ST JOSEPH ENGINEERING COLLEGE

MANGALURU - 575028

ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

PROJECT-BASED LEARNING

FIRST EVALUATION REPORT

By

Luke Roman Noronha	**4SO23AI034**
Mahammad Salim	**4SO23AI035**
Prathama S Salian	**4SO23AI049**
Harish Deepak Bhovi	**4SO24AI400**

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PROBLEM DESCRIPTION

Unpredictable climate patterns and extreme weather events are increasingly disrupting agricultural productivity and market stability. Farmers face uncertainty in crop yields due to irregular rainfall, rising temperatures, and a higher risk of pest and disease outbreaks. At the same time, fluctuating market conditions make it difficult for them to secure stable and fair incomes.

One of the key challenges is the lack of real-time, data-driven tools that can assist farmers in predicting yield, managing resources efficiently, and planning the right time to sell their produce. Without such insights, decision-making remains reactive, often leading to significant financial losses and reduced crop sustainability.

Emerging technologies such as the Internet of Things (IoT), machine learning, and satellite imagery present an opportunity to address these issues. By enabling early disease detection, adaptive yield forecasting, and accurate price prediction, these tools can support climate-resilient and profitable farming practices.

This problem is particularly relevant to arecanut (Adike) farming in India, where climate variability, disease outbreaks, and price volatility directly impact farmer livelihoods. Building an integrated solution can empower farmers with actionable insights, enabling them to adapt to changing environmental conditions, enhance productivity, and strengthen their financial security.

PROBLEM STATEMENT

Arecanut (Adike) farming is a vital cash crop sector in coastal Karnataka, particularly in Mangaluru, Udupi, and nearby regions, where it forms the economic backbone of thousands of smallholder farmers. The major varieties cultivated in this region include Mettuguda, Hirehalli Dwarf, South Kanara Local, and Sidthi, each having distinct productivity and market value. Despite its prominence, farmers in the Mangaluru region face a set of persistent challenges that directly affect crop yield, quality, and profitability.

One of the foremost challenges is the outbreak of diseases such as Yellow Leaf Disease (YLD) and Koleroga (fruit rot), which can reduce yields by 30–50% if left unmanaged. These diseases are strongly influenced by the humid coastal climate, irregular rainfall, and prolonged monsoons typical of the region. Farmers often lack timely access to disease diagnostics and preventive measures, leading to significant losses.

Water management is another critical issue. The heavy dependence on traditional irrigation methods and monsoon rainfall leads to inefficiencies such as over-irrigation, which triggers root diseases, or under-irrigation, which causes drought stress during dry spells. These practices compromise tree health, nut quality, and long-term plantation sustainability.

Additionally, price volatility and dependence on middlemen are major concerns for farmers in Mangaluru. Limited access to real-time market data and reliance on local traders result in price exploitation and reduced bargaining power. Coupled with fluctuating prices—ranging anywhere from ₹36,000 to ₹49,000 per quintal depending on season and quality—farmers struggle to secure predictable incomes.

Climate variability further intensifies these issues. Changing rainfall patterns, rising temperatures, and frequent droughts disrupt flowering and fruiting cycles, while also degrading soil health. These stresses increase vulnerability to pests and diseases, making farming riskier and more uncertain.

Finally, the low adoption of modern technology such as IoT, precision farming tools, and AI/ML-based forecasting means that farmers continue to rely on traditional methods, missing opportunities to enhance productivity, predict diseases, optimise irrigation, and forecast prices effectively.

The scope of this problem in the Mangaluru region is therefore multi-dimensional—crop health, water management, climate resilience, and market access. The boundaries of our investigation will focus on integrating IoT sensors, climate monitoring systems, and machine learning models to provide farmers with early disease detection, adaptive irrigation advice, climate-resilient yield forecasting, and reliable price predictions.

This refined problem statement sets the foundation for our project, aiming to create a sustainable, technology-driven solution for arecanut farmers in Mangaluru and similar regions.

REPORT ON SECONDARY RESEARCH

Arecanut cultivation is crucial for many local economies, but struggles with crop diseases, inefficient pesticide use, poor irrigation, and limited farmer support. Technological advancements like machine learning, IoT, and mobile platforms present solutions such as automated disease detection, weather-based spraying, smart irrigation, and timely information sharing. However, most research addresses these challenges separately, highlighting the need for integrated systems. This review explores current advancements and opportunities for comprehensive, farmer-focused solutions in arecanut cultivation.

Disease Detection in Arecanut Plants Using Machine Learning

Arecanut cultivation is significantly affected by diseases such as Yellow Leaf Disease (YLD) and Fruit Rot, which reduce yield and crop quality. Traditional manual disease identification is time-consuming and error-prone. Recent advancements use machine learning (ML), especially deep learning models such as Convolutional Neural Networks and YOLO (You Only Look Once), to automate disease detection from leaf and fruit images with high accuracy. Studies have demonstrated over 97% accuracy using ResNet-based CNN models for detecting multiple arecanut diseases. YOLOv8 models have also shown promise in quick and precise disease classification, even with limited datasets. These AI-driven solutions reduce reliance on experts and offer real-time assistance to farmers.

Weather-Based Prediction for Pesticide Spraying

Pesticide application is effective only when timed properly to avoid contact with water (rain or irrigation), which can wash away chemicals, reducing effectiveness and potentially harming plants. Integrating weather prediction models with disease detection allows for intelligent recommendations on the best spraying times. Although limited research directly combines both disease detection and spraying time optimisation, this gap highlights the need for comprehensive systems that guide farmers holistically.

Informing Farmers about Government Schemes and Subsidies

Awareness of government welfare schemes and subsidies is crucial for farmer empowerment and the adoption of modern agricultural practices. However, dissemination of this information remains a hurdle in many regions. Incorporating a recommendation system or notification feature to inform farmers about pertinent schemes can enhance socio-economic benefits and technical solutions.

Smart Irrigation Systems in Agriculture

Water management is critical for crop health, with issues like overwatering and waterlogging causing diseases. IoT-enabled smart irrigation systems utilising soil moisture sensors and microcontroller-based automation have gained traction in ensuring optimal water usage. Such systems offer remote control via mobile apps and real-time monitoring, helping prevent water-related stress and disease conditions in crops.

Research Gaps

Despite significant progress in the application of machine learning and IoT technologies in agriculture, several critical gaps remain, particularly in the context of arecanut plant disease detection and management. Most existing research focuses separately on disease identification from images or on weather prediction for general agricultural purposes. There is a lack of integrated systems that combine precise disease detection with environmental analytics, such as weather data, to optimise pesticide application schedules. This separation limits the practical utility of these technologies for arecanut farmers who need comprehensive guidance covering both identification and treatment timing. While numerous models exist for generalised plant disease detection, few specifically target major arecanut diseases such as Yellow Leaf Disease (YLD) and Fruit Rot with high accuracy. Existing agricultural technologies often overlook the critical need for socio-economic empowerment through awareness of government schemes, subsidies, and support programs. This gap results in missed opportunities for farmers to leverage financial and institutional assistance, which can enhance the adoption of technology and modern farming practices. Waterlogging and improper irrigation are known contributors to disease vulnerability in arecanut plants, but most smart irrigation systems do not explicitly link water management to disease prevention strategies. There is a deficit of platforms that integrate soil moisture and environmental sensors with irrigation control and disease risk alerts, creating an important gap in proactive disease management.

Proposed Innovations

Integrated ML and Weather Analytics for Disease Management: The project uniquely combines ML-based detection of predominant arecanut diseases (YLD and Fruit Rot) with predictive weather analytics to recommend optimal pesticide spraying windows.

Farmer-Driven Government Scheme Awareness Module, incorporating a dynamic notification system that informs farmers about relevant government subsidies, welfare schemes, and agricultural support initiatives, empowers farmers socio-economically.

Smart Irrigation Control with Disease Prevention Focus Beyond conventional irrigation automation, the project integrates soil moisture and waterlogging detection sensors with mobile-based control, enabling timely adjustments to irrigation schedules.

Real-Time Price Detection Module: Utilising web scraping, government market data APIs, and historical price databases to provide farmers with current arecanut prices specific to their region and grade of produce.

User-Friendly, Mobile-Centric Platform with Offline Capability Recognising the connectivity challenges in rural areas. This increases technology reach and usability among small-scale and marginal farmers, accelerating adoption.

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REPORT ON PRIMARY RESEARCH

1. Executive Summary

This primary research was conducted for the Adike Mithra project to understand the critical challenges faced by Arecanut farmers, spanning disease management, irrigation, and market price volatility. The methodology combined farmer-level interviews/surveys with market-level price trend analysis.

Key findings reveal that Yellow Leaf Disease (YLD) is a primary threat, with over half of respondents reporting significant yield loss and relying on delayed detection methods. Economically, farmers face a price variation ratio of 3.5:1 between peak and off-peak seasons, exacerbated by a significant income gap due to commission and transport costs. The primary barrier to technology adoption is cost/affordability. These findings collectively justify the need for an AI/ML-based solution to provide early warning systems and price prediction tools.

2. Introduction and Research Objectives

The Adike Mithra project aims to develop a technological solution to mitigate the risks associated with Arecanut farming. The core objectives of the primary research were:

- To understand farmer-level challenges concerning diseases (specifically Yellow Leaf Disease and Fruit Rot), irrigation practices, and access to market information.
- To analyse mandi-level price fluctuations and market dynamics in the Mangaluru region.
- To identify the existing gaps in current practices and justify the necessity for a proposed AI/ML-based solution.

3. Methodology Overview

The research employed a mixed-methods approach to gather comprehensive data across two key levels:

Research Level	Data Collection Methods
Farmer Level	Direct interviews and a Google Form survey
Market Level	Online data collection and price trend analysis of mandi data

4. Farmer-Level Findings:

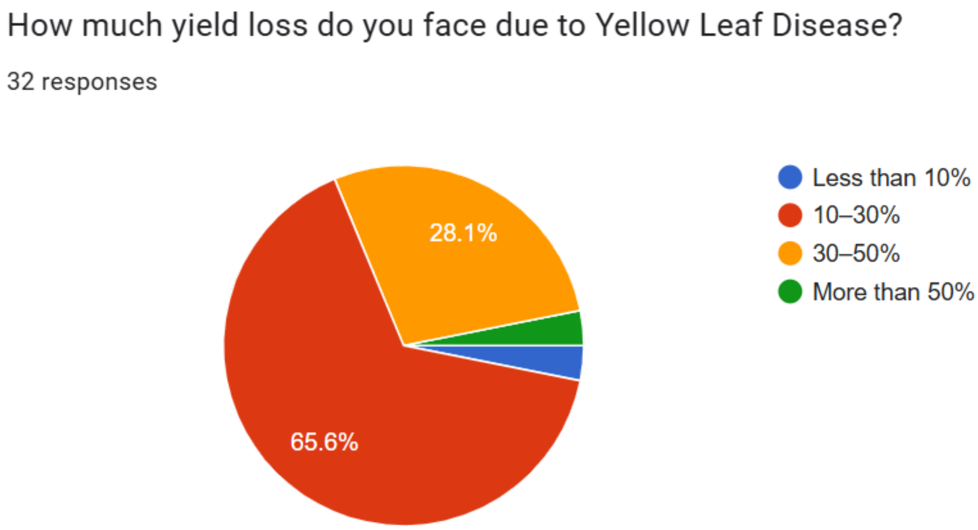
The farmer-level data were collected through a combination of structured surveys and direct interviews with Arecanut growers in the region.

4.1. Disease and Pest Management

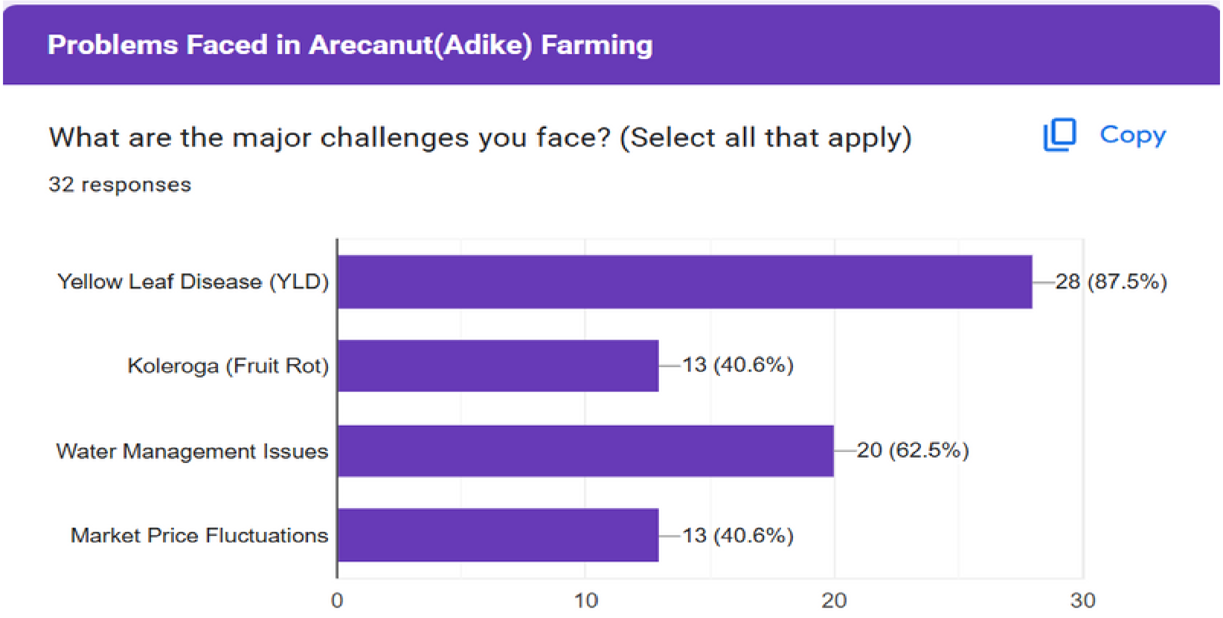
Common Diseases & Losses: The most prevalent issues reported are Yellow Leaf Disease (YLD) and Fruit Rot (Mahali). Farmers generally detect diseases late, after damage has occurred.

Key Visuals:

- Chart 1: "How much yield loss do you face due to Yellow Leaf Disease?"
    - ~33% reported 31–50% loss
    - ~25% reported 11–30% loss



- Chart 2: "What are the major challenges you face? (Select all that apply)"
  - YLD (~80%) and Price variation (~60%) emerged as the top challenges



Current Detection Methods:

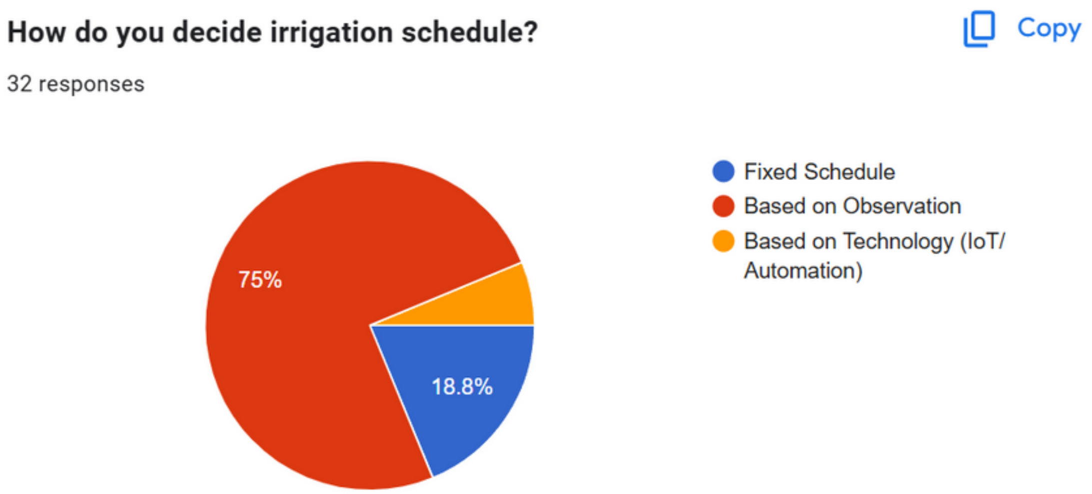
- Visual observation/personal experience (~40%)
- Farm Consultant/Expert (~40%)

4.2. Irrigation and Technology Adoption

Irrigation Dependency & Scheduling: Most farmers rely on rainfed irrigation or borewells.

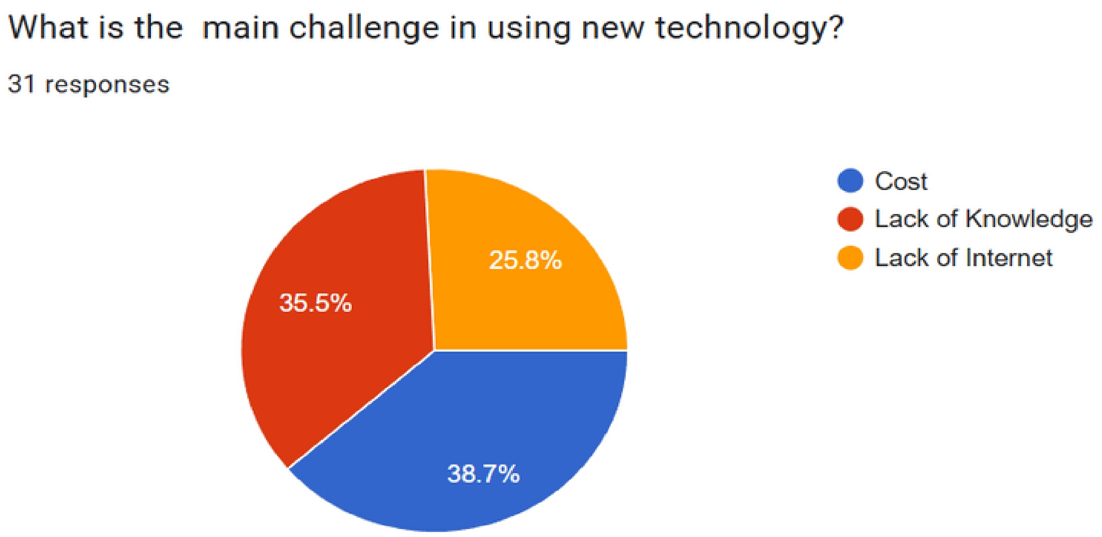
Key Visuals:

- Chart 3: "How do you decide irrigation schedule?"
  - Expert opinion/Traditional Knowledge (~75%)
  - Visual observation (~18%)
  - Around 0% using technology/apps



Barriers to New Technology:

- Chart 4: "What is the major challenge in using new technology?"
    - Cost/Affordability (~40%) is the main hurdle



Sensor Use:

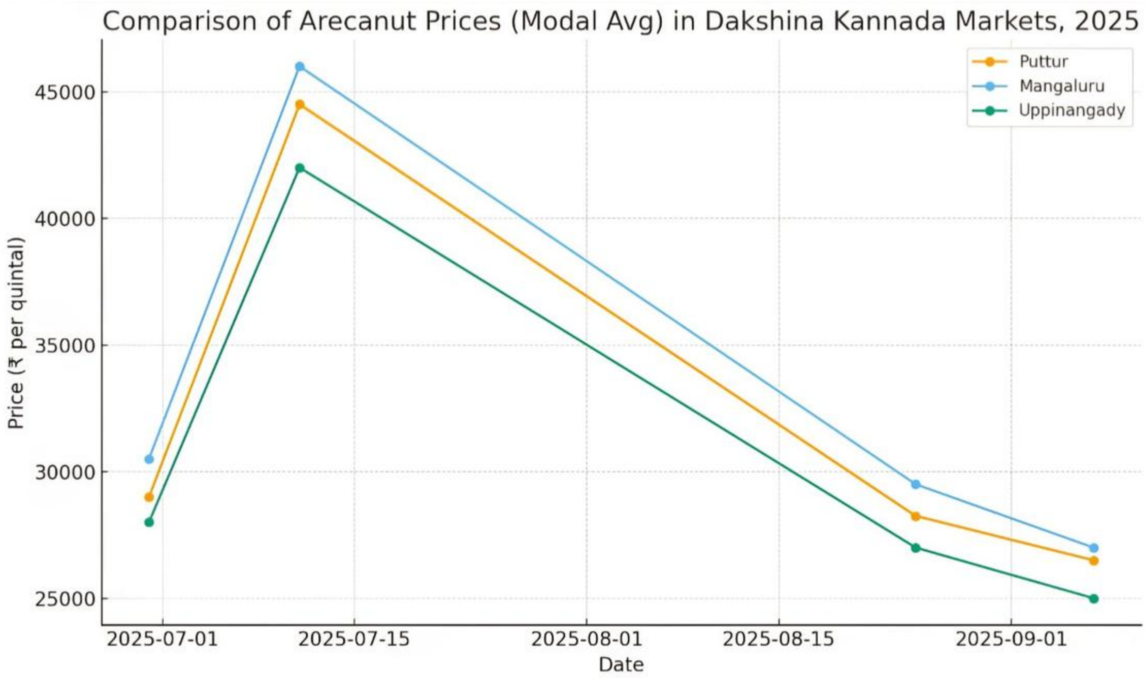
- ~65% of farmers do not use any soil moisture sensors

5. Market-Level Findings: Price Volatility and Dynamics (With Market Graphs)

5.1. Price Fluctuations and Regional Differences

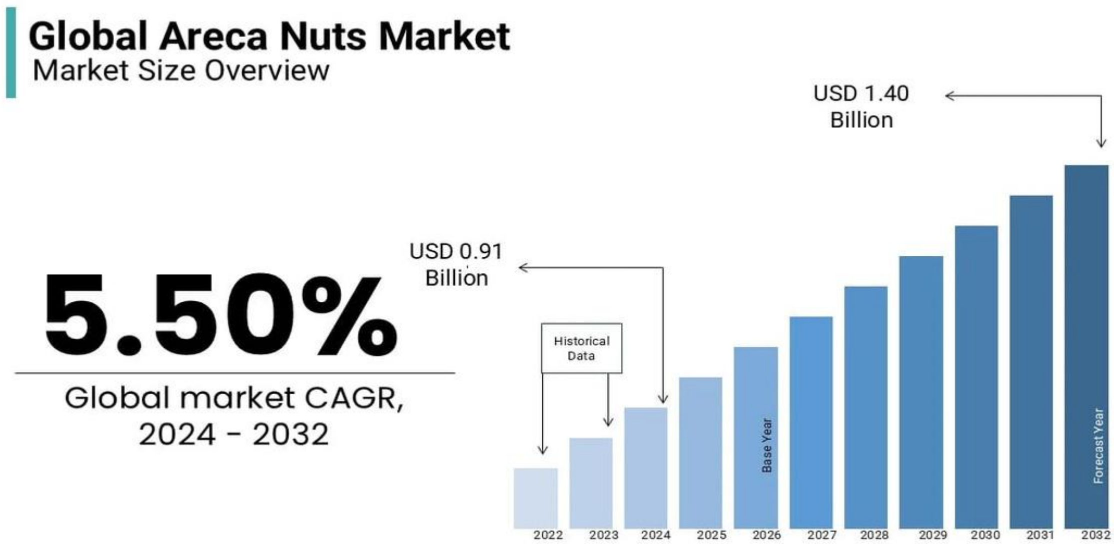
General Statistics:

- Price variation is exceptionally high (₹20,000 to ₹52,000 per quintal)
- Volatility ratio between peak and off-peak seasons is 3.5:1
- 25% of farmers are directly affected by this volatility
- Average seasonal mandi supply is 30,000 tons



Economic Gaps:

- Significant gap between final mandi price and actual farmer income
- High deductions for commission and transport costs reduce profitability



6. Conclusion and Implications

The research highlights three critical problem areas:

1. Disease Management: Farmers lack early detection tools for YLD and Fruit Rot, leading to substantial yield losses.
2. Irrigation Practices: Heavy reliance on traditional knowledge and a lack of affordable technology adoption hinder efficiency.

3. Market Volatility: Extreme price fluctuations and systemic deductions reduce farmer income stability.

These findings strongly justify the development of an AI/ML-based solution under the Adike Mithra project. The proposed system should focus on:

- Early disease detection through image-based AI models.
- Affordable irrigation advisory tools leveraging weather and soil data.
- Predictive price analytics to help farmers plan sales and reduce losses.

Such a solution has the potential to significantly improve farmer resilience, income stability, and long-term sustainability in Arecanut farming.

REPORT ON BRAINSTORMING

1. Project Identity

Parameter	Details
Project Name	Adike Mithra
Core Team Members	Luke Roman Noronha, Salim, Prathama, Harish
Core Problem Statement	Disease detection and management in Arecanut (Adike) plants, exacerbated by market volatility.

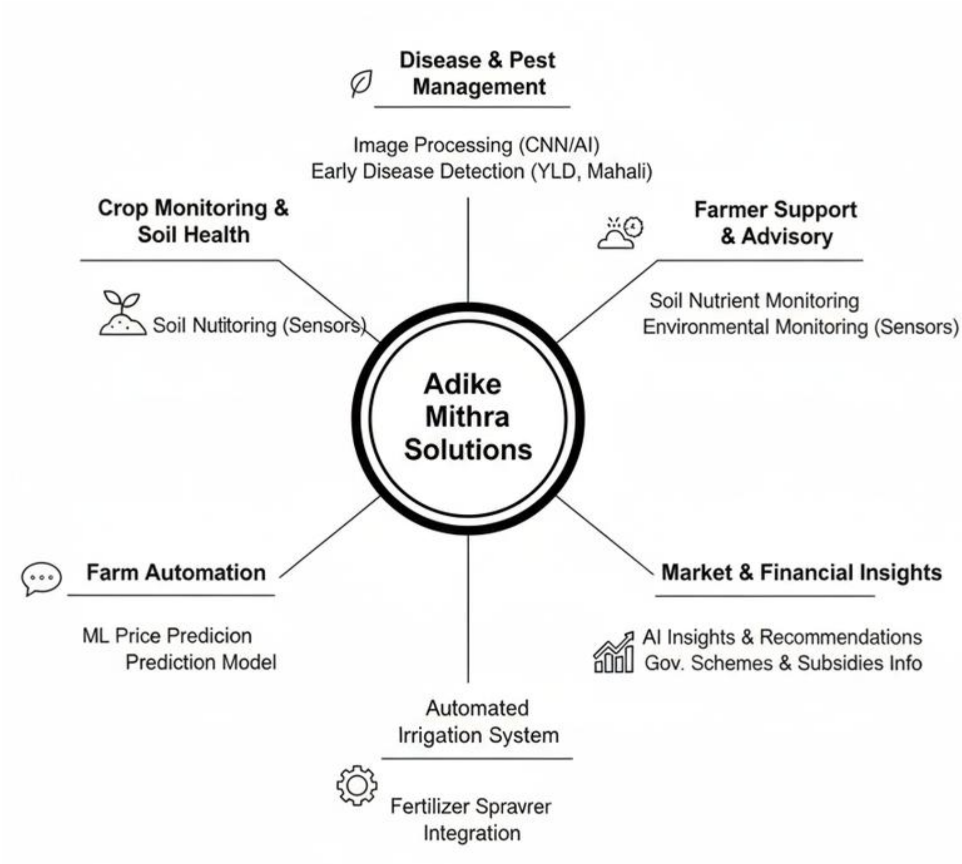
2. Solutions Brainstorming: Creative Ideas & Alternative Solutions Generated

The Adike Mithra team engaged in a dynamic brainstorming process, utilising techniques such as mind mapping, group discussions, and sketching to foster innovation and diverse thought. This collaborative effort generated a comprehensive set of creative ideas and alternative solutions, forming the core functionalities of the Adike Mithra technological system:

Solution Category	Key Functionalities & Innovative Ideas	Technology Focus
Disease & Pest Management	→ Usage of image processing (CNN/AI) for early disease detection (e.g., YLD, Mahali). This innovative approach aims for pre-symptom detection.	AI/ML, Computer Vision
Crop Monitoring & Soil Health	→ Monitoring of soil nutrients (via sensors). → Usage of sensors for environmental monitoring and management. Exploring continuous, real-time data for proactive insights.	IoT, Sensor Networks
Farm Automation	→ Automation of irrigation system (smart irrigation) tailored to crop needs. → Integration of a fertiliser sprayer (smart application) for precision farming.	IoT, Robotics

Market & Financial Insights	→ Price prediction using Machine Learning (ML) for optimised selling. → Climate prediction model for future planning and risk mitigation. These solutions provide crucial foresight.	ML, Time Series Forecasting
Farmer Support	→ Usage of AI for insights and recommendations, offering personalised advice. → Information about government schemes and subsidies, ensuring farmers have access to available support.	AI, Advisory Services

Mind Map:



3. Business Model Canvas (BMC) Summary

This section summarises the strategic framework for bringing the Adike Mithra solution to market.

BMC Component	Key Elements of Adike Mithra
Customer Segments	Areca nut farmers, Paddy farmers, and Other plantation farmers.
Value Propositions	→ Early disease detection. → Marketplace for produce (sales). → Plantation monitoring and management. → Smart irrigation (water/cost savings).
Channels	→ Mobile app (primary delivery). → Government schemes (partnering). → Tie-ups with agri dealers.
Customer Relationships	→ Online and offline support. → On-field support. → Subscription and updates. → Innovation (continuous improvement).
Revenue Streams	→ Subscription model (primary income). → Areca Sales/Loans (commission/finance facilitation). → Government Schemes (grants/subsidies). → Training & Advisory Services.
Key Resources	ML/AI models (core IP), APIs (weather/market data), Power data (big data), Technical team.
Key Activities	Product development (app/device), maintaining the platform, collecting data and providing insights.
Key Partners	Agri farmers/Agri experts, Government of India, Agri value chain bodies, Aqua Bio Company, Agricultural Universities, Financial institutions, Forward/Transport Organisations.
Cost Structure	Device Manufacturing, R&D of AI/ML models, Field demonstration, Maintenance (platform/app).

PROJECT BRIEF

Description Of the Project

Adike Mithra project aims to develop a comprehensive digital platform tailored specifically for arecanut farmers. The platform integrates advanced machine learning models to detect major arecanut diseases such as Yellow Leaf Disease (YLD) and Fruit Rot from plant images. Alongside this, it leverages weather prediction data to recommend optimal pesticide spraying times, ensuring pesticide application effectiveness while avoiding adverse weather like rain, which can wash away chemicals.

To empower farmers economically and socially, the system also includes a price detection module providing real-time market price updates and forecasts for arecanut, aiding farmers in making informed selling decisions. Further, it delivers timely notifications about government schemes, subsidies, and support programs relevant to arecanut cultivation, enhancing awareness and access to benefits.

An impactful extension of the project is the integration of a smart irrigation system. Using soil moisture and waterlogging sensors combined with mobile app controls, the system helps farmers monitor and manage irrigation remotely, preventing overwatering and associated diseases, thus promoting sustainable water use.

Objectives

- Develop and deploy an accurate ML model for identifying arecanut diseases (YLD, Fruit Rot) from images to facilitate early diagnosis and reduce crop loss.
- Incorporate real-time weather forecasting to advise farmers on optimal pesticide application times, maximising efficacy and reducing environmental harm.
- Provide dynamic, localised arecanut price updates and predictive insights to assist farmers in maximising sales returns.
- Inform farmers about relevant government assistance schemes, ensuring better awareness and easier access to financial benefits.
- Smart Irrigation Monitoring and Control to optimise irrigation practices and prevent disease-promoting conditions.

Target Users

- Small and medium-scale arecanut farmers.
- Agricultural extension workers and local advisory services are supporting arecanut farmers.

- Agribusiness stakeholders involved in supply chain and market analysis for arecanut.

Expected Outcomes

- Empowered farmers capable of independently diagnosing diseases and making timely management decisions.
- Enhanced crop yield and quality through timely disease intervention and optimised pesticide usage.
- Increased farmer income by leveraging real-time market price data and better selling strategies.
- Higher adoption of government welfare schemes and subsidies through targeted dissemination.
- Water savings and reduced disease incidence through smart irrigation management.

PLAN OF ACTION

Phase 1: Problem Analysis & Data Collection (Week 1–2)

- **Activities:**
    - Conduct a literature review on arecanut diseases, irrigation issues, and market trends.
    - Collect datasets (disease images, weather data, market price history).
    - Engage with local farmers in Mangalore and Udupi to gather real-world insights.
- **Responsibilities:** Research team + field survey team.
- **Milestone:** Problem scope finalised and datasets prepared.

Phase 2: System Design & Model Development (Week 3–5)

- **Activities:**
    - Design ML model for disease detection (Yellow Leaf Disease, Fruit Rot).
    - Develop weather-linked pesticide recommendation module.
    - Build a predictive model for market price forecasting.
- **Responsibilities:** Technical team (ML developers & data engineers).
- **Milestone:** Prototype ML models developed and validated with sample data.

Phase 3: Smart Irrigation Integration (Week 6–7)

- **Activities:**
    - Install soil moisture and waterlogging sensors.
    - Develop an IoT-based control system linked with a mobile app.
    - Integrate irrigation alerts into the platform.
- **Responsibilities:** IoT & hardware team.
- **Milestone:** Smart irrigation prototype is functional in the test field.

Phase 4: Platform Development & Integration (Week 8–9)

- **Activities:**
    - Build a mobile/digital platform combining disease detection, weather alerts, price forecasting, and government scheme notifications.
    - Integrate IoT irrigation module into the app interface.
- **Responsibilities:** Software development team.
- **Milestone:** First version of Adike Mithra platform ready.

Phase 5: Testing & Validation (Week 10–11)

- **Activities:**
    - Test platform with selected farmers in the Mangalore region.
    - Collect feedback on usability, accuracy, and relevance.
    - Refine models and platform based on feedback.
- **Responsibilities:** Testing team + farmer support team.
- **Milestone:** Validated platform with real-world performance data.

Phase 6: Deployment & Awareness (Week 12)

- **Activities:**
    - Launch pilot deployment with local arecanut farmers.
    - Conduct workshops and training sessions.
    - Disseminate the platform through cooperatives and extension workers.
- **Responsibilities:** Outreach & training team.
- **Milestone:** Platform officially deployed with active farmer participation.

Overall Timeline (12 Weeks)

- Weeks 1–2 → Problem study & data collection
- Weeks 3–5 → ML model development
- Weeks 6–7 → Smart irrigation integration
- Weeks 8–9 → Platform development
- Weeks 10–11 → Testing & validation
- Week 12 → Deployment & training