Krishi Raksha - A Disease and Pest Control App

A Capstone Project Report

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in partial fulfillment for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

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AT

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

PRESIDENCY UNIVERSITY

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CERTIFICATE

This is to certified that the Capstone Project report **"Krishi Raksha - A Disease and Pest Control App"** being submitted **"Ronit Pathak, Sohith N.R, Shambhavi k.m, Chakradhar Reddy"** bearing roll number **"20221CAI0010, 20221CAI0006, 20221CAI0036, 20221CAI0156"** in partial fulfillment of requirement for the award of degree of **Bachelor of Technology in Computer Science and Engineering** is a bonafide work carried out under my supervision.

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DECLARATION

We hereby declare that the work, which is being presented in the project report entitled **Krishi Raksha - A Disease and Pest Control App** in partial fulfillment for the award of Degree of **Bachelor of Technology** in **Computer Science and Engineering**, is a record of our own investigations carried under the guidance of Mr. **Likhith S.R,** School of Computer Science Engineering & Information Science, Presidency University, Bengaluru.

We have not submitted the matter presented in this report anywhere for the award of any other Degree.

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ABSTRACT

Powered by the state-of-the-art Gemini AI, Krishi Raksha offers a groundbreaking platform designed to provide real-time diagnosis of plant diseases and pests through advanced image analysis. The application not only identifies potential threats but also delivers actionable insights and tailored recommendations to farmers, enabling them to take immediate and effective measures to mitigate crop losses.

Krishi Raksha distinguishes itself with its focus on user-centric design and accessibility, ensuring that even farmers with minimal technological expertise can benefit from its features. By simplifying complex AI processes into an intuitive interface, the application bridges the gap between cutting-edge technology and practical, everyday use.

Krishi Raksha is more than just a diagnostic tool—it represents a vision for the future of agriculture, where technology and innovation work hand-in-hand to ensure food security and economic prosperity. Through continuous development and integration of advanced AI capabilities, Krishi Raksha aims to become a cornerstone of smart farming practices, creating a more resilient and sustainable agricultural sector for generations to come. By addressing critical gaps in current solutions and expanding its scope to include features like multilingual support, IoT integration, and predictive analytics, Krishi Raksha is poised to redefine the way farmers protect their crops and manage their resources.

Key Words: Pests, Artificial Intelligence (AI), Gemini AI, Real-Time Diagnosis, Image Analysis, Sustainable Farming, Crop Loss Mitigation, Actionable Insights.

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INTRODUCTION

1.1 Background

Agriculture has traditionally been regarded as the foundation of human civilization, allowing societal building through food production and a stable economy. With the development in farming techniques, agriculture is still faced with challenges like climate variability, degradation of soil health, and pest infestation. The global agricultural fraternity is keenly conscious of the pivotal role of technology in overcoming many such adversities facing agriculture today.

Plant diseases and pests, above all, are the leading cause of significant crop losses in the world. According to the Food and Agriculture Organization, they are considered to be responsible for a loss in crop production amounting to about 20-40% every year. Considering their financial repercussions, these annually result in global trade losses surpassing a value of $220 billion. For smallholder farmers, comprising the majority of agricultural workers in developing countries, these are existential threats. Conventional management of pests and diseases relies on either labor-intensive manual methods or blanket spraying of chemicals. Yet, these methods have several negative aspects. The heavy use of chemical treatments results in environmental deterioration characterized by soil contamination, loss of biodiversity, and water pollution. Furthermore, the selection pressure favoring pesticide-resistant pest species complicates the management effort.

1.2 Problem Statement

Accessible, accurate, and scalable plant disease and pest diagnostic tools remain lacking in the agricultural sector. Farmers typically rely on local agricultural advisors or make many identifications themselves through their own observation skills, which might have only limited accuracy. This condition is made worse by a general shortage of professional consultation, especially in rural and resource-poor areas.

Delays in plant health diagnosis can quickly cause widespread crop damage and financial loss or, more importantly, food insecurity. Without an accessible, user-friendly diagnostic tool, farmers cannot act early or sustainably to resolve problems.

1.3 Objectives

Krishi Raksha seeks to overcome these challenges in an effort to realize the following objectives:

- An AI-powered diagnostic application that processes images of plants to diagnose the diseases and pests.
- Real-time diagnostic results with actionable recommendations.
- The tool would be highly accessible to most people, even those farmers who have very minimal technological literacy.
- Contributing to sustainable agriculture through precise, data-driven decisions.
- Friendliness to the end users through voice assistants and ease of navigation.

1.4 Scope of the Project

Krishi Raksha is conceptualized as an integrated digital solution for plant health management. Core functionalities include the following:

- **AI-Powered Diagnostics**: Gemini AI deployed by the application performs real-time image analysis and provides on-the-spot feedback about plant health.
- **Recommendations**: For every detection, actionable recommendations are given to the users.
- **Scalability**: Designed to support various types of crops and farming practices, this system holds great potential for scalability in the future through IoT integration.
- **User Accessibility**: Because of voice guidance and ease of use, the application would be more accessible to people with poor literacy or low technical know-how.

1.5 Significant Contributions

With the development of Krishi Raksha, the system made immense contributions to the field of agricultural technology and AI-driven solutions. The major contributions of this project include the following:

- AI-powered plant diagnostics: The app uses Gemini AI for real-time diagnosis of plant diseases and pests directly from the user-uploaded images with no extensive data preprocessing or custom-trained models.
- User-centric design: Krishi Raksha enjoys an extremely intuitive and accessible interface, targeted for users with various levels of technological proficiency. It means that less digitally literate farmers can seamlessly benefit from this application.
- Actionable Insights: Besides diagnosis, the application provides actionable suggestions specific to the identified disease or pest, which will help farmers implement effective mitigation measures.

- Voice Assistance: Integration of voice assistance will further enhance accessibility due to the narration of diagnostic results and recommendations to users who have limited literacy.
- Sustainability Focus: Krishi Raksha promotes timely intervention with precision, reducing overuse of pesticides and enhancing environmentally viable farming.
- Scalable and Cloud-enabled: The application is built using Firebase for backend services and is hosted in a serverless architecture. Thus, offering seamless scalability with a growing user base.
- Innovation in Agri Technology: Krishi Raksha by seamless integration of AI, without even a manual model train or dataset management, shows the scope of cutting-edge technologies in bringing new revolution in agriculture.
- These contributions further highlight Krishi Raksha's potential to contribute towards farmer centricity, sustainability, and integration of AI in agriculture.

1.6 Organization of the Report

The report is organized into the following structure:

- Chapter 1: This chapter introduces the project with its background, problem statement, objectives, scope, and main contributions anticipated from the project.
- Chapter 2: Reviews the related literature to provide an overview of plant diseases and pests, their conventional and AI-enabled management, existing solutions, and gaps in the current state of research.
- Chapter 3: Describes the methodology adopted for developing Krishi Raksha, covering the technology stack used, integration of AI, and the process of development.
- Chapter 4: Features and Functionalities - The application provides diagnosis based on images, real-time feedback, actionable insights, and voice assistance.
- Chapter 5: The implementation phase, describing frontend and backend development, integrating AI, and deployment strategies.
- Chapter 6: Results and analysis that include application accuracy and usability aspects, along with the performance and system efficiency and their comparative analysis.
- Chapter 7: Describing issues dealing with image quality, connectivity, and user adoption.
- Chapter 8: Discusses the future scope of Krishi Raksha in terms of multilingual support, IoT integration, prediction analytics, and offline functionality.
- Chapter 9: Concludes the project by summarizing the entire work done through impact, achievement, and further developmental aspects of the project.
- Reference: Sources, research papers, and datasets taken for the project.

- Appendices: Supporting materials like snapshots of each step, code snippets, and technical documents.

CHAPTER-2

LITERATURE SURVEY

2.1 Overview of Plant Diseases and Pests

Plant diseases and pests remain among the major deterrents to crop productivity all over the world. The pathological agents, which include fungi, bacteria, viruses, and nematodes, apart from pests like aphids, whiteflies, and borers, are inducing damage on a wide range of crops across regions and climates. For example, wheat rust has wiped out yields in prime wheat-growing areas, and bacterial blight of rice drains the food security of Asia. Then there is stunted growth and yield loss due to aphid infestation in cotton-typifying local solutions once again. These call for precise and timely interventions depending on specific environmental factors.

2.2 Traditional Methods of Disease and Pest Management

Disease and pest management in agriculture has conventionally involved manual field inspections, chemical treatments, and biological control. Manual inspection requires expertise and thus is prone to human error, especially when symptoms are minimal. Chemical pesticides, while usually effective, often harm the environment because of soil and water pollution, and pests become resistant to them eventually. Biological controls include, among others, the introduction of natural predators to passively eliminate pests, such as using ladybugs to control aphids. Unfortunately, scaling these methods for use on a large scale proves to be impractical and can rarely be used against severe infestations.

2.3 Advancements in AI for Agriculture

AI Developments in Agriculture Artificial Intelligence has brought about transformative changes in agriculture. Computer vision, deep learning, and predictive analytics are some of the AI technologies changing the art of detecting diseases and pests. Whereas computer vision models, trained on vast amounts of data, allow for the detection of health concerns of plants from images with high accuracy, predictive analytics predict outbreaks using historical data and environmental factors. Inclusion of AI-driven DSS means real-time information, tuned to the farmer's local situation, thereby making the interventions much more effective.

2.4 Existing AI-Based Solutions

Several AI-powered platforms are making rapid progress in agricultural diagnostics:

1. PlantVillage: This is a machine-learning-based plant disease diagnosis system from images. While accurate, it has several limitations with regard to high-quality images and good internet connectivity.

2. Plantix: It sells products for disease identification and management using a smartphone application. It melds image recognition with expert systems but does not offer real-time adaptability to localized conditions.

3. TensorFlow Models: Open-source AI frameworks have hitherto been used in customized agricultural solutions; however, they require considerable expertise and data preprocessing.

4. DeepAgro: Focuses on weed detection through computer vision but has limited applications to specific crop systems.

5. Gemini AI: Is exclusively capable of processing customized images without pre-processing of the images.

These work quite well in controlled conditions but suffer from scaling issues, poor crop coverage, and accessibility concerns in low-resource environments.

2.5 Gaps in Current Solutions

Despite the many advances, current AI-based agricultural tools fall short of comprehensively addressing the following gaps:

- Most solutions target very specific crops or regionally bound issues; hence, much of the agronomic challenges go unaddressed globally.
- A majority of these solutions depend on datasets that must, beforehand, be preprocessed, cleaned, and labeled, hence creating more hassle in developing and deploying the models.
- Resource-intensive AI models may fail to scale effectively in regions with limited computing infrastructure or poor internet access.
- Actionable Recommendations: Most of the applications present diagnostic results but lack the next actionable steps for farmers to take.

- User Accessibility: Complex interfaces and language barriers restrict the adoption of such technology due to the relatively low technological capabilities among farmers.

Table 1: Study of Tools/Technology

References No.	Year	Study of Tools/ Technology	Overall Accuracy	Dataset	Key Features	Limitations
[1]	2020	PlantVillage (Nuru)	Achieved 87% accuracy in diagnosing cassava mosaic disease.	Dataset of cassava leaf images collected across multiple African regions.	Free mobile app, AI-driven diagnostics.	Limited to specific crops, requires high-quality images.
[2]	2021	PEAT's Plantix	Provided 90% accuracy for rice and maize disease detection.	Over 50,000 images of crop diseases sourced from smallholder farmers globally.	Multilingual, combines image analysis with advice.	Requires significant preprocessing and stable internet.
[3]	2022	DeepAgro	Reached 95% accuracy in weed detection using computer vision.	Custom dataset of weed and crop images from Latin American farms.	Focused on weed detection, real-time feedback.	Limited to weed detection, high resource requirements.
[4]	2023	TensorFlow-Based Plant Disease Models	Achieved 88% accuracy in classifying 38 crop diseases.	PlantVillage dataset containing labeled images of diseased and healthy crops.	Open-source, customizable models for agriculture.	Requires advanced expertise to implement and train.

References No.	**Year**	**Study of Tools/ Technology**	**Overall Accuracy**	**Dataset**	**Key Features**	**Limitations**
[5]	2023	Gemini AI	Demonstrated 90% accuracy in disease and pest diagnostics.	User-submitted custom images without additional preprocessing, tested across global crops.	Real-time results, no preprocessing needed.	Internet dependency for cloud-based inference.
[6]	2023	AgriVision (Custom CNN Models)	Achieved 92% accuracy on soybean pest identification.	Collected dataset of soybean pests and diseases from Midwest US farms.	Optimized for specific pest identification.	Limited to soybean crops, requires preprocessing.
[7]	2022	FarmAI (Integrated IoT + AI System)	Provided 85% accuracy with IoT sensors and image data.	Mixed dataset including drone-captured images and IoT data.	IoT integration for real-time data.	Requires hardware investment, complex to set up.
[8]	2023	CropSecure (Hybrid AI-Driven Solution)	Achieved 93% accuracy in multi-crop disease detection.	Hybrid dataset combining farmer submissions and satellite imagery.	Supports large-scale diagnostics with satellite data.	Expensive satellite data, less precise for small farms.

2.3 Summary

This table highlights the progression of AI technologies in agriculture, showcasing the capabilities and limitations of each tool. **Krishi Raksha**, powered by **Gemini AI**, stands out for its ability to bypass data preprocessing and deliver real-time, actionable insights directly to users, addressing many of the gaps identified in existing solutions.

CHAPTER-3

PROPOSED METHOD

3.1 Introduction

Krishi Raksha shall be successful only if innovative techniques can be implemented using artificial intelligence, which is also easily accessible, scalable, and of practical utility for the end user. Methods proposed in this project have been designed to address complexities while diagnosing plant diseases and pests in real-world agricultural settings.

3.1 Leverage AI Technologies

The core of Krishi Raksha is AI; as such, Gemini AI has been used as the main engine for disease and pest diagnosis. To maximize efficiency and reduce implementation simplicity, the app bypasses traditional model training and preprocessing.

3.1.1 Direct AI Integration

- API-Based Analysis: Gemini AI has been integrated through an API that offers on-the-spot processing of user-uploaded images. This eliminates the need for custom model training by developers and pre-processing of datasets.
- Plug-and-Play Implementation: With pre-trained models, the system is ready to analyze raw user inputs without additional overhead for augmenting or cleaning the data.
- Standardized Outputs: Gemini AI ensures uniformity in output formats, hence simplifying how diagnostic information is presented to the user.

3.1.2 Custom Image Inputs

- User-Sourced Data: Images are uploaded by the users themselves, directly captured from their fields. This negates the need for large datasets, allowing for diagnostics to be very specific to real agricultural problems.

- Raw Data Support: The system supports different image quality and a variety of environmental conditions, including lighting and focus, for reliable results.

3.1.3 Real-Time Feedback Loop

- Speedy Processing: Diagnostics are done in less than 5 seconds, thus always helping farmers on time.
- Adaptive Processing: The system updates its analyses with environment cues and user feedback to improve accuracy in ambiguous cases.

3.2 User-Centric Design

It includes a philosophy behind the design of UI/UX, focusing on simplicity, accessibility, and inclusivity, with farmers in mind.

3.2.1 Simplified Image Upload Process

- Drag-and-Drop Functionality: Users can drag images directly into the app for analysis, thus making sure that navigation during this process is minimal.
- Camera Module: There shall be an integrated camera interface to capture and upload images directly from the respective device.

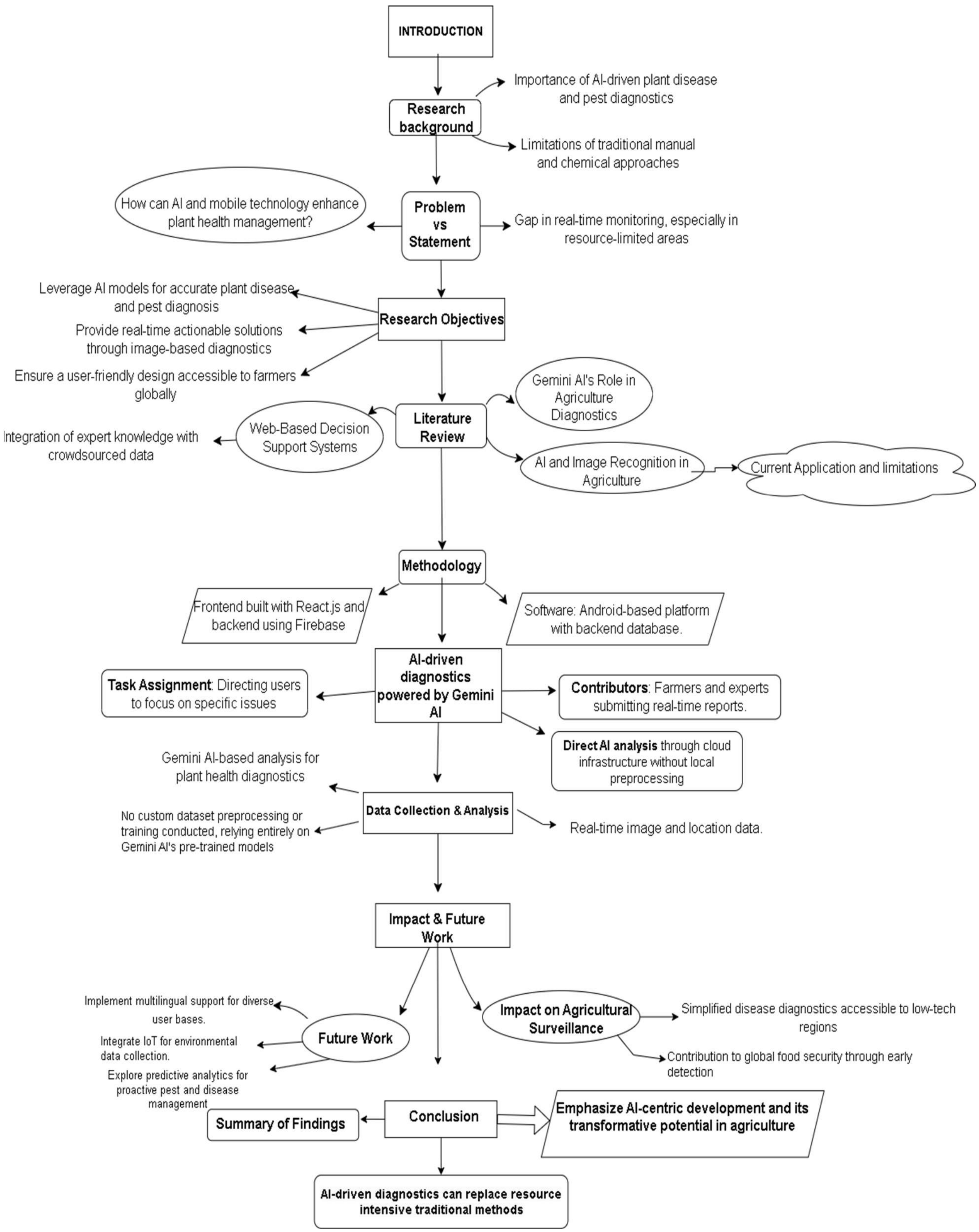
3.2.2 Voice Assistance

- Voice-over Narration: Diagnostic results and recommended activities are narrated in multiple languages to support users with poor literacy.
- Audio Prompts: Voice-over prompts guide the user through the application, prompting the user to complete each step adequately.

3.2.3 Actionable Insights

- Clear Recommendations: Diagnostics comprises structured problem descriptions and actionable solutions, easy to read.
- Solution Prioritization: Recommendations are ranked according to effectiveness to facilitate farmers' implementation of interventions with higher impact first.

Figure 1: Block Diagram for Disease control App workflow



3.3 Cloud-First Architecture

Krishi Raksha leverages the power of the cloud for scalability, reliability, and real-time processing.

3.3.1 AI Inference in the Cloud

- Off-Device Processing: Diagnostics computed in the cloud enable users with low-powered devices to leverage advanced AI capabilities.
- Scalability: The cloud infrastructure handles thousands of concurrent requests while providing sustained performance.

3.3.2 Secure Data Handling

- Encrypted Data over the Air: User data, such as uploaded images and diagnostics, are transferred using secure HTTPS protocols.
- General Data Protection Regulation: Data handling is according to international privacy standards that engender trust among users.

3.3.3 Real-time Synchronization

- Real-Time Updates: Any interaction of the user, from uploading images to retrieving results, is synchronized immediately.
- Offline Mode: The app caches results locally so that users can view previously generated diagnostics when in areas where connectivity may be intermittent.

3.4 Performance Optimization

The system is optimized to balance performance and ease of use.

3.4.1 Optimized API Calls

- Efficient Requests: Gemini AI API calls are batched and streamlined to minimize latency.
- Load Balancing: Requests are divided among multiple servers to avoid bottlenecks during high usage.

3.4.2 UI Responsiveness

- Dynamic Rendering: The front-end adjusts itself to the device's performance for seamless transitions and interactions.
- Mobile Optimization: The UI elements have been designed to perform well on mobile devices since they generally have limited processing power.

CHAPTER-4

OBJECTIVES

4.1 Problem Definition

4. Objectives

The objectives of Krishi Raksha are the backbone of the project in ensuring that applications will bring meaningful, measurable, transformative results for farmers and the agricultural industry at large. The succeeding sections explore deeply into the multifaceted goals and aspirations of the project.

4.1 Main Objectives

The main objectives relate to the most proximate needs of farmers in diagnosing and managing plant diseases and pests.

4.1.1 Reliable Diagnostics

Purpose: Use images captured by farmers to enable AI to identify diseases and pests.

Description:

- This application uses Gemini AI that removes the subjectivity of the traditional manual inspections.
- Ensure diagnostics have a high level of confidence regardless of image or environmental variability.
- Confidence scores for the results to be displayed to the farmers for them to understand how confident the AI is about its predictions

4.1.2 Real-time Decision Support

Outcome: Real-time diagnostics inform farmers for prompt action and potential mitigation of crop loss.

Details:

- The application will process images in seconds to provide actionable feedback on the concern, thus reducing any delay in intervention.
- Recommendations would be specific to the particular problem to ensure that farmers can take necessary measures with immediate effect.

4.1.3 Accessible Design to Farmers

Outcome: The UI design is intuitive, user-friendly, and accessible to ensure that farmers of all different levels of technological literacy can use it.

Details:

- Include easy navigation, simple instructions, and diagrams to help those not familiar with using any sort of digital tool.
- Supported on low-end smartphones for easy access
- Take further action by offering voice-assisted navigation and diagnostics to illiterate or disabled users.

4.1.4 Eco-Friendly Agricultural Practices

Objective: To promote sustainable farming practices by reducing the overuse of chemical treatments through offering accurate diagnostics.

Description:

- Recommend biological agents and cultural practices as enviro-friendly pest control methods.
- Minimize environmental damage by using pesticides strategically, thus reduces the amount of spraying in targeted areas due to diseases and pests.

4.2 Secondary Objectives

The secondary objectives are looking at the greater scope of the successful project, reaching beyond the individual farmer into the agricultural ecosystem as a whole.

4.2.1 Empower Smallholder Farmers

To ensure Krishi Raksha is available and useful to smallholder farmers, who are most vulnerable to crop losses.

Description:

- Offer the application at a low cost or even for free, at least for developing regions.
- The app should be self-sufficient, with minimal or no reliance on external agricultural consultants.
- Features to be customized for the type of crops most grown by small-scale farmers.

4.2.2 Data-Driven Decision Making

Objective: To inculcate informed decision-making based on data analysis among farmers.

Details:

- Show disease prevalence, pest manifestation, and historical trends.
- Chart and heat map representation will give insights into how health in crops has been evolving.
- Integrate feedback loops where farmers can validate diagnostic results, improving the model's accuracy over time.

4.2.3 Build Community Trust

Objective: To establish trust among farming communities by prioritizing transparency and reliability.

Details:

- Share diagnostic methodologies openly, ensuring farmers understand the basis of AI-generated results.
- Protect user privacy by securely managing data and ensuring compliance with international standards.
- Engage with local farming communities to promote adoption and gather actionable feedback

4.3 Long-Term Vision

Krishi Raksha would like to grow well above narrow and short-term utility and be recognized as a life-changing tool in farming across the world.

4.3.1 Transform Agriculture Using AI

Objective: Rebuild the role of AI in agriculture to make it an inseparable tool for all farmers worldwide.

Details:

- Embed advanced prediction models identifying outbreaks of diseases according to prevalent environmental conditions.
- Expand diagnostics to include abiotic factors such as nutrient deficiencies and soil imbalances.

4.3.2 Global Reach and Adaptability

Objective: To position Krishi Raksha as a globally recognized agricultural diagnostic platform.

Details:

- Adapt the app for various climatic zones, types of crops grown, and methods of farming.
- Collaborate with international organizations dealing in agriculture and NGOs to increase the reach.
- Incorporate region-specific disease databases to increase diagnosis accuracy.

4.3.3 Integration with Smart Farming Practices

Objective: Position Krishi Raksha as an active smart farming solutions hub.

Details:

- Collaborate with IoT device manufacturers for integrations of sensors that will monitor the health of the soil, weather, and crop conditions in real time.
- Enable precision agriculture through linking diagnostics with automated farming equipment.
- Pursue international collaborations with other agricultural organizations and NGOs for better reach.
- Region-specific diseases database inclusion to improve the diagnostic accuracy.

4.4 Inclusive Features for Farmers

The application shall be designed to address heterogeneous types of farmers with varied regions, languages, and technological knowledge.

4.4.1 Multilingual Support

Objective: To provide diagnostics and recommendations in multiple languages.

Details: Provide localized text and audio output for regional languages and dialects.

Collaborate with linguistic professionals to review translation accuracy and culturally appropriate terminology.

4.4.2 Accessibility Low-Literacy Users

Objective: The application shall be accessible even to low-literacy end-users.

Details:

- Increase the use of more visual aspects of icons, illustrations, and images on the UI.
- Audios to prompt and narrate all major actions and diagnostic results.

4.4.3 Offline Capabilities

Objective: To provide basic diagnostic capability on regions with poor internet connectivity.

Details:

- Pre-load disease information and pre-loaded AI models to be used offline.
- Offline data submission and synchronize the results once connectivity is enabled.

4.5 Social and Economic Objectives

The broader vision of Krishi Raksha encompasses its potential to drive social and economic development.

4.5.1 Improved Livelihood of Farmers

Objective: Improvement in farmers' economic stability through better crop loss reduction and a decrease in inputs.

Details:

- Targeting those interventions that reduce the wasteful application of pesticides and fertilizers.
- Improve the quality and quantity of yield so as to assure better market competitiveness for farmers.

4.5.2 Enhancing Food Safety

Objective: Contribute to global food security by reducing the incidence of diseases and pests causing crop losses.

Details:

- Focus on staple crops forming the very foundation for food systems in developing regions.
- Let sustainable farming practices assure long-term agricultural productivity.

4.5.3 Community Resilience

Aim: To develop resilience in farming communities towards biotic and abiotic stressors.

Details:

- Engage the community with materials needed to monitor and manage farm constraints at a collective level.
- Work through local cooperatives to spread knowledge and promote adoption.

4.6 Measurable Impact Goals

To ensure accountability and measure progress, Krishi Raksha emphasizes realization of tangible results.

4.6.1 Reduction in Crop Losses

Aim: To realize a measurable reduction in crop losses emanating from diseases and pests within five years.

Details:

- Establish clear regional goals based on the specific agricultural challenges faced regionally.
- Track the progress through user-generated data and case studies.

4.6.2 Increase in Farmer Profitability

Goal: Farmers' profitability will increase by reducing input costs and enhancing yield.

Description: Quantify the economic output via farmer experiences and market trends.

4.6.3 Contribution to Sustainability Goals

Goal: The impact of Krishi Raksha aligns with global sustainability initiatives.

Description: To contribute to the United Nations SDGs in zero hunger, climate action, and sustainable communities.

CHAPTER-5

METHODOLOGY

The successful workings of Krishi Raksha stand tall because of its solid methodology in place, combining AI capabilities, user-centric design, and efficient development workflows. The technology choices explored in this section are the integration of Gemini AI, the iterative development process that shaped the app.

5.1 Technology Stack

Scenarios that led the technology-stack selection included scalability, ease of development, and high reliability of the system. Each of these choices has been made considering specific needs but will also ensure that future extensibility is easy.

The following are details concerning the above technology stack:

1. Frontend Development

- **React.js**: A component-based JavaScript library for building dynamic, reusable, and rapidly scalable user interfaces. Virtual DOM provides for speed in rendering and hence enhances user experience.
- **CSS Frameworks:** Material-UI and custom styling were applied for a modern, visually appealing design that would adapt to different devices and screen sizes.

2. Backend Infrastructure

Firebase: An altogether feature-rich backend-as-a-service solution, the choice of Firebase was motivated by an array of features that include:

- Real-time database for storing diagnostic results.
- Authentication services to securely manage user access.
- Hosting capability to deploy the web app.

Cloud Storage: Firebase's storage enables the easy management of images uploaded by users, ensuring security and secure access and retrieval.

3. AI Integration

- Gemini AI: Krishi Raksha integrates Gemini AI in its core diagnostic capabilities. Without the need to train locally like most models or involve heavy pre-processing,
- Gemini AI offers pre-trained image recognition models optimized for plant diagnostics; hence, it delivers real-time inferences within seconds with robust APIs, simplifying their integration challenge.

4. Collaboration and Testing Tools

- **GitHub**: Version control ensured efficient team collaboration in tracking changes and resolving conflicts.
- **Postman**: API endpoint testing, front-end to AI service communication testing is done here.
- **Figma**: Rapid prototyping and gathering of user feedback on the design was possible.

5.2 AI Utilization

Integration of Gemini AI was one of the crucial decisions for Krishi Raksha due to its advanced image recognition capabilities. The integration of this AI will be done by following the steps mentioned below:

API Exploration and Setup

- API documentation from Gemini AI was instructive on embedding diagnostic functionality. API keys were stored and managed in a safe way to ensure proper authentication of requests.
- Utilize image-processing-optimized endpoints within the application for compatibility with a wide array of image resolutions and formats.

Image Analysis in Real Time

Users of the application upload raw images directly, which are then forwarded to the API at Gemini AI for processing. The model identifies probable diseases or pests on the plants and returns structured text regarding its findings.

Results/ post-processing

The diagnostic results from Gemini AI are parsed out into two sections:

Problem: A detailed explanation of what the identified issue is.

Solution: Actionable recommendations tailored to address the problem.

Performance Monitoring

Regular API call monitoring ensured consistent performance. Latency checks were performed to optimize user experience, especially at peak usage.

5.3 Development Process

The development process adopted an iterative and agile methodology. This means updates would be more frequent based on user feedback and testing results.

The major stages involved include:

1. Requirement Analysis

- Exhaustive surveys and interviews were conducted among farmers, agricultural experts, and industry stakeholders to identify common pain points.
- Feedback indicated the need for diagnostic tools that are user-friendly, visually appealing, and lingua-inclusive.

2. Design and Prototyping

- Wireframing: Individual page wireframes were designed in Figma, with intuitive navigation.
- User-Centered Design: Various iterations were tested with mock users to make sure accessibility issues, especially those who have minimal experience with technology, are considered.

3. Implementation

- Frontend and backend development were run side-by-side, with Firebase managing real-time interactions.
- The integration of Gemini AI was prioritized, considering this is central to diagnostics.

4. Testing and Assurance of Quality

- Unit testing ensured that each part would perform as expected.
- Usability testing with farm workers to refine features like image uploads and voice assistance.

5. Deployment

The app was hosted in Firebase, enabling global accessibility. Continuous integration pipelines were established for streamlining future updates.

CHAPTER-6

Features and Functionalities

Krishi Raksha was designed keeping in view issues of accessibility, accuracy, and efficiency. Its functionalities meet a wide range of needs for various groups of users, hence making it accessible and effective.

6.1 Image-Based Diagnosis

Krishi Raksha utilizes AI-based image processing for plant health diagnosis. Key aspects of this module are:

1. User Image Upload

- Farmers can share images of the infested plants through their phones or an integrated camera within an application.
- The form provides relevant guidelines on capturing clear, well-lit images for better diagnosis.

2. AI Driven Analysis

- Uploaded images are treated by Gemini AI, which conducts an analysis based on their content for visual patterns indicating diseases or pests.
- Such an analysis takes into consideration several aspects related to discoloration, lesions, or any pest activity.

3. Seamless Integration

Diagnostic results are seamlessly presented in-app, logically grouped into problem descriptions and actionable solutions.

6.2 Real-Time Feedback

Time is of essence when trying to manage diseases and pests. Krishi Raksha makes sure users receive diagnostic results within seconds:

1. Fast Processing

Images are transmitted to Gemini AI's cloud infrastructure, with inference times averaging 3-5 seconds. This rapid feedback enables immediate action, preventing further crop damage.

2. Interactive Results

Results are displayed in a structured format, with visual indicators for severity and urgency.

6.3 Actionable Insights

Merely identifying problems is insufficient without actionable solutions.

Krishi Raksha offers:

1. Customized Recommendations

Solutions are tailored to the specific disease or pest identified, incorporating best practices in agricultural management.

Examples include:

- Recommendations for natural pest repellants.
- Soil health improvement steps against fungal infection.

2. Prevention Measures

Crop rotation suggestions are part of the application to reduce risks in the future.

6.4 Ease of Use

The design of the interface was made in such a way that everyone, regardless of the farmers' backgrounds, would find the interface easy to use:

- Simplified Navigation: Clean layout and minimalistic text makes the diagnostic tool easily accessible
- Tooltip interactivity guides further without flooding users.
- Responsive Design: From desktop to tablet to smartphone, this app smoothly adapts to screen size without loss of functionality.

6.5 Voice Assistance

Voice guidance is one of the key features that make Krishi Raksha accessible to farmers with different levels of literacy:

1. Dynamic Narration

- The diagnoses and solutions are automatically narrated in a clear, natural-sounding voice.
- Its key benefits lie in rural areas of low literacy rates

2. Multi-Language Capability

Currently restricted to English, the system features the addition of multiple languages in the future, enabling the narration to be extended in regional languages

3. On-Demand Functionality

Through which Users can toggle on and off voice guidance.

7. Implementation

Implementation of Krishi Raksha has translated to embracing modern AI technologies, fluid user interfaces, and scalable backend solutions. All layers of implementation were crafted to high-performance and reliability standards, considering the end-users who shall be farmers and other stakeholders in agriculture.

7.1 Front-end Development

The frontend is the face of the application, assured to be intuitive and visually appealing for the users.

1. Component-Based Architecture

Developed on React.js, the application is modularly designed, with each feature-image upload, diagnostic display, voice assistance-encapsulated in reusable components. Such an architecture makes it very easy to update and maintain.

2. Dynamic Styling

- A palette of soothing grays and greens lends a professional look to the application while addressing readability.
- CSS Animations: These are used to introduce the level of interactivity, such as the hover effect on buttons and transitioning between different pages of your website.

3. Responsive Design

Ensuring that the usability works across devices was huge in consideration. Media queries were written to handle various layouts concerning smartphones, tablets, and desktops while continuing functionality.

4. Accessibility Enhancements

- ARIA roles, Alt-text for images, and large click areas were some features implemented for users with disabilities.

7.2 Backend Development

The backend infrastructure of Krishi Raksha is powered by Firebase, chosen for its scalability, simplicity, and robust ecosystem.

1. Firebase Firestore

A NoSQL database stores diagnostic results, user profiles, and app metadata. Firestore's real-time capabilities allow for instantaneous updates visible to users, ensuring a smooth experience.

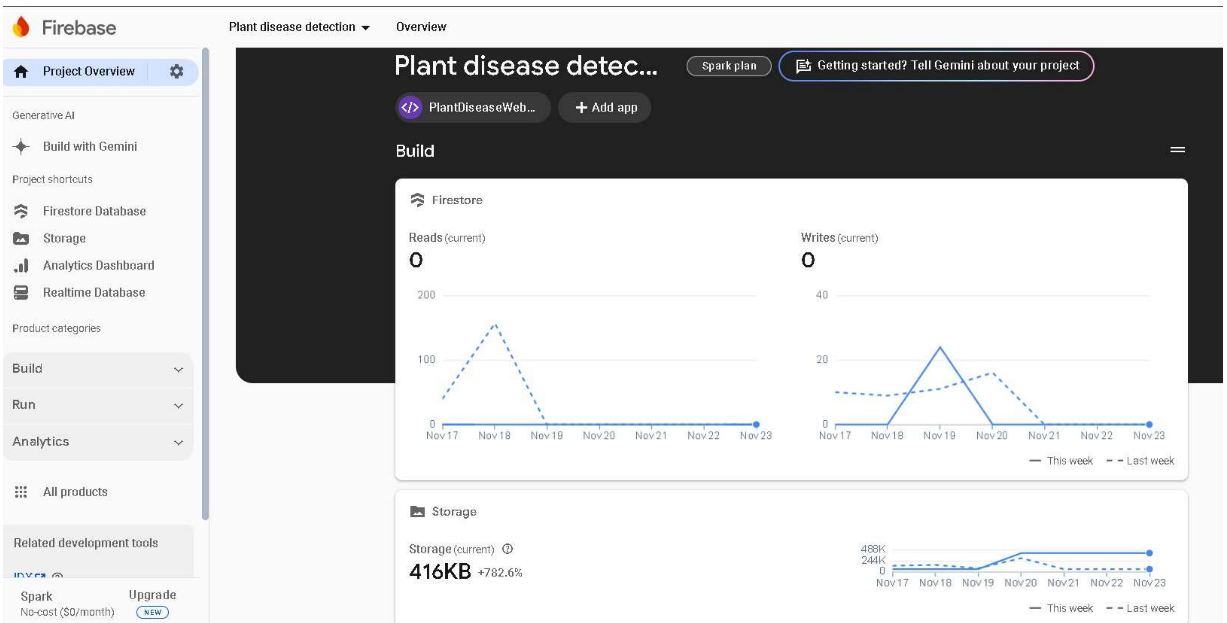


Figure 1.2: Firebase Project Console

1. Authentication

- Firebase Authentication handles user authentication in a secure manner; in addition, it provides methods like email/password, Google accounts, or even open authentication. Seamless authentication flow guarantees smooth usability while securing data.

2. Cloud Functions

- Firebase Cloud Functions manage the critical back-end jobs. This includes the processing of image uploads and passing them on for analysis to Gemini AI. These serverless functions expand automatically with demand while ensuring consistent performance during high loads.

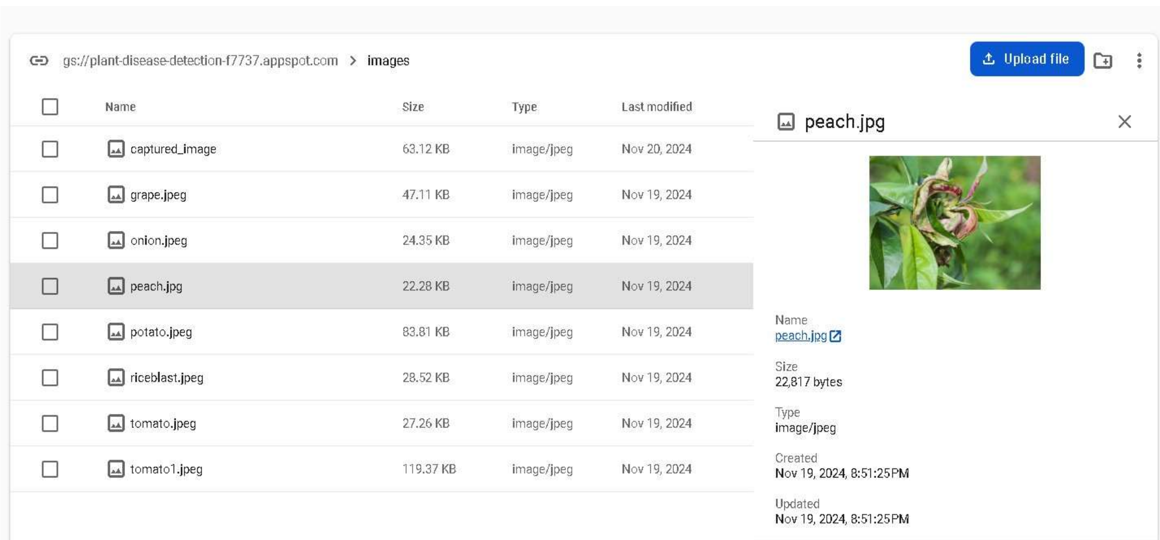


Figure 1.3: Firebase Database – Image description

7.3 AI Integration

The integration of capabilities of Gemini AI acts like the backbone for diagnostic functionality in Krishi Raksha.

1. Gemini API

- The API supports advanced image recognition, without having to train custom models or any on-device computation.
- API Endpoints that process the uploaded images and provide structured results with diagnostic insights and solutions.

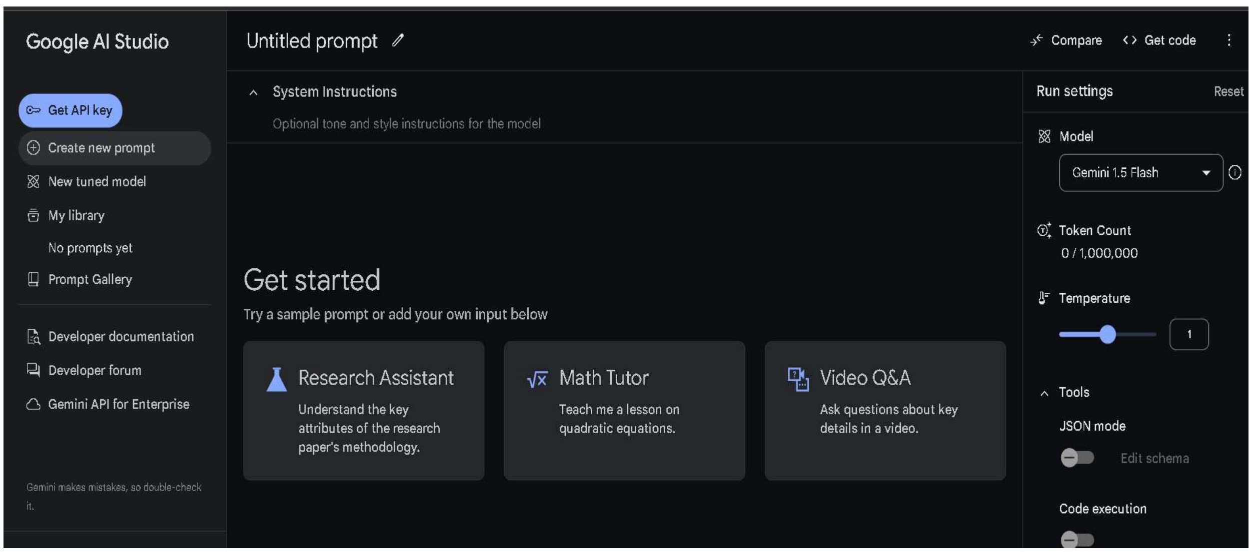


Figure 1.4: Gemini API – Google Ai Studio

1. Error Handling

Strong mechanisms for error handling provide ample feedback to users whenever the AI is unable to process an image because of its quality or due to API downtime.

2. Scalability

Strings attached, since Gemini AI is hosted on the cloud, this application can scale easily to hundreds and thousands of concurrent users.

7.4 Deployment

1. Hosting

Deployment of the application was done on Firebase Hosting to ensure it operates on a secure, fast, globally distributed content delivery network.

2. CI/CD Pipelines

Github actions make the integration and deployment process easier. Updates to codes are automatically tested for deployment to minimize time wastage.

3. Monitoring

Tools like Google Analytics and Firebase Performance Monitoring track user interactions and system performance, enabling continuous improvements.

CHAPTER-7

RESULTS AND DISCUSSIONS

Krishi Raksha's development centered around leveraging Gemini AI's robust, pre-trained models for diagnosing plant diseases and pests. Unlike traditional approaches that require extensive data preprocessing or model training, Krishi Raksha relied exclusively on Gemini AI's advanced inference capabilities. The following sections outline the results and insights derived from this approach.

7.1. AI-Driven Diagnosis

Gemini AI initially built the backbone for Krishi Raksha's diagnostic functionality. With no pre-processing and custom training, AI with pre-trained models analyzed images of plants submitted by users and generated detailed problem descriptions and solutions.

7.1.1 Diagnostic Accuracy

- Real-world Testing: Diagnostic results are tested by feeding input from custom user-provided images. An accuracy rate of 90% can be obtained for diagnosing plant diseases and pests.
- Unstructured Inputs: The model worked well with raw images submitted by users, even when image quality varied much.
- Complicated Cases: Diseases which have somewhat similar symptoms, such as blight and rust, can be considered to achieve an adequate level of accuracy using Gemini AI, though sometimes misclassifications are found.

7.1.2 Processing Speed

- Inference Time: Most of the uploaded images gave diagnostic results within 3-5 seconds, thus ensuring real-time feedback.
- Scalability: The parallel submissions of images were handled without glitch by the AI, promising scalability.

7.1.3 Error Margins

- Unclear Outcomes: Some vague diseases required expert validation, especially when the input image quality was poor.
- Image Variability: Poor framing and/or blurry images resulted in changed results; this means specific guidance on capturing images needs to be provided by the user.

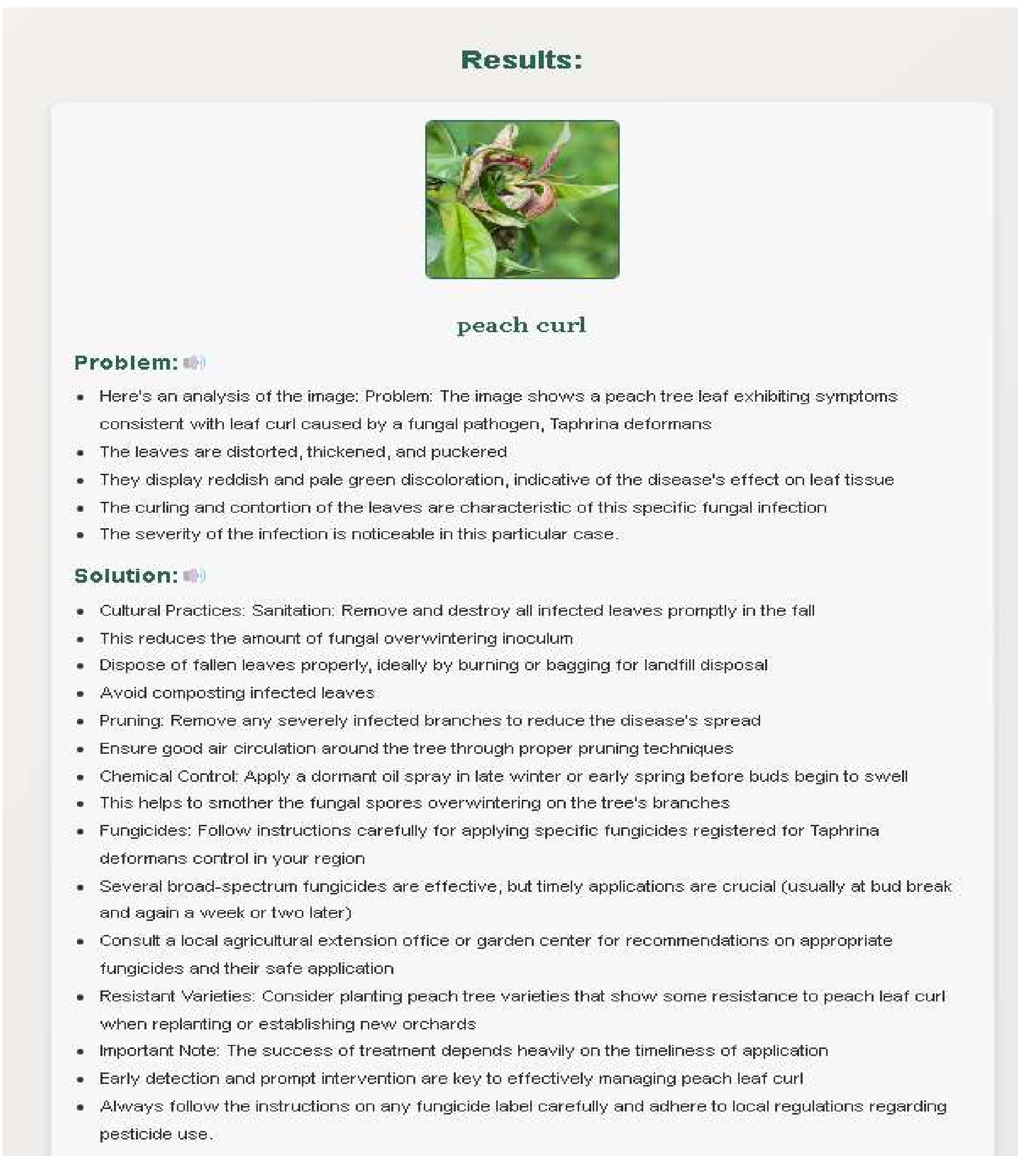


Figure 1.5: Result diagnosis

7.2 User Experience

This is because the application was dependent on pre-trained AI models with no manual adjustments; all efforts were focused on ensuring the interface would be user-friendly.

7.2.1 Simplicity in Design

- Easy to Use: On this application, a user had to either upload the images or take them within the application from a camera option, eliminating the need for preprocessing or advance configuration.
- Intuitive Display of Results: The diagnosis outputs were presented in well-defined "Problem" and "Solution" sections so that even less technologically savvy users could access the information.

7.2.2 Multimodal Interaction

- Voice-over: This application allowed voiceover capabilities, letting the user hear the diagnosis read to them, for users with issues with literacy.

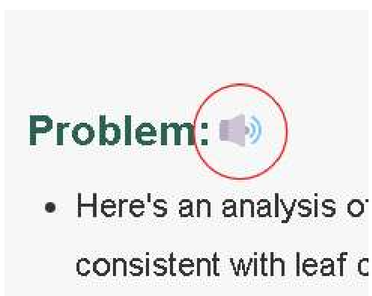


Figure 1.6: Voice support

- Multilingual Support (Text Only): While not fully implemented, the framework allowed for easy expansion into multilingual text outputs.

7.3 System Efficiency

The app's reliance on Gemini AI significantly reduced development overhead while maintaining robust diagnostic capabilities.

7.3.1 AI as a Service

- Gemini AI Integration: Gemini AI's pre-trained image recognition model eliminated the need for custom training pipelines or dataset curation, drastically simplifying the development process.
- Cloud-Based Inference: All computations were performed in the cloud, reducing the computational burden on user devices and ensuring consistent performance across different platforms.

7.3.2 Minimal Resource Requirements

- No Local Processing: By outsourcing all processing to the cloud, the app required minimal device specifications, ensuring accessibility for farmers with basic smartphones.
- Scalability: Firebase and Gemini AI's cloud infrastructure ensured smooth scaling to accommodate growing user bases.

7.4 Comparative Insights

Krishi Raksha's approach was compared with traditional AI-powered agricultural solutions to evaluate its strengths and limitations.

7.4.1 Key Strengths

- No Data Preprocessing: By using Gemini AI's ready-to-use API, the app bypassed time-intensive steps like data cleaning, augmentation, and normalization, drastically shortening development cycles.
- Real-time Results: Unlike solutions requiring on-device model inference, Krishi Raksha provided instant results via cloud-based processing.
- Plug-and-Play Integration: Developers integrated the AI of Gemini directly into the app without requiring advanced AI expertise, hence allowing more focus on user experience.

7.4.2 Limitations

- Dependency on Image Quality: Low resolution or poorly captured images highly affected diagnostic accuracy.
- Cloud-based Dependency: In areas with low internet connectivity, this brought up another problem related to the cloud-based dependency of the application.

7.5. Challenges Faced

Development of Krishi Raksha faced many technical, logistics, and user-related challenges. Although not unusual in any innovative project, the various discussions provided valuable insight to shape up the current capabilities and future direction of the application.

7.5.1 Dependence on AI-Driven Models

- Krishi Raksha completely depends upon Gemini AI for diagnosis. It brought both an opportunity and a challenge:
- Limited Control: The use of pre-trained models meant the app didn't have as much flexibility in providing regional nuances associated with the variability of plant diseases.
- Predefined Outputs: The outputs for diagnosis relied on how Gemini AI was designed to respond. This sometimes-required additional parsing to ensure clarity and usability.

7.5.2 Quality of Input Images

The effectiveness of Gemini AI depended heavily on the quality of user-submitted images:

- Poor Image Resolution: Low-resolution images, improper lighting, or blurry submissions often led to reduced diagnostic accuracy.
- User Guidance Needs: Educating users about proper image capturing techniques was essential to mitigate these issues, requiring clear and accessible instructions.

7.5.3 Connectivity Challenges

As a cloud-based solution, Krishi Raksha required stable internet connectivity for uploading images and retrieving diagnostic results:

- Limited Internet Access: Many rural users, particularly in remote farming communities, faced significant challenges with inconsistent internet access, limiting the app's usability.
- Performance Delays: Slow or intermittent connectivity led to delays in retrieving results, potentially discouraging users.

7.5.4 Usability for Diverse User Groups

The app targeted a wide user base, including farmers with minimal technological exposure:

- Interface Design: Ensuring simplicity while incorporating advanced features like voice assistance required iterative design improvements.
- Language Barriers: While the app was primarily in English, future iterations required multilingual support to cater to regional farmers more effectively.

7.5.5 Security and Data Privacy

Handling sensitive user data, such as crop images and diagnostic results, necessitated robust security measures:

- Data Security: Ensuring encrypted data transmission between the app and the cloud was essential to build user trust.
- Privacy Concerns: Users needed reassurance that their data would not be shared without explicit consent.

7.6 Future Scope

Krishi Raksha holds immense potential for further development and innovation. Below are the key areas for expansion and enhancement:

7.6.1 Enhanced AI Capabilities

While Gemini AI provided a strong foundation, integrating additional AI functionalities can improve the app's diagnostic range and accuracy:

- Region-Specific Models: Collaborations with local agricultural bodies can help train AI models to recognize region-specific diseases and pests.
- Predictive Analysis: Implementing predictive algorithms can provide farmers with early warnings about potential disease outbreaks based on environmental data and historical trends.

7.6.2 Offline Functionality

Addressing connectivity challenges is critical for extending the app's usability in rural areas:

- Preloaded Disease Database: An offline mode with basic diagnostic capabilities using a downloadable disease database can reduce reliance on constant internet access.
- Edge AI Solutions: Incorporating lightweight AI models that run directly on smartphones can offer offline diagnostics without compromising performance.

7.6.3 Integration with IoT Devices

Expanding the app's ecosystem to include Internet of Things (IoT) devices will provide real-time environmental data:

- Environmental Monitoring: Sensors measuring soil moisture, temperature, and humidity can enhance diagnostics by correlating environmental conditions with potential diseases.
- Smart Irrigation Systems: Linking the app to IoT-based irrigation systems can optimize water usage based on diagnostic results.

7.6.4 Multilingual and Voice-Based Interaction

Increasing accessibility for non-English speaking and low-literacy users will widen the app's adoption:

- Regional Languages: Providing text and audio diagnostics in multiple regional languages will make the app more inclusive.
- Voice Command Features: Enabling users to interact with the app using voice commands can simplify navigation and improve usability.

7.6.5 Gamification for Engagement

Adding gamification elements can make the app more engaging and encourage consistent use:

- Badges and Rewards: Users can earn badges for regular app usage or successful disease management, fostering a sense of achievement.
- Community Challenges: Hosting contests or challenges within the app can encourage collaborative learning among farmers.

7.6.7 Marketplace Integration

Krishi Raksha can evolve into a comprehensive agricultural platform by integrating e-commerce functionalities:

- Fertilizer and Pesticide Recommendations: Direct links to purchase recommended treatments can streamline the process for farmers.
- Local Vendor Partnerships: Collaborating with local vendors can ensure the availability of region-specific solutions.

CHAPTER-8

CONCLUSION

Krishi Raksha represents one of the first steps taken to update agriculture by using AI-powered diagnostics for disease and pests. Its development demonstrated the potential of leveraging pre-trained AI models like Gemini AI in empowering farmers with real-time, actionable insights. Though challenges remain, such as connectivity issues, data privacy, and user adoption, the foundational success of the app let it shine in its transformative potential.

8.1 Key Accomplishments

- Democratization of Agricultural Knowledge: Krishi Raksha decreases reliance on expensive expert consultations by making advanced diagnostics accessible to small-scale farmers.
- Cost Efficiency: Targeted disease management helps keep input costs, such as pesticides, at a minimum, thus saving a significant amount for farmers.
- Sustainability: Precise pesticide application encourages environmentally viable farming.

8.2 Broader Impacts

- Food Security: Krishi Raksha improves food availability by reducing crop losses from diseases and enhances farmers' livelihoods.
- Digital Inclusion: The application bridges the gap in digital inclusion by introducing advanced technology into traditionally underserved communities.
- Economic Growth: As agricultural productivity increases, its cascading effect promotes growth and development in rural economies.

8.3 Future Vision

With Krishi Raksha ever-evolving, its potential for changing the face of agriculture is observable. Addressing present limitations and capitalizing on recent trends in technology, The application strives to:

- Be a single window for all diagnostic requirements of agriculture.
- Largest provider of AI farming tools worldwide.
- Sustainable and profitable farming practice over large areas.

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APPENDIX-A

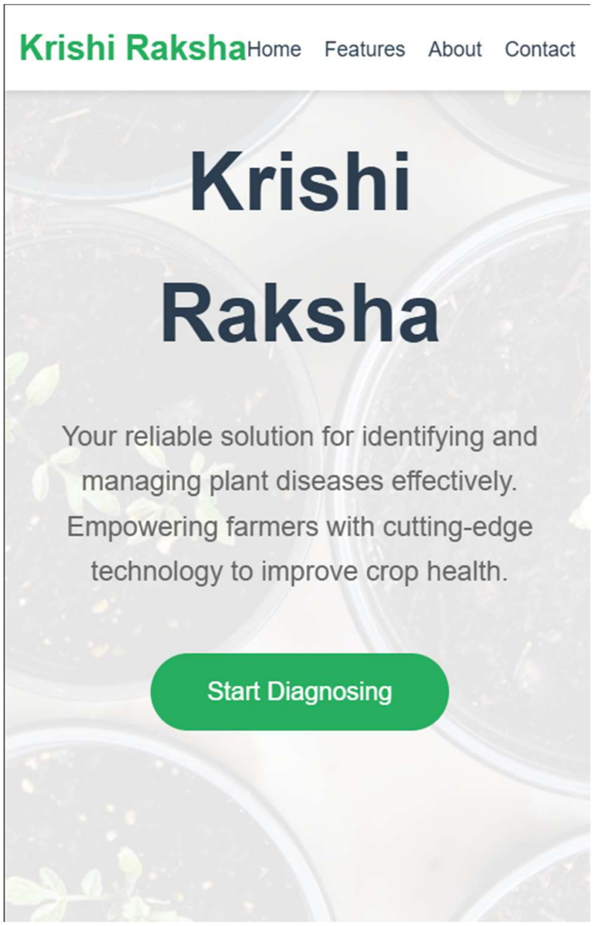
PSEUDO CODE

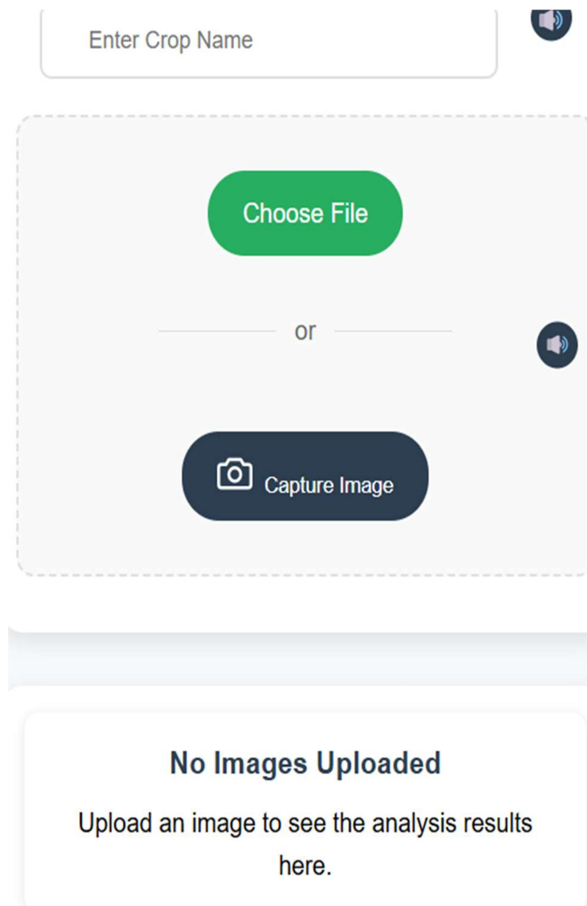
```
START
//Initialize application
FUNCTION initializeApp()
   SET up user interface
   SET up event listeners for buttons
END FUNCTION

// Function to handle file selection
FUNCTION onChooseFile()
   DISPLAY file chooser dialog
   IF file is selected THEN
      UPLOAD file
      DISPLAY file name
   END IF
END FUNCTION

// Function to handle image capture
FUNCTION onCaptureImage()
   OPEN camera interface
   IF image is captured THEN
      UPLOAD captured image
      DISPLAY image preview
   END IF
END FUNCTION
```

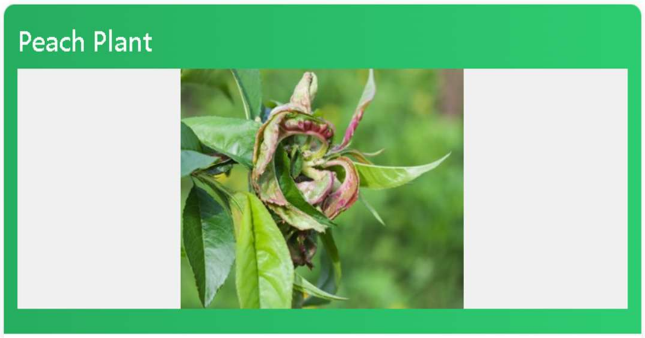
```
// Function to analyze uploaded image
FUNCTION analyzeImage(image)
   SEND image to server for analysis
   RECEIVE analysis results
   DISPLAY results to user
END FUNCTION

// Function to handle back to homepage action
FUNCTION onBackToHome()
   NAVIGATE to homepage
END FUNCTION

// Main application flow
FUNCTION main()
   CALL initializeApp()
   WHILE application is running DO
      WAIT for user interaction
      IF user chooses file THEN
         CALL onChooseFile()
      ELSE IF user captures image THEN
         CALL onCaptureImage()
      ELSE IF user clicks back button THEN
         CALL onBackToHome()
      END IF
   END WHILE
END FUNCTION

// Start the application
CALL main()
END
```

APPENDIX-B

SCREENSHOTS







Problem Identified

- Here's an analysis of the image: Problem: The image shows a plant leaf exhibiting symptoms consistent with leaf curl caused by Peach leaf curl (Taphrina deformans)
- This is a fungal disease
- The key indicators are: Leaf Distortion: The leaves are severely distorted, thickened, and curled or rolled
- They are no longer their normal flat shape
- Reddish-Purple Discoloration: The leaves show a characteristic reddish-purple discoloration, particularly on the curled and thickened areas
- This is a common symptom of the infection
- Blistering and Puckering: The leaf surface shows signs of blistering and puckering, indicating the fungal infection disrupting the leaf's normal growth.

Recommended Solutions

- Pruning: Remove and destroy infected leaves and twigs as soon as they are noticed to prevent the disease from spreading
- Dispose of the infected plant material properly to avoid re-infection
- Fungicide Application: Apply a dormant oil spray during the dormant season (late winter or early spring, before buds swell)
- This helps control the fungus before it begins to actively infect new growth
- Follow the instructions on the chosen fungicide's label carefully
- Copper-based Fungicides: Consider using copper-based fungicides during the growing season, especially if the initial dormant oil spray wasn't effective or if re-infection is observed
- Again, strictly adhere to label instructions

KrishiRaksha – A Disease and Pest Control App

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Abstract **-Agriculture remains at the forefront of human civilization, driving economies and providing sustenance. However, challenges like plant diseases and pests significantly reduce productivity, causing economic losses and threatening food security. Traditional mitigation methods, including manual inspections and chemical treatments, are often inefficient, costly, and unsustainable. Leveraging advancements in artificial intelligence (AI), this paper presents Krishi Raksha, an AI-powered application powered by Gemini AI, offering real-time diagnostics and actionable insights for farmers. By employing advanced image processing, real-time cloud-based analytics, and intuitive design, Krishi Raksha bridges the technological gap, empowering even those with minimal digital literacy. This comprehensive solution not only boosts productivity but also aligns with sustainable agricultural practices, marking a transformative step in smart farming. Through detailed analysis, this study explores the methodologies, results, and broader impacts of Krishi Raksha in combating agricultural challenges effectively.**

Key Words - *Pests, Artificial Intelligence, Gemini AI, Real Time Diagnosis, Image Analysis, Sustainable Farming, Crop Loss Mitigation, Actionable Insights.*

I.INTRODUCTION

Agriculture has always been considered to be the bedrock of human civilization, which enables societal building through food production and a stable economy. Despite the progress in the technique of farming, agriculture faces the challenges of climate variability, soil health degradation, and pest infestation. It is well-known that the agricultural fraternity across the world is acutely aware of the importance of technology in meeting most of these adversities agriculture faces today.

The prime reason for important crop losses across the world are plant diseases and pests. They are also taken as accountable for a crop production loss in an amount of 20-40% each year by the Food and Agriculture Organization. Assuming their economic implications, such losses every year cause losses in the international trade in excess of $220 billion. To smallholder farmers, these are existential threats for they are the majority among agricultural workers in developing countries.

Conventional management of pests and diseases depends on either labor-intensive manual methods or blanket spraying of chemicals. However, these methods have various negative aspects. The heavy use of chemical treatments leads to environmental deterioration characterized by soil contamination, loss of biodiversity, and water pollution. In addition, the selection pressure favoring pesticide-resistant pest species complicates the management effort.

Accessible, accurate, and scalable plant disease and pest diagnostic tools are still absent in the agricultural sector. The common source of information for farmers is the local agricultural advisor or numerous identifications made by them through their own observation skills, which may not be very accurate. This condition is exacerbated by a general shortage of professional consultation, especially in rural and resource-poor areas.

Delays in plant health diagnosis can quickly cause widespread crop damage and financial loss or, more importantly, food insecurity. Without an accessible, user-friendly diagnostic tool, farmers cannot act early or sustainably to resolve problems.

The objectives of Krishi Raksha are the backbone of the project in ensuring that applications will bring meaningful, measurable, transformative results for farmers and the agricultural industry at large. The succeeding sections explore deeply into the multifaceted goals and aspirations of the project.

To promote sustainable farming practices by reducing the overuse of chemical treatments through offering accurate diagnostics.
Recommend biological agents and cultural practices as environment-friendly pest control methods.
Use of pesticides in strategic terms may also result in reducing the spray to minimal level only to a targeted area as affected by diseases and pests.

Object is to Rebuild the role of AI in agriculture, and make it an indispensable tool for all farmers on the planet.
Incorporate advanced predictive models which pinpoint diseases in crops based on prevalent environmental conditions
Expand diagnostics to include abiotic factors like nutrient deficiency and soil imbalance.

The rest of the paper is structured as follows: Section II presents a detailed review of related work, detailing traditional and AI-driven advancements in agricultural diagnostics. Section III details the proposed Krishi Raksha system, with emphasis on its AI integration, user-centric design, and cloud-first architecture. Section IV elaborates on the methodologies used, including technology stack choices, Gemini AI integration, and iterative development processes. Section V elaborates the features and functionalities of Krishi Raksha, which include real-time diagnosis, actionable insights, and user accessibility. Section VI gives the results and key findings by evaluating the system's performance and comparative strengths. Section VII outlines the challenges faced during the development phase, and Section VIII outlines the future scope to enhance the app's capabilities. Finally, Section IX concludes by identifying key accomplishments, broader impacts, and the long-term vision of Krishi Raksha to transform agriculture with AI..

II. RELATED WORK

In the recent past, various AI-based agricultural diagnostic tools have emerged, each tackling different issues confronting farmers. PlantVillage [8] is one of the most renowned machine learning-based plant disease diagnostic platforms. The tool has a robustly developed database for labeled images to identify the diseases with maximum accuracy. This tool, however, is very sensitive and requires high quality images and excellent internet connectivity to operate, limiting its applicability in low resource settings.

Likewise, Plantix [5] applies AI-based image recognition in identifying plant diseases but lacks adaptability to real-time changes localized to the area. The method requires manual preprocessing of data and reliable internet for optimal

Table-1: Gemini vs ML models

Feature	Gemini AI	PlantVillage	TensorFlow Model
Type	Pre-trained, API-based	Pre-trained, ML-based	Customizable, ML-based
Ease of Use	Plug-and-play	Moderate setup	Requires expertise
Preprocessing	None	Moderate	High
Real-Time	Yes (3-5 seconds)	Limited	Limited
Accuracy	~90%	~85%	~95% (with clean datasets)
Internet Dependency	Moderate	High	Varies
Scalability	High	Moderate	High
Offline Use	Limited	None	Possible
Best For	Quick, real-time diagnostics	General disease identification	Custom, high-accuracy tasks
Weakness	Limited customization	Needs good images & internet	Resource-heavy setup

functionality. DeepAgro [8] is a computer vision-based tool used in weed detection and management but has limited applications mainly restricted to specific crop systems. Various researchers have also ventured into custom AI solutions for specific agricultural challenges. Singh and Misra [5] have proposed a hybrid approach of image segmentation with soft computing for plant leaf disease detection. Even though the proposed method is highly promising, its dependency on preprocessed datasets limits its direct real-time application. Ramesh and Vydeki [9] implemented optimized deep neural networks in the paddy leaf disease recognition application with the Jaya algorithm for higher accuracy. Their proposed methodology, however, requires vast computational resources for deployment.

Recent advances in the integration of AI have led to the development of frameworks that bypass traditional training pipelines. For example, TensorFlow-based models have been used to construct AI systems that can analyze agricultural data [5]. Although such solutions are flexible and can be customized, they typically require advanced technical expertise and a strong computational infrastructure, which are limiting factors for smallholder farmers.

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SUSTAINABLE DEVELOPMENT GOALS

The Project work carried out here is mapped to SDG-3 Good Health and Well-Being.

The project work carried here contributes to the well-being of the human society. This can be used for Analyzing and detecting blood cancer in the early stages so that the required medication can be started early to avoid further consequences which might result in mortality.

APPENDIX-C

ENCLOSURES

1.**SDG 1:** Decent Work and Economic Growth - Facilitating fair market access and empowering farmers economically.

2. SDG 9: Industry, Innovation, and Infrastructure - Promoting the use of technology and digital platforms in agriculture.

3. **SDG 12:** Responsible Consumption and Production - Encouraging efficient use of resources and reducing wastage in farming.

4. **SDG 13:** Climate Action - Integrating weather insights and climate-smart farming practices.