Project Synopsis

On

FARM CONNECT: PATHWAY TO PROGRESS

Submitted to Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur in partial fulfillment of requirement for the award of the degree of

BACHELOR OF TECHNOLOGY

In

Computer Science & Engineering

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Department of Computer Science & Engineering

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Department of Computer Science & Engineering

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Mission of the Institute:

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- To equip students with need based technical skills through continual improvement in Teaching Learning Processes and research activity.
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- **PSO-1**: To demonstrate knowledge and understanding of CS engineering concepts and apply these to the industries.
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- **PEO3:** To create and sustain a community of learning in which students acquire knowledge and apply in their concerned fields with due consideration for ethical, ecological, and economic issues.

Program Outcomes (UG)

- **PO1. Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
- **PO2. Problem analysis:** Identify, formulate and analyze real world problems to reach substantial conclusions using computer science and engineering concepts.
- **PO3. Design/development of solutions:** Design a system component and process to meet desired needs.
- **PO4. Conduct problem investigations:** use research based knowledge and methods including design, interpretation of data, analysis & synthesis of the information to provide valid conclusion.
- **PO5. Modern tool usage:** apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
- **PO6. The engineer, industry and society:** communicate effectively both in written & oral formats.
- **PO7. Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts.
- **PO8. Ethics:** Demonstrate professional skills and ethics .
- **PO9. Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
- **PO10. Communication:** Ability to communicate effectively with peer community and society on complex software/system engineering activities through unambiguous spoken language, written reports, presentations.
- **PO11. Project management and finance:** Ability to apply the knowledge of Engineering and Management principles to manage projects as a team member or leader in multidisciplinary teams.
- **PO12. Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

YEAR/SEM: IV/VIII **COURSE NAME: PROJECT**
COURSE CODE: BTECHCSE705T

BTECHCSE705T	**PROJECT**
	After studying the course, the students will be able to
CO1	To display the working knowledge and skills to the industry.
CO2	Deeper knowledge of methods in major fields of study.
CO3	Collection To gain a consciousness of ethical aspects of research and development work.
CO4	Capability to plan and use adequate methods to conduct qualified tasks in given frameworks and evaluate the work.

ABSTRACT

Farm Connect: Pathway to Progress is a comprehensive, multi-functional agricultural support system developed to empower farmers through the integration of technology into rural development. The project addresses critical challenges faced by farming communities, particularly the lack of timely information, limited market access, and difficulties in availing government schemes, loans, and machinery. By offering real-time data, direct market linkages, and early warning alerts, Farm Connect seeks to bridge the information and accessibility gap that often hinders agricultural productivity and farmer welfare.

The system has been designed with a strong user-centric approach, incorporating multilingual support and voice input features to ensure inclusivity for farmers with limited literacy or technological skills. Its modular architecture allows each component—such as disease detection, market access, government scheme integration, and weather alert systems—to be developed, tested, and validated individually before being integrated into the full platform.

Key Features of Farm Connect:

- **AI-Powered Disease Detection:** Image analysis using configurable AI providers (Groq LLM by & Google Gemini Vision AI) to analyze crop images and provide disease identification, severity assessment, and treatment recommendations
- **Smart Weather Dashboard:** Real-time weather forecasting with agricultural insights and farming alerts
- **Machinery Marketplace:** Platform for farmers to rent and share agricultural equipment
- **Government Schemes Portal:** Consolidated information on subsidies, loans, and support programs
- **Voice-Enabled Interface:** Multilingual voice assistant for farmers with limited literacy
- **AI-Powered Chatbot (Voice & Text):** Interactive farming assistant where farmers can ask queries via voice input OR text chat in 5 regional languages (Hindi, Marathi, Malayalam, Punjabi, English). Features include speech recognition and text-to-speech output for accessibility; AI responses use Groq LLM by default (Gemini is also supported).
- **User Profile:** Personal dashboard for managing bookings and preferences

The platform is built using modern web technologies (React.js, Node.js, MongoDB) ensuring scalability, responsiveness, and cross-platform accessibility.

Keywords: Agriculture, AI Disease Detection, Real-time Weather, Machinery Rental, Government Schemes, Voice Interface, Rural Development, Technology Integration

1. INTRODUCTION

1.1 Background

Agriculture continues to be a foundational pillar of emerging economies such as India, where a substantial proportion of the population—approximately 58%—depends on farming as its primary source of livelihood. Despite the sector's importance, farmers—especially small and marginal cultivators—face persistent challenges in accessing timely and reliable information related to crop management, weather changes, market prices, and government support services. Traditional information-dissemination channels remain slow, fragmented, and often inaccessible due to language barriers and limited digital exposure. With the rapid expansion of mobile connectivity and digital infrastructure in rural regions, there is a significant opportunity to leverage technology to bridge these longstanding gaps. The Indian government's Digital India initiative and the proliferation of affordable smartphones have created an environment conducive to technology-driven agricultural solutions.

1.2 Motivation

The motivation for developing Farm Connect stems from several critical observations:

1. **Information Asymmetry**: Farmers often lack access to real-time market prices, leading to exploitation by middlemen and reduced profit margins.
2. **Disease Management Challenges**: Delayed disease identification results in crop losses averaging 15-25% annually. Early detection through AI can significantly reduce these losses.
3. **Underutilization of Government Schemes**: Despite numerous agricultural support programs, awareness and accessibility remain low among rural farmers.
4. **Weather Vulnerability**: Unpredictable weather patterns and lack of timely alerts contribute to crop failures and financial losses.
5. **Equipment Access Barriers**: High costs of agricultural machinery prevent small farmers from modernizing their practices.

1.3 Need for Farm Connect

In response to these needs, the proposed system **Farm Connect: Pathway to Progress** seeks to provide a comprehensive, user-friendly, and regionally adaptable digital platform designed specifically for Indian farmers. The platform aims to integrate:

1. Real-time weather updates with agricultural insights
2. AI-powered pest and disease detection and alerts
3. User profile and booking management
4. Government schemes and subsidy information
5. Agricultural machinery rental marketplace
6. Voice-enabled multilingual interface

1.4 Theoretical Foundation

The theoretical foundation of this research draws upon established frameworks such as:

1. **Diffusion of Innovations Theory (Rogers, 2003)**: Explains technology adoption patterns and how innovations spread through social systems.
2. **Technology Acceptance Model (TAM):** Focuses on perceived usefulness and ease of use as primary determinants of technology adoption.
3. **Information Systems Success Model (DeLone & McLean):** Emphasizes system quality, information quality, and service quality as key factors in system success.
4. **Socio-Technical Systems Theory:** Underlines the importance of alignment between technology and users' cultural and social environments.

These models collectively guide the design, implementation, and evaluation of Farm Connect.

1.5 Scope of the Project

The scope of Farm Connect encompasses:

1. **AI-Powered Disease Detection Module**: Image analysis using configurable AI providers (Groq LLM by default; optionally Google Gemini Vision AI)
2. **Smart Weather Dashboard:** Integration with WeatherAPI for real-time forecasting
3. **Machinery Marketplace**: Peer-to-peer equipment rental platform
4. **Government Schemes Portal**: Database of agricultural subsidies and support programs
5. **User Profile**: Personal dashboard with booking history and preferences
6. **AI Chatbot (Voice & Text):** Multilingual assistant supporting Hindi, Marathi, Malayalam, Punjabi, and English - farmers can ask questions via voice or text input, with AI-powered responses from Groq LLM by default (Google Gemini is also supported) and text-to-speech output
7. **User Authentication:** Secure login system with JWT token authentication

2. LITERATURE SURVEY

1.Patil & Deshmukh (2021) – Smart Agriculture System Using IoT

Patil and Deshmukh present an IoT-based smart agriculture framework that uses sensors to monitor soil moisture, temperature, humidity, and environmental conditions. Their study highlights how real-time data collection and automated alerts enable farmers to take timely decisions, improving crop health and reducing resource wastage. The system demonstrates how IoT can reduce labour dependency while supporting precision farming practices. The paper also identifies common barriers such as cost, connectivity issues, and sensor calibration. This study is relevant to Farm Connect as it supports real-time monitoring, advisory generation, and the integration of low-cost IoT solutions in digital agriculture platforms.

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2. Rao & Kumar (2022) – Smart Agriculture Monitoring with Low-Cost Sensors

Rao and Kumar's work focuses on creating a cost-effective agricultural monitoring system using affordable sensors and microcontrollers. Their research demonstrates that even smallholder farmers can benefit from digital tools when designed with affordability and simplicity in mind. By integrating sensors like DHT11 and soil moisture probes, the system automates irrigation decisions and provides continuous environmental updates. The study also emphasizes data accuracy, ease of deployment, and resource optimization. This directly supports Farm Connect's objective of enabling accessible digital monitoring, reinforcing the possibility of scalable solutions for small- and marginal-farmer communities.

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3. Ministry of Agriculture (2020) – eNAM: Transforming Agricultural Markets

The Government of India's eNAM report evaluates the impact of digital marketplaces on agricultural trade. It highlights how eNAM improves transparency, market competitiveness, and access to national buyers, reducing dependence on middlemen. The report identifies operational constraints such as inadequate grading, digital literacy gaps, and infrastructural limitations. Despite these challenges, eNAM has significantly enhanced price realization for participating farmers. This literature is important for Farm Connect as it shows the transformative potential of digital marketplaces and emphasizes the need for user-friendly interfaces, training, and seamless integration to support fair and efficient agricultural trade.

4. Singh & Mehta (2021) – Mobile Apps for Agricultural Extension in India

Singh and Mehta analyze several mobile applications used in agricultural extension and find common issues such as language barriers, fragmented data, poor interface design, and inconsistent content quality. Their study reveals that farmers tend to abandon apps that lack clarity, reliability, or local-language support. They emphasize that for digital tools to succeed, they must provide region-specific advisories, simple navigation, and clear visual aids. The paper supports the idea that technology should adapt to user limitations rather than expecting rural farmers to adapt to complicated systems. This directly strengthens Farm Connect's focus on inclusive, local-language, user-centered design.

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5. Kumar & Verma (2022) – Mobile-Based Agricultural Extension Services

Kumar and Verma assess the adoption and impact of mobile-based extension services across Indian farming communities. Their results indicate that mobile advisories significantly improve farmers' knowledge and decision-making related to crop management, input selection, and risk mitigation. The study identifies trust, clarity of information, and source credibility as the strongest determinants of adoption. Farmers who receive regular, actionable, and localized suggestions show measurable improvements in productivity. The authors also stress the importance of two-way communication between farmers and extension officers. These insights guide Farm Connect in designing reliable, trustworthy advisory modules supported by credible data sources and expert validation.

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6. Google Research Team (2019) – Voice Access for the Next Billion Users

The Google Research report studies voice interface adoption among low-literacy users in developing regions. It highlights that voice technology significantly reduces barriers to digital engagement by offering a natural, intuitive mode of interaction. However, challenges remain, particularly in handling diverse accents, dialect variations, contextual understanding, and noisy environments. The study recommends building region-specific speech models and designing simple, structured conversational flows. These findings are crucial to Farm Connect, which aims to serve semi-literate farmers through voice-enabled navigation, content retrieval, and advisory access, ensuring accessibility even for individuals unfamiliar with smartphones or text-based interfaces.

7. Medhi, Sagar & Toyama (2011) – Text-Free User Interfaces

This study explores the effectiveness of text-free user interfaces for low-literate populations, demonstrating how icons, visuals, and guided navigation can dramatically improve usability. The authors identify limitations of text-heavy systems and show how intuitive visual layouts reduce cognitive load and support independent use. The research recommends using culturally relevant icons, audio cues, and minimal text to enhance comprehension. These insights are directly applicable to Farm Connect, which intends to incorporate icon-based navigation and voice instructions for easier app usage in rural areas. The findings support the need for multimodal interfaces combining text, visuals, and speech.

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8. Hansen & Coffey (2020) – Climate Information for Agricultural Risk Management

Hansen and Coffey emphasize the importance of integrating weather forecasts, climate predictions, and advisory systems to mitigate agricultural risks. Their study examines how timely, localized weather information helps farmers plan irrigation, fertilizer use, and pest control strategies. They highlight the need for accurate downscaling of regional forecasts to local farm-level conditions. The research also discusses the challenges of communicating scientific data in formats farmers can easily understand. These insights support Farm Connect's real-time weather and early-warning module, ensuring that the information delivered is both accurate and actionable, reducing crop losses and improving farm productivity.

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9. Sharma & Rao (2021) – Weather-Based Agro-Advisory Services

Sharma and Rao examine the effectiveness of Weather-Based Agro-Advisory Services (WBAAS) and their role in improving farming outcomes. Their findings show that farmers who regularly receive weather-based recommendations experience fewer losses related to unexpected rainfall, pests, and climatic variability. The study also highlights the importance of localized advisories, delivered through channels like SMS, IVR, and mobile apps. Farmer trust and timely dissemination are key factors influencing adoption. This research validates Farm Connect's approach of combining real-time forecasts with crop-specific recommendations, delivered through multiple channels to ensure reach across varying literacy and connectivity levels.

10. FAO (2021) – Digital Agriculture Transformation in Developing Countries

The Food and Agriculture Organization's report highlights how digital agriculture solutions such as mobile advisory services, e-markets, and remote sensing are transforming farming in developing nations. The study emphasizes that digital platforms improve productivity, improve supply chain transparency, and enhance farmer resilience to climate risks. However, it also stresses the importance of digital capacity building and gender-inclusive technology access. This report is highly relevant to Farm Connect as it validates the global need for inclusive, farmer-centered digital platforms that integrate advisory, market access, and climate intelligence in a unified ecosystem.

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11. Joshi & Kulkarni (2022) – Farmer Adoption of Mobile-Based Advisory Systems

Joshi and Kulkarni analyze behavioral factors influencing farmers' adoption of mobile advisory services in India. Their findings show that ease of use, trust in information sources, and language compatibility play a crucial role in sustained app usage. The study highlights that farmers prefer platforms that offer localized content, simple visuals, and practical problem-solving features. The authors also observe that peer influence and community promotion significantly accelerate adoption. These findings strongly support Farm Connect's design philosophy of localized language support, community engagement, and expert-verified advisory systems for higher user trust and long-term adoption

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12. Mishra & Tiwari (2020) – Digital Supply Chain Management in Agriculture

Mishra and Tiwari assess the impact of digital supply chain platforms on agricultural logistics and market efficiency. Their study demonstrates that digital integration reduces post-harvest losses, improves price discovery, and enhances coordination between farmers, traders, and transporters. The research highlights the role of real-time data sharing in minimizing delays and market volatility. However, infrastructural constraints and fragmented adoption remain challenges. This study strengthens Farm Connect's scope of integrating market connectivity, logistics support, and transparent digital trading mechanisms for better farmer profitability.

13. Verma & Singh (2021) – Impact of Weather Forecast-Based Decision Support Systems

Verma and Singh evaluate weather forecast-based decision support systems and their influence on farm-level decision-making. Their findings reveal that farmers using predictive weather tools improve crop scheduling, reduce pest damage, and enhance fertilizer efficiency. The study also indicates that acceptance increases when information is delivered in simple language with clear actionable recommendations. The research validates Farm Connect's weather advisory module by highlighting the importance of transforming complex climate data into simplified, farmer-friendly decision guidance.

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14. Choudhary & Jain (2022) – AI-Based Crop Disease Detection Systems

Choudhary and Jain analyze the application of artificial intelligence in crop disease detection using image processing and machine learning models. Their research demonstrates that AI-based systems can accurately identify early-stage crop diseases, enabling timely preventive action. The authors highlight the importance of image quality, dataset diversity, and user-friendly interfaces for effective field deployment. This study directly contributes to Farm Connect's future AI roadmap, particularly in integrating automated crop health monitoring and disease diagnosis tools for precision farming.

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15. Narayanan & Iyer (2021) – Digital Literacy and Rural Technology Adoption

Narayanan and Iyer investigate how digital literacy levels influence technology adoption in rural India. Their findings reveal that lack of basic smartphone skills limits farmers' ability to utilize advanced digital services. The study stresses the importance of training programs, voice-based systems, and assisted digital onboarding. This literature strongly reinforces Farm Connect's emphasis on voice interfaces, guided navigation, training content, and digital inclusion strategies to ensure maximum farmer participation and sustainable system adoption.

3.PROJECT OBJECTIVES

The primary objectives of the Farm Connect project are designed to address the critical challenges faced by Indian farmers through an integrated digital platform.

3.1 Primary Objectives

- **To develop an integrated digital platform** that connects farmers with essential agricultural resources and services through a single unified interface.
- **To provide AI-based crop disease detection** for improved decision-making using Google Gemini Vision AI with treatment recommendations and prevention strategies.
- **To deliver real-time weather updates** with agricultural insights, farming alerts, and actionable recommendations for irrigation, pest control, and crop protection.
- **To create a unified platform** that integrates all essential agricultural services into a single accessible interface.
- **To provide a machinery rental marketplace** enabling farmers to access agricultural equipment without significant capital investment.

3.2 Secondary Objectives

- **To include a multilingual, voice-enabled interface** to ensure accessibility for farmers of all literacy levels, supporting Hindi, Marathi, Malayalam, Punjabi, and English.
- **To offer consolidated information on government schemes**, subsidies, and agricultural support programs with eligibility checking functionality.
- **To issue early warning alerts** for adverse weather conditions, pest outbreaks, and crop diseases using AI-powered predictive analytics.
- **To build a secure authentication system** with OTP verification for user protection.
- **To develop a secure, scalable, and user-friendly platform** capable of supporting large numbers of rural users with responsive design for mobile accessibility.

3.3 Technical Objectives

- **To implement a modern tech stack** using React.js for frontend, Node.js/Express for backend, and MongoDB for database management.
- **To integrate third-party APIs** including Weather API for weather data, Google Gemini AI for disease detection and farming advice.
- **To ensure PWA (Progressive Web App) capabilities** for one functionality and mobile installation.
- **To create RESTful API architecture** for seamless communication between frontend and backend services

4.PROBLEM FORMULATION

4.1 Existing System

The existing agricultural support system in India suffers from major fragmentation and inaccessibility:

4.1.1 Information Fragmentation

- Government schemes, market prices, and weather updates are available across multiple platforms with no unified source.
- Farmers must navigate numerous websites, apps, and offices to access different services.
- Information is often outdated, inconsistent, or difficult to understand.

4.1.2 Language Barriers

- Most agricultural apps operate primarily in English or Hindi.
- Regional language support is limited or poorly implemented.
- Text-heavy interfaces exclude farmers with limited literacy.

4.1.3 Disease Detection Challenges

- Manual disease identification requires expert knowledge not readily available in rural areas.
- By the time farmers identify diseases, significant crop damage has often occurred.
- Existing solutions require expensive equipment or specialized training.

4.1.4 Market Access Issues

- Farmers depend heavily on middlemen who often exploit information asymmetry.
- Real-time price information is not accessible to most farmers.
- Direct buyer connections are rare for small and marginal farmers.

4.1.5 Equipment Accessibility

- High costs of agricultural machinery prevent modernization.
- No organized platform exists for equipment sharing or rental.
- Underutilization of existing machinery in rural communities.

4.1.6 Government Scheme Awareness

- Low awareness of available subsidies and support programs.
- Complex application processes discourage participation.
- Eligibility criteria are often unclear or difficult to verify.

4.2 Proposed System

The proposed system, Farm Connect, aims to address the limitations of current agricultural information platforms by creating a unified, intelligent, and accessible digital ecosystem for farmers.

4.2.1 System Overview

Farm Connect is a responsive web application built using:

- **Frontend:** React.js with TypeScript, Tailwind CSS, Shadcn/UI components.
- **Backend:** Node.js with Express.js
- **Database:** MongoDB for flexible data storage.
- **AI Services:** Google Gemini AI for disease detection and farming advice.
- **Weather API:** WeatherAPI.com for real-time weather data.

4.2.2 Core Modules

Module	Description	Key Features
Disease Detection	AI-powered crop disease identification	Image upload, instant analysis, treatment recommendations
Weather Dashboard	Real-time weather with farming insights	7-day forecast, farming alerts, crop advisory
Machinery Marketplace	Equipment rental platform	Browse, book, review machinery
Government Schemes	Subsidy and scheme information	Search, filter, category browsing, scheme details
Voice Interface	Multilingual voice assistant	Speech recognition, voice responses
User Profile	Personal dashboard	Booking history, saved schemes, preferences

4.2.3 Key Innovations

- **Unified Platform:** Single interface for all agricultural needs.
- **AI-First Approach**: AI-based disease detection using Groq and Gemini Vision AI for accurate diagnosis and recommendations.
- **Voice Accessibility:** Natural language interaction for low-literacy users.
- **Real-time Data:** Live weather updates with agricultural context.
- **Direct Market Access:** Peer-to-peer machinery sharing and produce sales.

4.2.4 Expected Benefits

- Reduced crop losses through early disease detection (estimated 15-20% improvement)
- Increased scheme utilization through simplified access
- Reduced equipment costs through sharing economy
- Improved decision-making through weather-based advisory

5. RESEARCH METHODOLOGY & PROPOSED SOLUTIONS

The research methodology for Farm Connect follows a systematic and structured approach combining software engineering principles with user-centered design practices.

5.1 Development Methodology

Farm Connect was developed using an **Agile Scrum** methodology with the following phases:

Phase 1: Requirements Gathering

- Stakeholder interviews with farmers and agricultural experts
- Analysis of existing agricultural applications and their limitations
- Documentation of functional and non-functional requirements

Phase 2: System Design

- Architecture design using modular component-based approach
- Database schema design for MongoDB collections
- API endpoint design for RESTful services
- UI/UX wireframing and prototyping

Phase 3: Iterative Development

- Sprint-based development cycles (2-week sprints)
- Continuous integration and testing
- Regular stakeholder feedback and iteration

Phase 4: Testing & Deployment

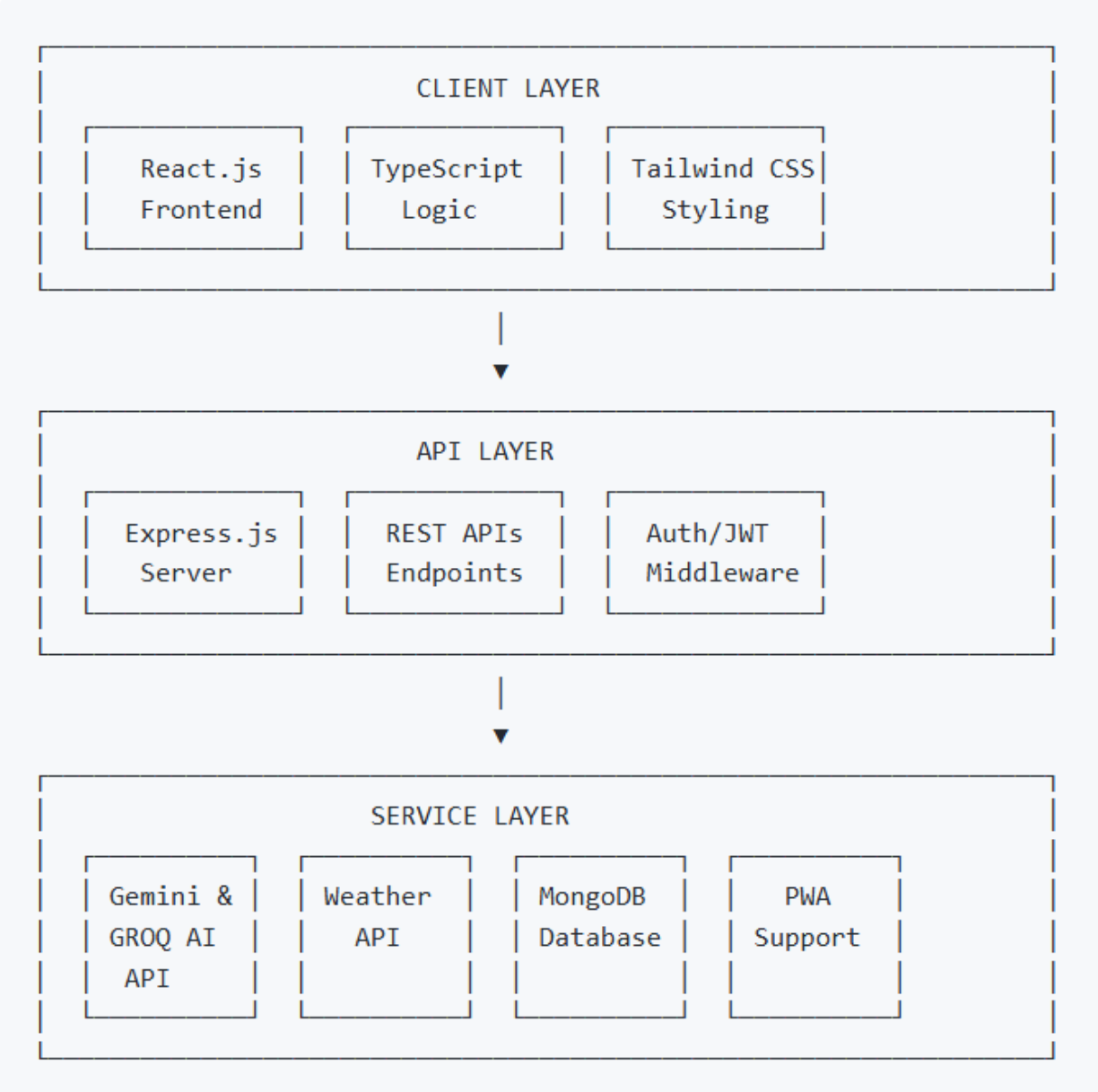
- Unit testing and integration testing
- User acceptance testing with target farmers
- Cloud deployment and performance optimization

5.2 Data Collection Methods

Method	Purpose	Data Collected
Farmer Surveys	Understanding user needs	Pain points, feature requests, literacy levels
API Integration	Real-time data	Weather data, government scheme information
Literature Review	Best practices	Technology trends, existing solutions

5.3 System Architecture

5.3.1 High-Level Architecture



5.3.2 Component Architecture

Layer	Components	Technologies
Presentation	Pages, Components, UI Elements	React.js, Shadcn/UI, Lucide Icons
State Management	Context API, React Query	React Context, TanStack Query
Routing	Page Navigation	React Router DOM
API Communication	HTTP Client	Axios, Fetch API
Backend Services	REST APIs	Express.js, Node.js
Database	Data Persistence	MongoDB
External APIs	Third-party Services	WeatherAPI, Groq LLM,Gemini AI

5.3.3 Layer-wise Code Implementation

The following code snippets demonstrate the 3-tier architecture implementation:

1. CLIENT LAYER (React.js + TypeScript + Tailwind CSS)

```tsx
// src/pages/HomePage.tsx - Client Layer Implementation
import HeroSection from "@/components/homepage/HeroSection";
import QuickActions from "@/components/homepage/QuickActions";
import AIInsights from "@/components/homepage/AIInsights";

export default function HomePage() {
  return (
    <div className="min-h-screen bg-background">
      {/* 3rd Layer UI Component Interaction */}
      <HeroSection />

      <main className="container py-12 space-y-24">
        {/* Dynamic Data Fetching & State Handling */}
        <QuickActions />
        <AIInsights />
      </main>
    </div>
  );
}
```

2. **API LAYER (Express.js Server + REST APIs + Auth/JWT Middleware)**

Express.js Server Setup:

```
// server.js - Main Express Server
import express from 'express';
import cors from 'cors';
import dotenv from 'dotenv';
import { connectToDatabase } from './database.js';

// Import route handlers
import usersRouter from './api/users.js';
import machineryRouter from './api/machinery.js';
import weatherRouter from './api/weather.js';

dotenv.config();
const app = express();

// Middleware
app.use(cors());
app.use(express.json({ limit: '50mb' }));

// Mount REST API routes
app.use('/api/auth', usersRouter);
app.use('/api/machinery', machineryRouter);
app.use('/api/weather', weatherRouter);

// Start server
const PORT = process.env.PORT || 4174;
connectToDatabase().then(() => {
    app.listen(PORT, () => console.log(`Server running on port ${PORT}`));
});
```

Client-Side JWT Storage & API Calls:

```
// src/contexts/AuthContext.tsx - Token Storage
const login = async (email: string, password: string) => {
    const response = await fetch('/api/auth/login', {
        method: 'POST',
        headers: { 'Content-Type': 'application/json' },
        body: JSON.stringify({ identifier: email, password }),
    });
    const data = await response.json();

    if (data.success) {
        localStorage.setItem('FarmConnect_token', data.data.token);  // Store JWT
        setUser(data.data.user);
    }
};

// src/lib/api - Sending JWT with requests
const getAuthHeaders = () => ({
    'Content-Type': 'application/json',
    'Authorization': `Bearer ${localStorage.getItem('FarmConnect_token')}`
});

const fetchProtectedData = async () => {
    const response = await fetch('/api/auth/me', { headers: getAuthHeaders() });
    return response.json();
};
```

3. **SERVICE LAYER (AI Providers & External Services)**

Groq LLM AI Service (Primary):

```
// src/lib/groq.ts
import OpenAI from 'openai';

class GroqAIService {
    private getClient() {
        const apiKey = localStorage.getItem('groq_api_key') || '';
        return new OpenAI({
            baseURL: "https://api.groq.com/openai/v1",
            apiKey: apiKey,
            dangerouslyAllowBrowser: true,
        });
    }

    async analyzeCropImage(imageBase64: string): Promise<AICropAnalysis> {
        const response = await this.getClient().chat.completions.create({
            model: "meta-llama/llama-4-scout-17b-16e-instruct",
            messages: [{
                role: "user",
                content: [
                    { type: "text", text: "Analyze this crop for diseases..." },
                    { type: "image_url", image_url: { url: imageBase64 } }
                ]
            }],
            max_tokens: 1500,
            temperature: 0.2,
        });
        return JSON.parse(response.choices[0]?.message?.content || '');
    }
}

export const groqAI = new GroqAIService();
```

Google Gemini AI Service (Alternate):

```
// src/lib/gemini.ts
import { GoogleGenAI } from '@google/genai';

class GeminiAIService {
    private getModel() {
        return new GoogleGenAI({ apiKey: localStorage.getItem('gemini_api_key') || '' });
    }

    async analyzeCropImage(imageBase64: string): Promise<AICropAnalysis> {
        const base64Data = imageBase64.replace(/^data:image\/[a-z]+;base64,/, '');
        const response = await this.getModel().models.generateContent({
            model: 'gemini-2.5-flash',
            contents: {
                parts: [
                    { text: 'Analyze this crop for diseases...' },
                    { inlineData: { data: base64Data, mimeType: 'image/jpeg' } }
                ]
            },
            config: { responseMimeType: "application/json", temperature: 0.2 },
        });
        return JSON.parse(response.text.trim());
    }
}

export const geminiAI = new GeminiAIService();
```

Centralized AI Provider (User-Switchable):

```
// src/lib/ai.ts - Routes to Groq or Gemini based on user settings
import { groqAI } from './groq';
import { geminiAI } from './gemini';

export type ModelProvider = 'gemini' | 'groq';

export const getModelConfig = () => {
    const stored = localStorage.getItem('farm-connect-model-settings');
    return stored ? JSON.parse(stored) : { diseaseDetection: 'groq', chatbot: 'groq' };
};

export const analyzeCropImage = async (imageBase64: string) => {
    const provider = getModelConfig().diseaseDetection;
    console.log(`🔬 Disease Detection using: ${provider.toUpperCase()}`);
    return provider === 'groq'
        ? groqAI.analyzeCropImage(imageBase64)
        : geminiAI.analyzeCropImage(imageBase64);
};
```

MongoDB Database Connection:

```
// database.js
import { MongoClient, ServerApiVersion } from 'mongodb';

const client = new MongoClient(process.env.MONGO_URI, {
    serverApi: { version: ServerApiVersion.v1, strict: true }
});

let db = null;

export async function getDatabase() {
    if (!db) {
        await client.connect();
        db = client.db("FarmConnect");
    }
    return db;
}

export const collections = {
    users: 'users',
    machinery: 'machinery',
    bookings: 'bookings',
    reviews: 'reviews'
};
```

PWA Service Worker:

```
// src/registerSW.ts
export function registerServiceWorker() {
    if ('serviceWorker' in navigator) {
        window.addEventListener('load', async () => {
            const registration = await navigator.serviceWorker.register('/sw.js');
            console.log('Service Worker registered:', registration);
        });
    }
}

export function isPWAInstalled(): boolean {
    return window.matchMedia('(display-mode: standalone)').matches;
}
```

5.4. PROPOSED SOLUTION

5.4.1 AI Disease Detection Module

Technology: Groq LLM and Google Gemini Vision AI (gemini-2.0-flash-exp model)

Process Flow:

1. User uploads crop image via drag-and-drop or file selection.
2. Image is converted to Base64 format.
3. Image sent to Gemini Vision AI with structured prompt.
4. AI analyzes image for diseases and pest infestations.
5. Response includes disease name, confidence, severity, treatment, prevention.
6. Results displayed with visual indicators and actionable recommendations.

Key Features:

1. Support for JPEG, PNG, Web image formats
2. Detection of both diseases and pest infestations
3. India-specific disease and pest database
4. Treatment recommendations with locally available solutions
5. Detection history stored for user reference

5.4.2 Smart Weather Dashboard Module

Technology: WeatherAPI.com integration with AI-powered insights

Features:

- Real-time current weather conditions
- 7-day weather forecast
- Agricultural-specific metrics (humidity, temperature, wind speed)
- AI-generated farming recommendations based on conditions
- City search functionality
- Geolocation-based automatic detection

Data Points Displayed:

Metric	Description	Agricultural Relevance
Temperature	Current temperature	Crop stress indicators
Humidity	Relative humidity %	Disease risk assessment
Wind Speed	km/h	Spraying conditions
Rain Forecast	Chance of rain	Irrigation planning

5.4.3 Machinery Marketplace Module

Features:

- Equipment listing with images and specifications
- Category-based filtering (Tractors, Harvesters, Sprayers, etc.)
- Location-based search
- Booking system with date selection
- Owner dashboard for equipment management
- Review and rating system
- Messaging between farmers and owners

Database Collections:

- Machinery : Equipment listings
- bookings : Rental bookings
- reviews : User reviews
- messages : Communication threads

5.4.4 Government Schemes Portal Module

Features:

- Comprehensive database of central and state schemes
- Category filtering (Irrigation, Seeds, Livestock, Credit, etc.)
- State-wise scheme filtering
- Scheme details and benefits display
- Status indicators (Active, Deadline Soon, Closed)

Scheme Categories Covered:

1. PM-KISAN (Pradhan Mantri Kisan Samman Nidhi)
2. PMFBY (Pradhan Mantri Fasal Bima Yojana)
3. Kisan Credit Card
4. Soil Health Card Scheme
5. National Mission on Sustainable Agriculture
6. State-specific subsidy programs

Note: Uses curated static data that is regularly updated by the team to ensure accuracy and relevance of scheme information.

5.4.5 Voice Interface Module

Technology: Web Speech API (browser native) with AI-powered response generation

Supported Languages:

- Hindi (hi-IN)
- Marathi (mr-IN)
- English (en-IN)
- Malayalam (ml-IN)
- Punjabi (pa-IN)

Capabilities:

- Voice-to-text input using Web Speech API
- AI-powered intelligent farming advice and recommendations
- Text-to-speech output using Speech Synthesis API
- Multilingual support for accessibility

Note: Utilizes Google Gemini AI for intelligent response generation and farming advice.

5.4.6 MongoDB Collections Schema

Users Collection:

```
{
  _id: ObjectId,
  name: String,
  email: String,
  phone: String,
  password: String,   // Hashed with bcrypt (salt rounds: 10)
  location: String,   // Default: 'India'
  language: String,   // Default: 'hindi' (Multilingual support)
  farmSize: Number,   // In acres; Default: 0
  crops: [String],    // Array of crop types
  createdAt: Date,
  updatedAt: Date
}
```

Machinery Collection:

```
{
  _id: ObjectId,
  ownerId: ObjectId,                // Reference to owner user
  name: String,
  type: String,                     // Category: Tractor, Harvester, Sprayer, etc.
  brand: String,                    // Equipment brand name
  description: String,
  pricePerDay: Number,              // Daily rental rate in INR
  location: {
    state: String,
    coordinates: {
      type: "Point",                // GeoJSON for geospatial queries
      coordinates: [longitude, latitude]
    }
  },
  specifications: Object,           // Machine-specific specs
  images: [String],                 // Array of image URLs
  available: Boolean,               // Current availability status
  isActive: Boolean,                // Soft delete flag
  deliveryAvailable: Boolean,       // Whether delivery is offered
  deliveryChargePerKm: Number,      // Delivery pricing
  securityDeposit: Number,          // Booking security amount
  rating: Number,                   // Average rating (0-5)
  reviewCount: Number,
  bookedDates: [                    // Periods when machinery is booked
    {
      startDate: Date,
      endDate: Date
    }
  ],
  createdAt: Date,
  updatedAt: Date
}
```

Bookings Collection:

```
{
  _id: ObjectId,
  bookingNumber: String,          // Unique booking ID (format: BK-
timestamp-random)
  machineryId: ObjectId,          // Reference to machinery
  renterId: ObjectId,             // Reference to renter (farmer) user
  renterName: String,
  renterPhone: String,
  renterEmail: String,
  startDate: Date,
  endDate: Date,
  totalDays: Number,              // Calculated number of days
  totalAmount: Number,            // Base amount (pricePerDay ×
totalDays)
  deliveryRequired: Boolean,      // Whether delivery is requested
  deliveryAddress: String,        // Delivery location
  deliveryCharge: Number,         // Calculated delivery cost
  securityDeposit: Number,        // From machinery record
  discount: Number,               // Applied discount (if any)
  finalAmount: Number,            // Total after all charges/discounts
  purpose: String,                // Booking purpose/notes
  specialRequirements: String,    // Any special handling requests
  paymentMode: String,            // Payment method (e.g., 'demo',
'online', 'cash')
  status: "pending" | "confirmed" | "completed" | "cancelled",
  createdAt: Date,
  updatedAt: Date
}
```

5.4.7 API Design

5.4.7.1 RESTful API Endpoints

Endpoint	Method	Description
/api/auth/register	POST	User registration
/api/auth/login	POST	User authentication
/api/auth/me	GET	Get current logged-in user
/api/users/:id	PUT	Update user profile
/api/machinery	GET	List all machinery with filters
/api/machinery/:id	GET	Get machinery details
/api/machinery	POST	Add new machinery
/api/machinery/:id	PUT	Update machinery
/api/machinery/:id	DELETE	Delete machinery
/api/bookings	GET	Get bookings
/api/bookings	POST	Create booking
/api/bookings/user/:userId	GET	Get user's bookings and history
/api/bookings/:id/status	PUT	Update booking status
/api/reviews	GET/POST	Get reviews / Submit review
/api/reviews/machinery/:machineryId	GET	Get all reviews for machinery
/api/messages	GET/POST	Get messages / Send message
/api/messages/conversation/:userId/:otherUserId	GET	Get conversation with specific user
/api/weather/forecast	GET	Get weather forecast data

5.4.7.2 External API Integrations

1. **Supported AI Providers:**

- **Groq LLM : Model**: meta-llama/llama-4-scout-17b-16e-instruct (vision) and llama-3.3-70b-versatile (text); supports crop disease detection and multilingual chatbot via OpenAI-compatible endpoints with structured JSON responses.
- **Google Gemini Vision AI : Model**: gemini-2.5-flash (vision) and gemini-2.5-flash-lite (text); supports vision and text generation via generateContent with structured JSON schema responses when configured.

2. **WeatherAPI.com:**

- Endpoint: /v1/forecast.json
- Parameters: location, days, uv, alerts
- Response: Current conditions + forecast

5.4.7.3 Security Implementation

Security Measure	Implementation
Password Hashing	bcrypt with salt rounds (10)
API Authentication	JWT tokens (7-day expiry)
CORS Protection	Open CORS policy (Allow-Origin: *)
Input Validation	TypeScript interface validation
API Key Protection	Environment variables (.env)

5.4.8 User Interface Design

5.4.8.1 Design Principles

1. **Simplicity:** Clean, uncluttered interfaces with clear navigation
2. **Accessibility:** Large touch targets, high contrast, voice alternatives
3. **Responsiveness:** Mobile-first design for smartphone access
4. **Localization:** Support for regional languages and cultural context
5. **Visual Hierarchy:** Important actions prominently displayed

5.4.8.2 Key UI Components

Component	Purpose	Design Considerations
Navigation	Page access	Header navigation for desktop, hamburger menu for mobile
Cards	Information display	Visual hierarchy, scannable content
Forms	Data input	Large inputs, clear labels, validation feedback
Modals	Focused actions	Overlay with clear close options
Alerts	Notifications	Color-coded severity indicators

5.4.8.3 Color Scheme

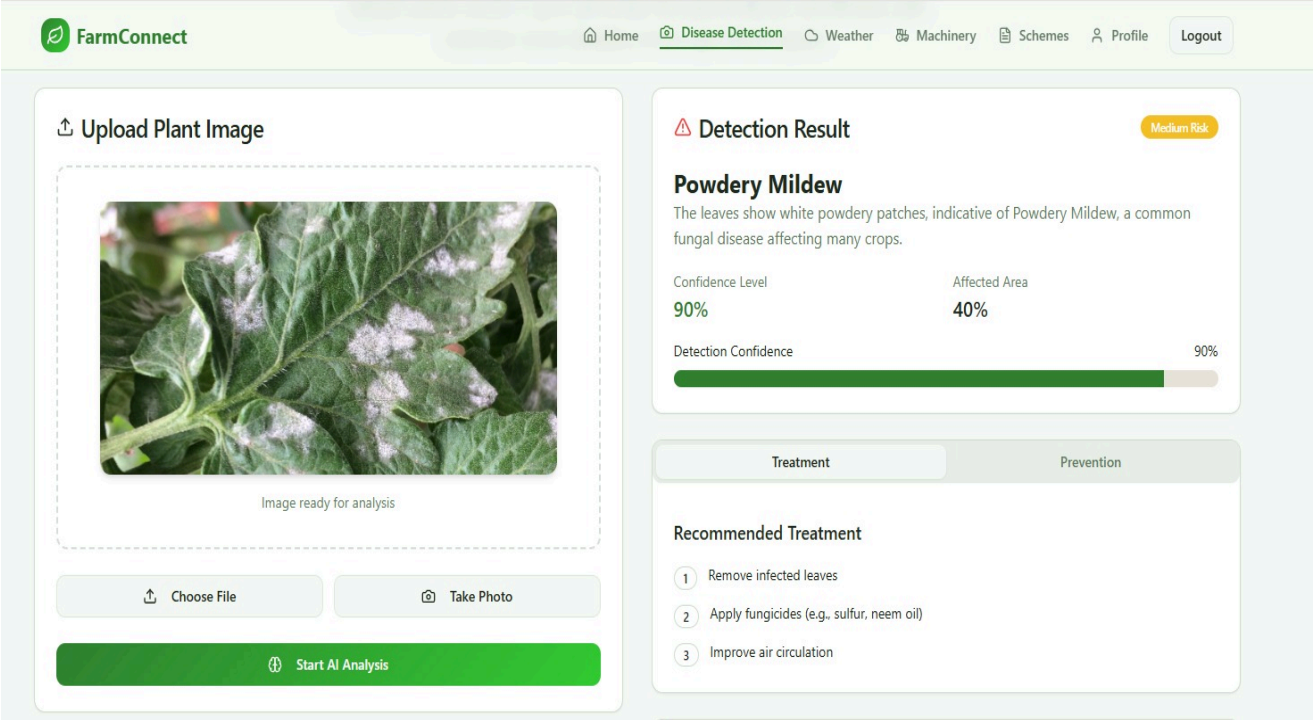
Color	Usage	Hex Code
Primary Green	Actions, success	HSL(120 45% 35%)
Warning Yellow	Alerts, caution	HSL(45 90% 55%)
Danger Red	Errors, high severity	HSL(0 84% 60%)
Info Blue	Information, links	HSL(90 35% 75%)
Background	Page background	HSL(120 25% 97%)
Text Primary	Main content	HSL(120 15% 15%)

5.4.9 Testing Strategy

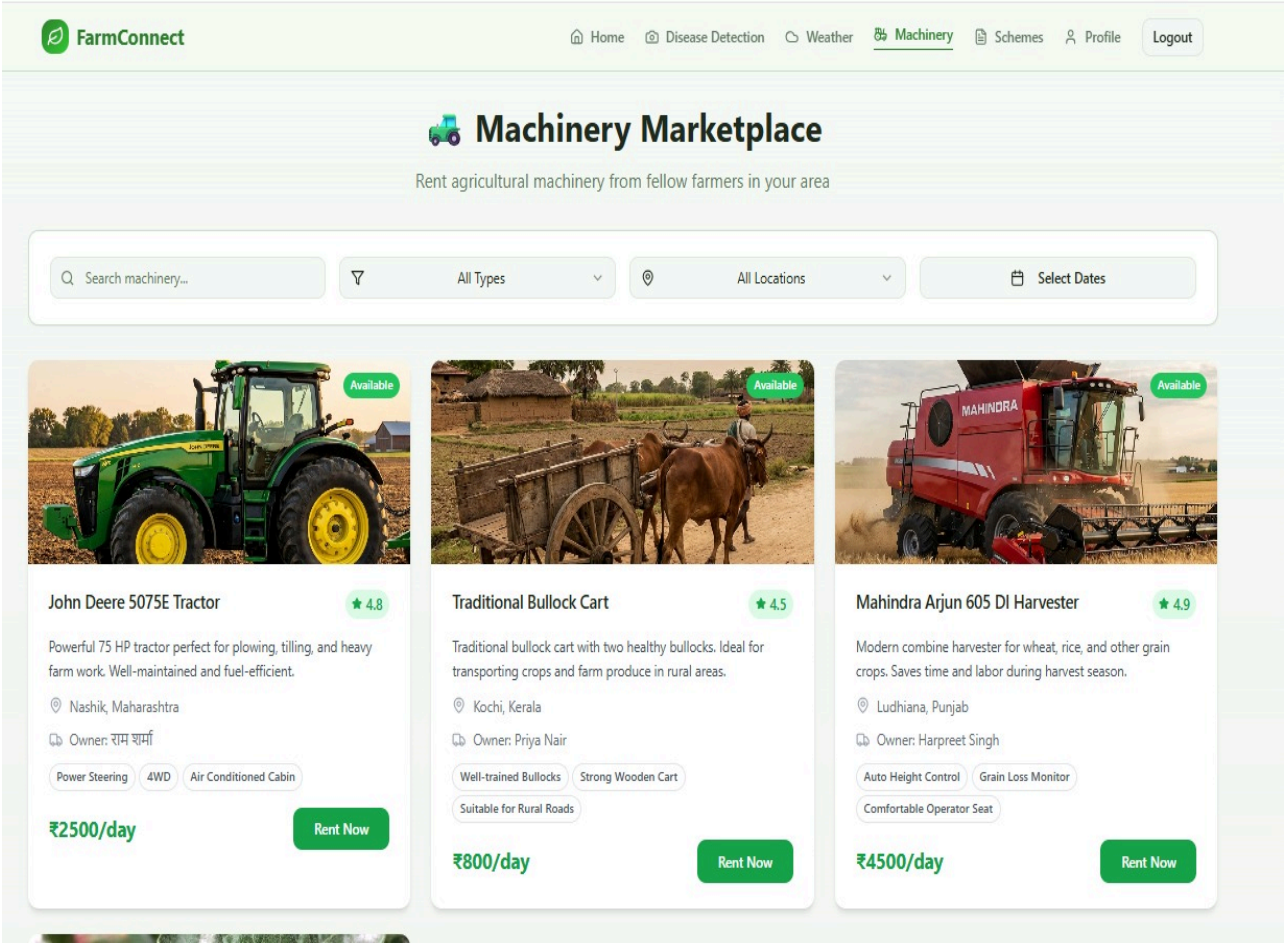
Testing Type	Tools	Coverage
Manual Testing	Browser DevTools	Component functionality
API Testing	Postman, Thunder Client	API endpoints
Usability Testing	Manual user testing	UX validation

6.RESULT

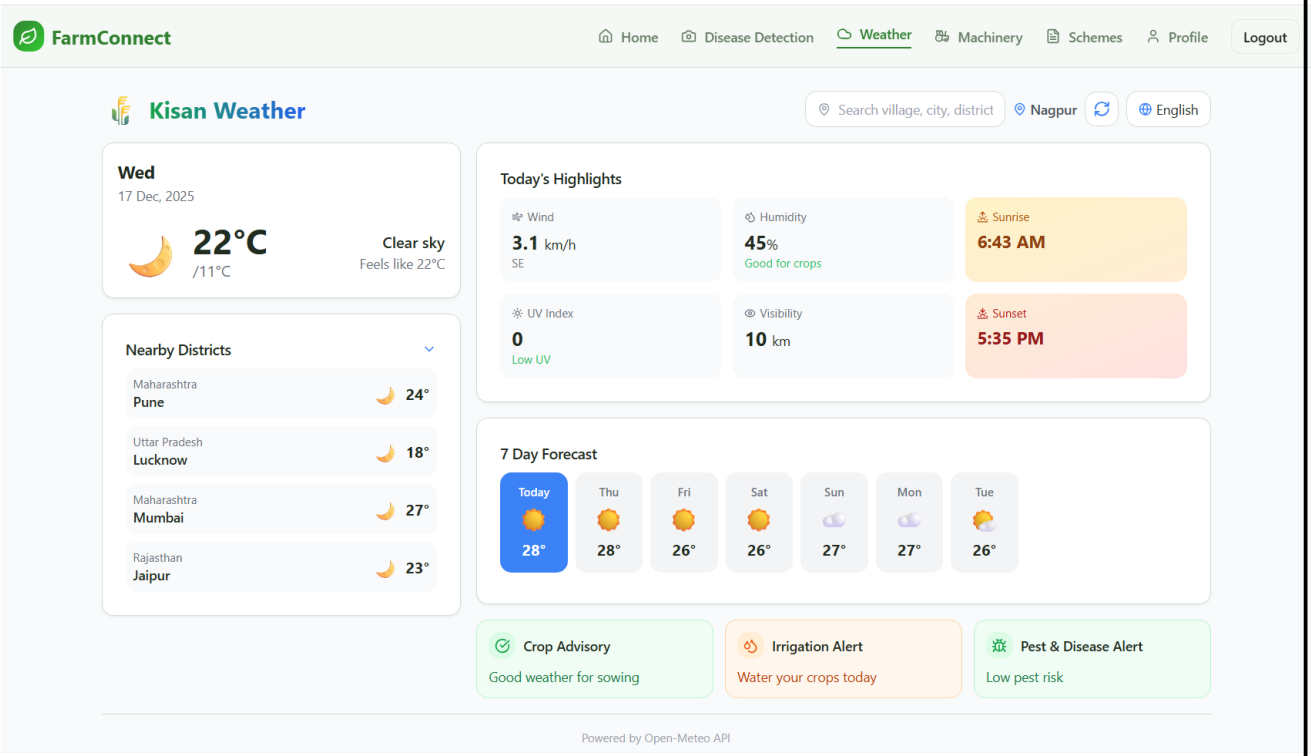
This image shows the FarmConnect homepage, featuring the platform's AI-powered farming assistance, multilingual support, and quick access to major features.



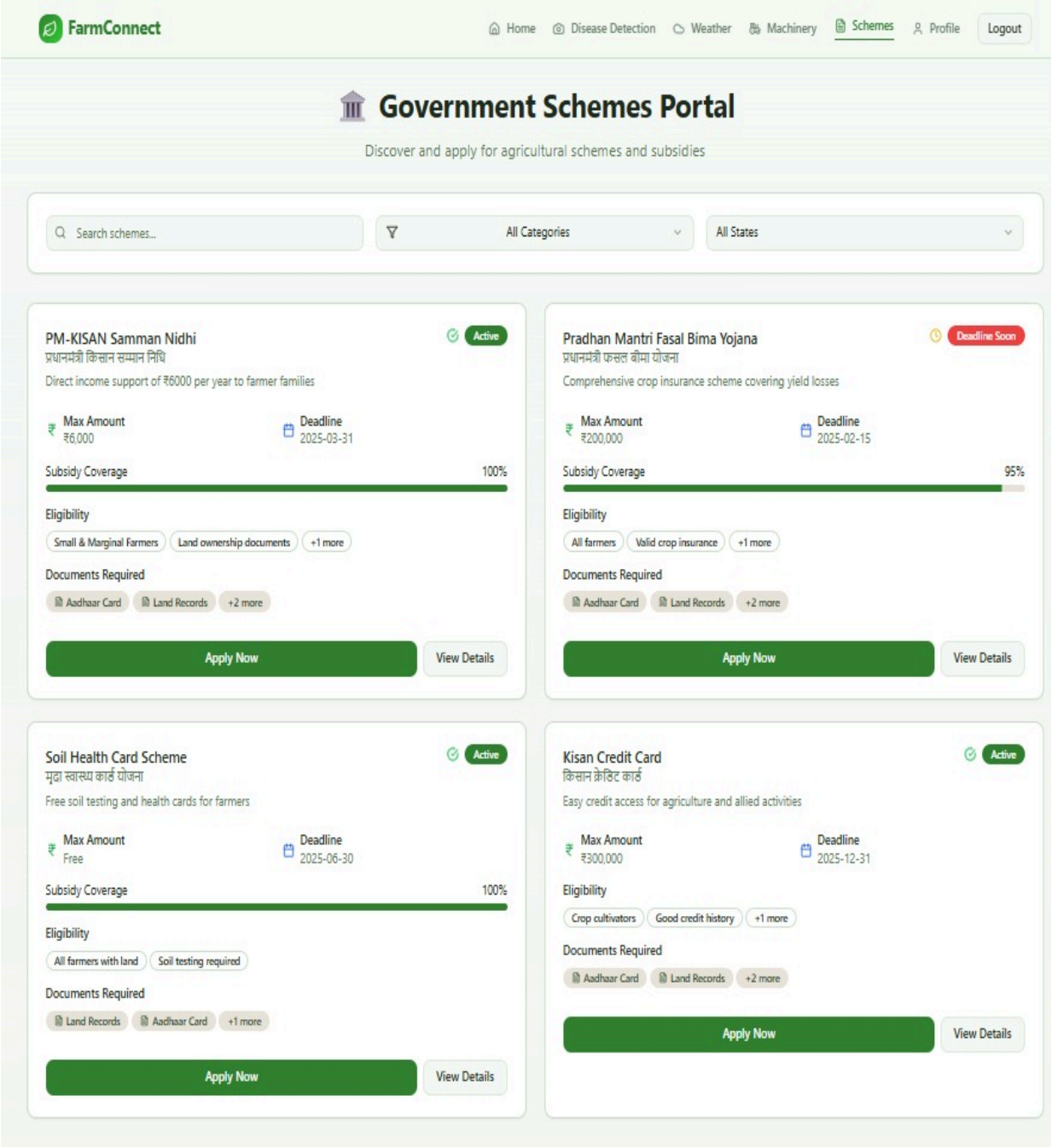
This image displays the AI Disease Detection module, where farmers can upload crop images and instantly get disease identification, confidence levels, and treatment suggestions.



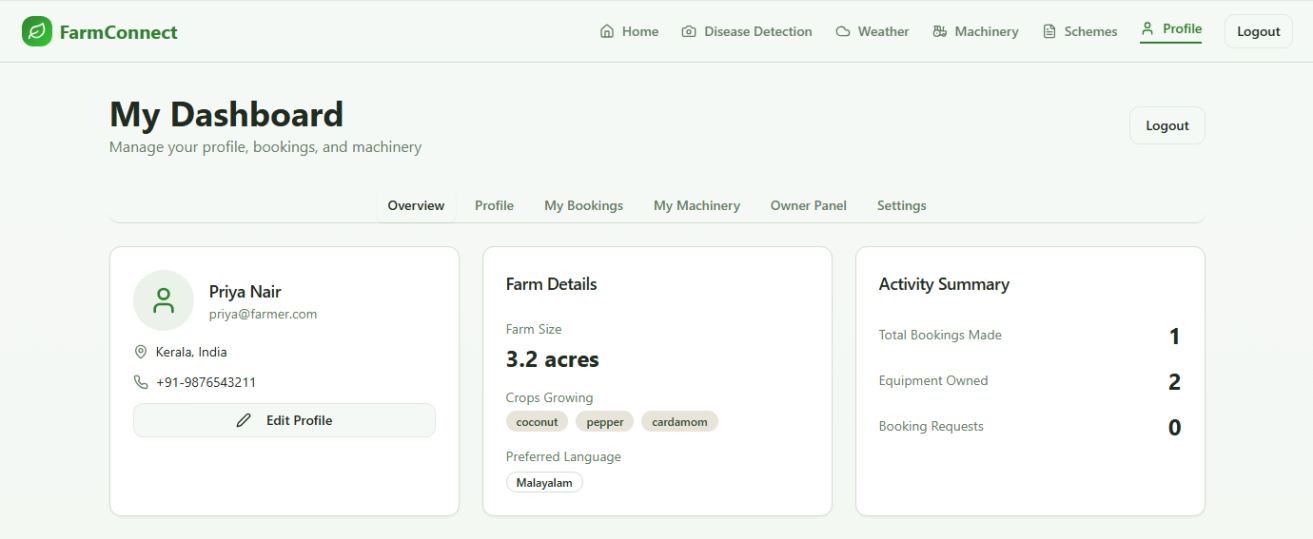
The screenshot highlights the Machinery Marketplace, allowing farmers to browse, compare, and rent agricultural machinery from nearby locations.

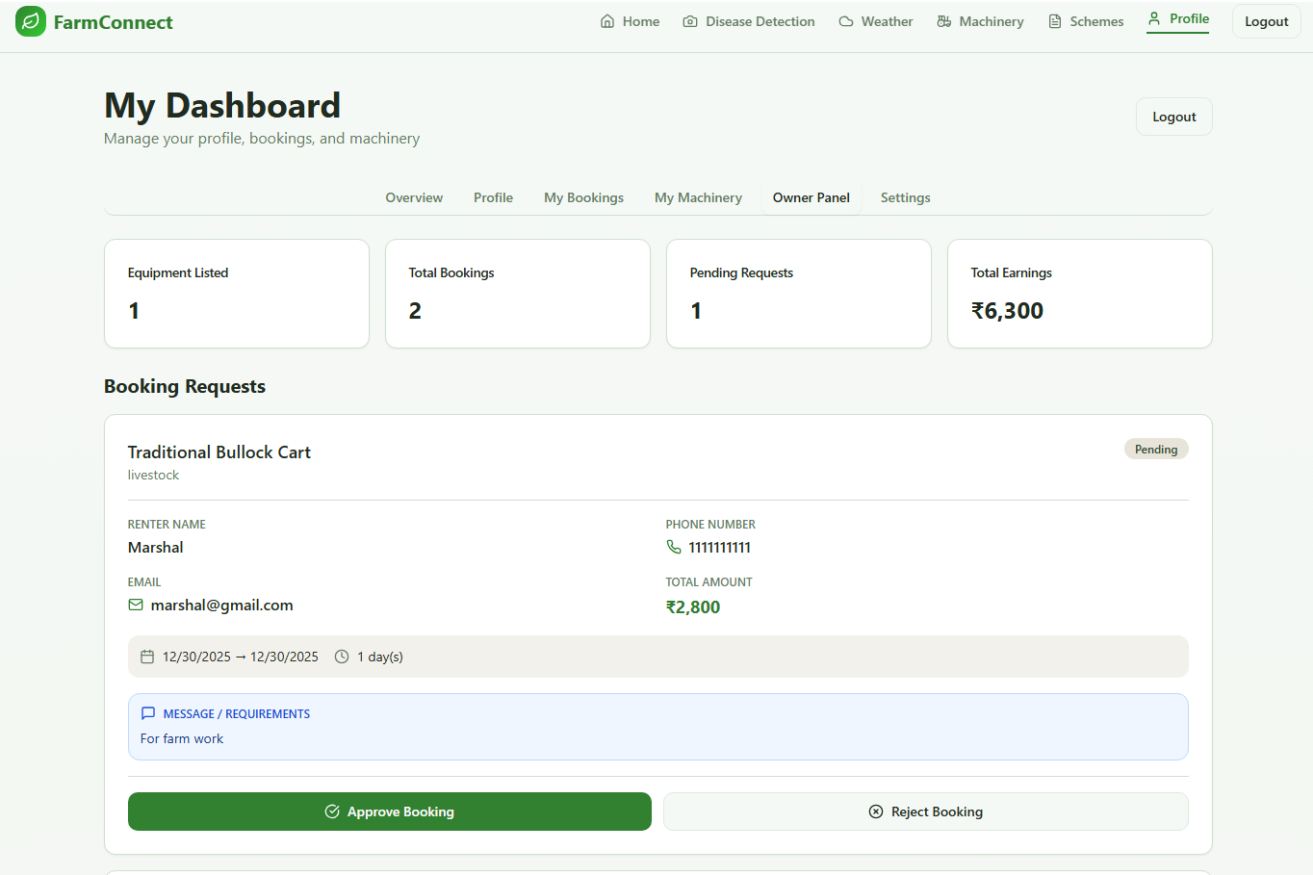


This image shows the Weather Dashboard, providing real-time weather updates, rain forecasts, alerts, and personalized irrigation and crop protection advice.



The screenshot displays the Government Schemes Portal, where farmers can discover, check eligibility, and apply for various agricultural schemes and subsidies.


FarmConnect
Home
Disease Detection
Weather
Machinery
Schemes
Profile
Logout
My Dashboard
Manage your profile, bookings, and machinery
Logout
Overview
Profile
My Bookings
My Machinery
Owner Panel
Settings
Priya Nair
priya@farmer.com
Kerala, India
+91-9876543211
Edit Profile
Farm Details
Farm Size
3.2 acres
Crops Growing
coconut
pepper
cardamom
Preferred Language
Malayalam
Activity Summary
Total Bookings Made
1
Equipment Owned
2
Booking Requests
0


FarmConnect
Home
Disease Detection
Weather
Machinery
Schemes
Profile
Logout
My Dashboard
Manage your profile, bookings, and machinery
Logout
Overview
Profile
My Bookings
My Machinery
Owner Panel
Settings
Equipment Listed
1
Total Bookings
2
Pending Requests
1
Total Earnings
₹6,300
Booking Requests
Traditional Bullock Cart
livestock
Pending
RENTER NAME
Marshal
PHONE NUMBER
1111111111
EMAIL
marshal@gmail.com
TOTAL AMOUNT
₹2,800
12/30/2025 → 12/30/2025
1 day(s)
MESSAGE / REQUIREMENTS
For farm work
Approve Booking
Reject Booking

7.FACILITIES REQUIRED:

7.1 Hardware Requirements

7.1.1 For Development Team

Component	Minimum Specification	Recommended Specification
Processor	Intel Core i5 (8th Gen)	Intel Core i7/AMD Ryzen 7
RAM	8 GB DDR4	16 GB DDR4
Storage	256 GB SSD	512 GB SSD
Display	1080p Full HD	1440p+ with accurate colors
Network	Stable broadband (10 Mbps)	High-speed fiber (50+ Mbps)

7.1.2 For Testing Devices

Device Type	Specifications
Android Smartphones	Android 7.0+, 2GB+ RAM, Chrome browser
iOS Devices	iOS 13+, Safari browser
Tablets	8"+ screen, any modern browser
Desktop/Laptop	Any modern browser (Chrome, Firefox, Edge)

7.1.3 For End Users (Farmers)

Component	Minimum Requirement
Smartphone	Android 7.0+ or iOS 13+
RAM	2 GB minimum
Storage	100 MB free space for PWA
Camera	5 MP+ for disease detection photos
Internet	3G/4G mobile data or WiFi

7.1.4 Server Infrastructure

Component	Specification
Backend Hosting	Render (Node.js server)
Frontend Hosting	Vercel
Database	MongoDB Atlas (Cloud)
CDN	Cloudflare or similar
SSL	HTTPS encryption

7.2 Software Requirements

7.2.1 Development Tools

Category	Tools
Code Editor	Visual Studio Code
Version Control	Git, GitHub
API Testing	Postman, Thunder Client
Design	Canva, Figma, Draw.io, Lucidchart
Browser DevTools	Chrome DevTools, React DevTools

7.2.2 Programming Languages & Frameworks

Layer	Technology	Version
Frontend Language	TypeScript	5.x
Frontend Framework	React.js	18.x
Build Tool	Vite	5.x
CSS Framework	Tailwind CSS	3.x
UI Components	Shadcn/UI, Radix UI	Latest
Backend Runtime	Node.js	18.x+
Backend Framework	Express.js	4.x
Database	MongoDB	6.x

7.2.3 Libraries & Packages

Package	Purpose
Axios	HTTP requests
react-router-dom	Client-side routing
@tanstack/react-query	Server state management
react-hook-form	Form handling
Bcrypt	Password hashing
Jsonwebtoken	JWT authentication
lucide-react	Icon library
Recharts	Data visualization
openai	Groq LLM API integration
@google/genai	Google Gemini AI integration

7.2.4 External APIs & Services

Service	Purpose	Provider
AI/Vision API	Disease detection (image analysis)	Groq LLM / Google Gemini AI (gemini-2.5-flash, gemini-2.5-flash-lite)
Weather API	Real-time weather data	WeatherAPI.com
Speech Recognition	Voice input (STT)	Web Speech API (browser native)
Speech Synthesis	Voice output (TTS)	Speech Synthesis API (browser native)
Database Hosting	Cloud MongoDB	MongoDB Atlas
Deployment	Web hosting	Render (backend) / Vercel (frontend)

8. PLAN OF WORK:

Sr. No.	Phase	Activities	Timeline
1	Topic Selection & Analysis	Selecting project theme, understanding farmer problems, identifying scope and objectives	Aug 2025
2	Literature Review	Studying research papers, agricultural platforms, government schemes, market systems	Aug-Sep 2025
3	Requirements Gathering	Collecting feature requirements, user needs through surveys and interviews	Aug-Sep 2025
4	Requirements Analysis	Analyzing requirements, identifying modules, preparing flowcharts	Sep 2025
5	SRS Documentation	Finalizing functional/non-functional requirements, completing documentation	Sep 2025
6	System Design	Designing architecture, DFDs, module interactions, technology selection	Sep-Oct 2025
7	Dataset Collection	Gathering weather data, market data, crop disease information from APIs	Oct-Nov 2025
8	AI Integration	Integrating AI providers (Groq default, Gemini optional), implementing disease detection logic	Oct-Dec 2025
9	Prototype Development	Building React frontend, implementing core features (login, dashboard, weather)	Nov-Dec 2025
10	Testing & Documentation	Preparing reports, testing, creating presentation materials	Dec 2025-Jan 2026

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