable design to address diverse agricultural needs. The frontend, developed with React.js and Tailwind CSS, offers a responsive interface for farmers, dealers, and consumers, enabling seamless data input, AI-assisted recommendations, marketplace access, and chatbot interaction. The backend comprises two coordinated services: a Python FastAPI module for AI tasks such as crop recommendation, fertilizer guidance, and plant disease detection using deep learning, and a Node.js/Express service for authentication, role management, subsidy information, and marketplace operations. Data is securely stored in a PostgreSQL database, while integrations with Google Cloud, Google Maps, and Cloudinary provide real-time weather, geolocation, and media management. The architecture's loosely coupled components ensure flexibility, reliability, and ease of future expansion.

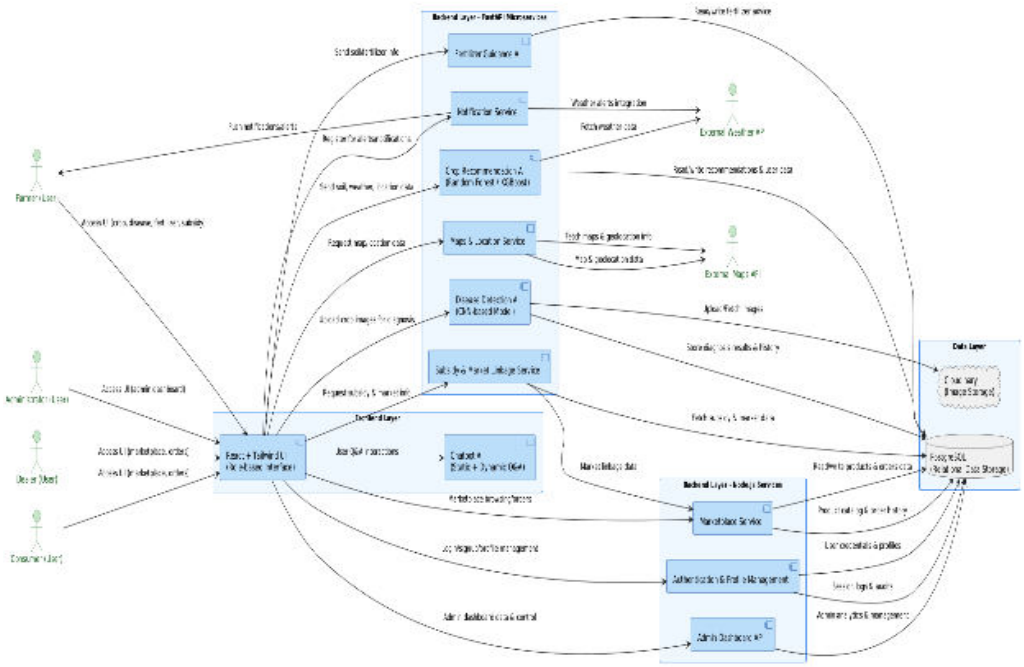

Fig 3.1 System Architecture Diagram

IV. METHODOLOGY

RaithaNet employs a modular, role-based architecture to serve diverse agricultural stakeholders. Farmers provide essential inputs such as soil parameters, geolocation, and crop images, enabling AI-powered modules to deliver personalized crop and fertilizer recommendations alongside rapid disease detection with treatment guidance. Dealers and consumers utilize the platform to explore marketplace listings, access weather forecasts, interact with the chatbot, and locate nearby farms.

The system integrates two coordinated backend services: an AI engine for processing agricultural data and generating insights, and a service layer for managing user roles, marketplace transactions, and subsidy information. Additional features include real-time weather integration, geospatial mapping, and multilingual chatbot assistance to enhance

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accessibility. This framework ensures improved farm productivity, efficient market connectivity, and tailored support for all user categories.

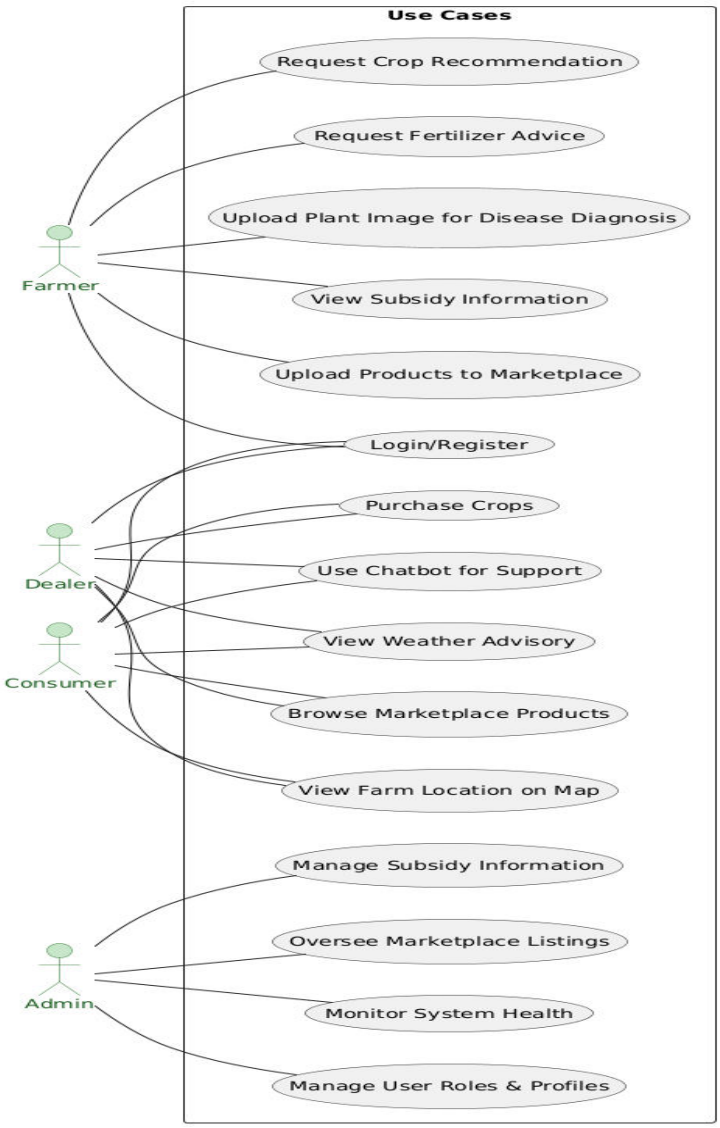

Fig 4.1 Use Case Diagram

V. DESIGN AND IMPLEMENTATION

RaithaNet is developed as a role-oriented agricultural decision support platform, tailored to meet the specific needs of farmers, dealers, consumers, and administrators. The frontend leverages React.js combined with Tailwind CSS to deliver a highly responsive, user-friendly interface that adapts seamlessly across devices. Farmers can access AI-driven crop and fertilizer recommendations, perform real-time plant disease diagnosis through image uploads, explore relevant government subsidy schemes, and connect with buyers via the integrated marketplace. Dealers and consumers benefit from product listings, weather insights, and location-based services, while administrators oversee platform operations, user management, and subsidy updates.

The backend follows a robust microservices architecture, with Python FastAPI dedicated to hosting machine learning models for explainable AI predictions, and Node.js/Express managing authentication, role-based access, marketplace

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operations, and subsidy services. PostgreSQL ensures secure and scalable data storage, while Google Maps API enables precise geospatial mapping. Cloudinary is used for efficient media management, and a multilingual chatbot powered by natural language processing provides interactive guidance.

This modular and distributed architecture allows independent development, easier maintenance, and rapid scalability, ensuring RaithaNet remains adaptable to evolving agricultural challenges while delivering reliable, real-time decision support.

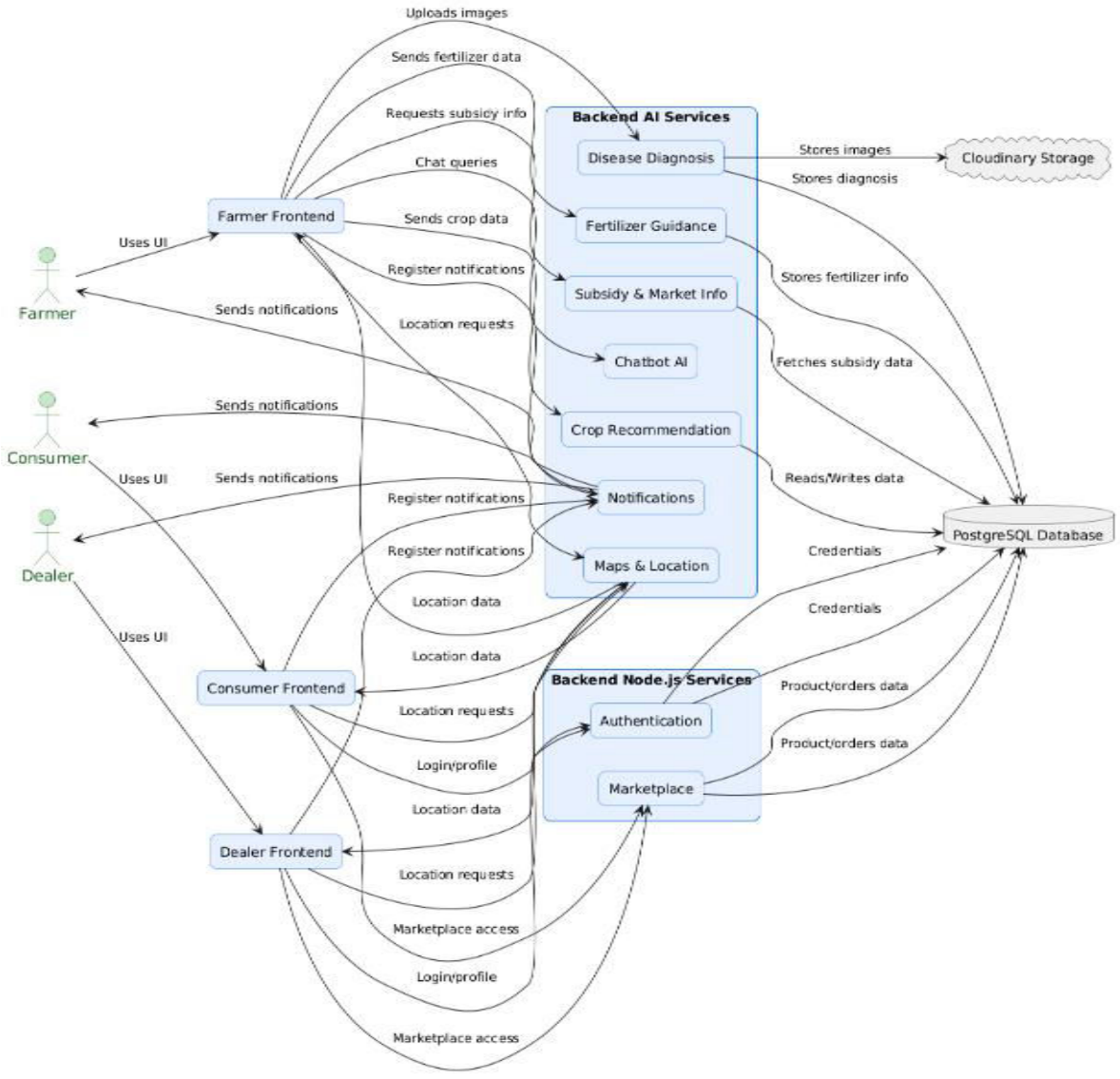

Fig 5.1 Working Flow Diagram

VI. OUTCOME OF RESEARCH

The implementation of RaithaNet has demonstrated significant improvements and practical benefits across multiple dimensions of agricultural management:

- Enhanced crop productivity through AI-driven, site-specific crop and fertilizer recommendations, enabling farmers to optimize inputs based on soil and climatic conditions.

- Rapid and accurate disease diagnosis using deep learning techniques, providing farmers with timely treatment advice that reduces crop losses and improves yield quality.
- Streamlined access to government subsidy programs, increasing farmer awareness and uptake of financial support mechanisms, thereby easing economic pressures.
- Strengthened market connectivity by linking farmers directly with dealers and consumers, reducing intermediaries and ensuring more equitable pricing and transaction transparency.
- Improved user experience and engagement facilitated by a multilingual, context-aware AI chatbot that offers role-specific guidance and support.
- A flexible and scalable microservices architecture, allowing the platform to adapt to evolving agricultural needs and incorporate new technological advancements seamlessly.
- Promotion of sustainable agricultural practices by integrating data-driven insights with traditional knowledge, contributing to environmentally responsible and economically sound farming.

These outcomes highlight the potential of intelligent, integrated digital platforms to transform agricultural ecosystems, supporting farmers in making informed decisions and fostering rural economic development.
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VII. RESULT AND DISCUSSION

RaithaNet was tested with farmers, dealers, and consumers to measure its real-world value. Farmers reported that personalized crop and fertilizer advice, based on local soil, climate, and geospatial data, improved planning and resource use. The AI-driven disease detection module, using mobile image uploads, proved highly accurate, delivering clear diagnoses with visual treatment guides and medicine instructions—helping reduce losses through timely action.
The subsidy guidance feature simplified the complex process of finding and applying for government schemes, with direct links boosting participation. Dealers and consumers valued the marketplace for transparent listings, quality details, and farm locations, enabling direct trade and fair pricing.

The AI chatbot, with multilingual and context-aware responses, supported queries on crops, subsidies, markets, and locations, enhancing usability. Technically, the modular microservices design ensured scalability, while explainable AI increased trust across regions.

Overall, RaithaNet effectively blends advisory, diagnostics, subsidy access, and marketplace tools, showing strong potential to empower agricultural communities and promote sustainable farming.

VIII. CONCLUSION

This research introduces RaithaNet, an integrated decision support system designed to meet the varied needs of farmers, dealers, and consumers in agriculture. Utilizing explainable AI and modular microservices, RaithaNet provides personalized crop and fertilizer advice, precise plant disease diagnosis, subsidy guidance, and a transparent marketplace. Role-based access control ensures users access relevant, context-aware features, improving usability and trust.

A multilingual AI chatbot enhances user engagement and accessibility, offering timely support across diverse user groups. The modular design supports scalability and easy maintenance, allowing the platform to adapt to new technologies and evolving user needs.

Early evaluations show RaithaNet aids better farming decisions, reduces disease-related losses, and boosts farmers' incomes by connecting them directly with markets and subsidy programs. This platform highlights the power of technology-driven, user-focused solutions to uplift rural agricultural communities.

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