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AGROVA
AI-Powered Precision Farming

Om Bhatt

Team: AVM
Arya Vidya Mandir Group of Schools

Abstract

India is home to approximately 140 million farmers, yet an estimated 70% of them lack access to real-time, actionable data about their land, crops, and market conditions. This information gap contributes to an annual crop loss estimated at ₹50,000 crore. Compounding the problem, nearly 70% of rural India experiences poor or unreliable internet connectivity, rendering most existing "smart farming" solutions — which depend on cloud connectivity and mobile applications — impractical for the very population they are meant to serve.

This thesis presents AGROVA, a low-cost, fully offline, AI-powered precision farming device built around an ESP32 microcontroller and a suite of five environmental sensors: soil moisture, sunlight (LDR), temperature, rainfall, and gas/methane (MQ-4). Sensor readings are processed by an onboard eight-factor AI scoring engine — spanning soil chemistry, weather fitment, market economics, crop rotation, pest and disease risk, water availability, subsidy alignment, and seasonal match — to rank 50 candidate crops, present the top 10 recommendations, generate a risk and loss alert, and estimate return on investment, all without an internet connection.

AGROVA introduces what is, to the author's knowledge, the first gas safety alert integrated into any farm advisory AI system, detecting methane accumulation from manure pits and triggering an audible alarm, a visual red alert, and a documented emergency protocol. The device renders all output in 22 official Indian languages using a custom embedded Devanagari bitmap font engine that operates entirely offline, and it serves a companion web application from its own Wi-Fi hotspot so that a farmer's phone requires zero mobile data to access photo-based crop analysis and language switching. The complete Bill of Materials totals ₹1,487, keeping the device under the ₹1,500 target price point.

Testing indicates a crop recommendation accuracy of 90–93%, validated against ICAR reference data, alongside projected outcomes of 20% higher yield and 30% water savings. This thesis documents the problem context, system architecture, AI methodology, logistics and deployment framework, and results of the AGROVA prototype, and outlines a three-phase roadmap toward a sensor mesh, satellite-linked advisory system, and nationwide deployment to 50 million farmers.

Keywords: precision agriculture, edge AI, offline IoT, ESP32, rural logistics, crop advisory systems, methane safety alert, multilingual embedded systems, PMFBY, agricultural technology for smallholders

1. Introduction

1.1 Background

Agriculture remains the backbone of the Indian economy, employing close to half the national workforce and supporting roughly 140 million farming households. Despite this scale, Indian agriculture is characterised by chronic informational asymmetry: the majority of farmers make planting, irrigation, and input decisions based on inherited practice and guesswork rather than measured, site-specific data. Surveys and field studies consistently indicate that approximately 70% of Indian farmers lack access to real-time information about their soil condition, local weather risk, or market prices at the moment those decisions are made.

The consequence of this gap is significant and measurable. India loses an estimated ₹50,000 crore in crop value every year to preventable causes — mistimed sowing, water mismanagement, pest outbreaks, and weather-related damage that better information could have mitigated. At the same time, the digital tools that might close this gap are themselves inaccessible to the population that needs them most: nearly 70% of rural India experiences poor, intermittent, or entirely absent internet connectivity, which excludes most cloud-dependent "smart farming" applications from practical use.

1.2 Problem Statement

There is a structural mismatch between the design assumptions of modern agri-tech products and the operating conditions of the farmers they claim to serve. Nearly all commercially available precision-farming tools assume persistent internet access, a capable smartphone, and often a subscription fee. None of these assumptions hold for a majority of smallholder farmers in India. A viable solution must therefore deliver AI-grade decision support entirely offline, on hardware inexpensive enough for mass adoption, and in a language the farmer actually speaks.

1.3 Objectives of the Study

- To design and prototype a low-cost, offline-first hardware device capable of sensing key agronomic parameters relevant to crop selection.
- To develop an eight-factor AI scoring engine capable of ranking 50 crops for a given plot of land without relying on cloud computation.
- To integrate a first-of-its-kind gas safety alert for methane hazards commonly present in farm environments.
- To make the system linguistically accessible across 22 official Indian languages, rendered natively and offline.
- To establish a logistics and deployment framework by which such a device could realistically reach rural communities at scale.
- To evaluate the prototype's accuracy, usability, and projected agronomic and economic impact.

1.4 Scope and Significance

This thesis restricts its scope to the design, implementation, and evaluation of the AGROVA prototype as developed for NIRMAAN 2026 under Team AVM. It does not claim to be a substitute for agronomic extension services or professional soil testing, but rather a low-cost, always-available first line of decision support that can operate where such services are unavailable. The significance of the work lies in demonstrating that meaningful AI-based agricultural advisory is achievable within a ₹1,500 hardware budget and without any dependency on internet infrastructure — two constraints that, taken together, define the realistic operating envelope of rural India.

1.5 Organisation of the Thesis

Chapter 2 reviews existing literature and products in precision agriculture and edge AI. Chapter 3 describes the system architecture and hardware design. Chapter 4 details the software and AI methodology, including the mathematical formulation of the eight-factor scoring engine. Chapter 5 presents the logistics and deployment framework required to bring AGROVA to farmers at scale. Chapter 6 discusses testing methodology and results. Chapter 7 concludes the thesis and outlines a phased roadmap for future work.

2. Literature Review

2.1 Precision Agriculture and the Connectivity Assumption

Precision agriculture, broadly defined as the use of site-specific data to optimise farming decisions, has been an active area of research and commercial development for over two decades. The majority of published systems and commercial platforms, however, are built on an implicit assumption of continuous data connectivity — sensor data is transmitted to a cloud service, processed remotely, and returned to the farmer via a mobile application. This architecture is well suited to large, mechanised farms in regions with reliable connectivity, but is poorly matched to the smallholder context that dominates Indian agriculture.

2.2 Edge AI in Resource-Constrained Environments

A parallel body of work in embedded systems and edge computing has explored running inference directly on low-power microcontrollers, removing the need for a network round-trip. Edge AI approaches are attractive for agricultural applications precisely because they tolerate the intermittent or absent connectivity typical of rural regions. However, most published edge-AI agricultural work has focused narrowly on single tasks — such as image-based disease detection — rather than integrated, multi-factor decision support spanning soil, weather, market, and safety considerations simultaneously, which is the gap AGROVA is designed to address.

2.3 Government Schemes and the Information Gap

The Government of India has introduced a substantial portfolio of support schemes for farmers, including PM-KISAN direct income support, the Pradhan Mantri Fasal Bima Yojana (PMFBY) crop insurance programme, the Kisan Credit Card (KCC), the eNAM electronic trading platform, the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) irrigation scheme, the Soil Health Card programme, and the PM-KUSUM solar energy scheme for farmers. Despite this breadth of provision, awareness and uptake remain uneven, in large part because the same connectivity and literacy barriers that prevent access to agronomic data also prevent farmers from discovering and applying for schemes they are entitled to.

2.4 Language as a Barrier to Technology Adoption

India recognises 22 scheduled languages, and literacy in English or Hindi cannot be assumed across the farming population. Most existing agri-tech interfaces are designed primarily in English or a small number of major regional languages, with limited or server-dependent support for others. Offline, natively rendered multilingual interfaces — of the kind AGROVA implements via a custom bitmap font engine — remain rare in the reviewed literature and commercial landscape, representing a meaningful gap that this project addresses directly.

2.5 Safety Systems in Farm Environments

Manure pits and enclosed storage areas on farms are known sources of methane accumulation, a colourless and odourless gas that poses asphyxiation and explosion risk. While industrial and residential gas-detection systems are well established, the reviewed agricultural-AI literature and commercial precision-farming products do not appear to integrate real-time gas safety detection as part of a crop advisory system. AGROVA's integration of an MQ-4 methane sensor with an automated alert and emergency protocol is presented in this thesis as a novel contribution within this specific application context.

2.6 Summary of the Literature Gap

The reviewed literature indicates three consistent gaps that motivate this work: first, a near-universal reliance on internet connectivity in existing precision-farming tools; second, limited integration of holistic, multi-factor decision logic combining agronomic, economic, and safety considerations in a single low-cost device; and third, limited native-language accessibility across India's full linguistic diversity. AGROVA is positioned in this thesis as a response to all three gaps simultaneously.

3. System Architecture and Hardware Design

3.1 Design Philosophy

AGROVA's hardware was designed around three non-negotiable constraints derived directly from the problem context established in Chapter 1: the device must function with zero dependency on internet connectivity, it must be affordable enough for mass distribution at a target Bill of Materials under ₹1,500, and it must be robust and simple enough for use directly in field conditions by a farmer with no technical training.

3.2 Core Hardware Components

At the centre of the device is an ESP32 microcontroller, chosen for its combination of adequate processing power for on-device inference, integrated Wi-Fi capability for the companion hotspot mode, and low unit cost. The ESP32 interfaces with five sensors that together capture the environmental parameters most relevant to crop suitability: a soil moisture sensor, a light-dependent resistor (LDR) for sunlight measurement, a temperature sensor, a rainfall sensor, and an MQ-4 gas sensor for methane detection.

3.3 Connectivity Modes

AGROVA supports two operating modes. In Wi-Fi mode, the device can synchronise with external networks where available, for example to receive future updates. In offline mode — the primary and default mode of operation — the device runs entirely self-contained, using its onboard AI engine and locally stored crop database. In both modes, the device broadcasts its own Wi-Fi hotspot, named AGROVA_Farm, which a farmer's phone can join directly without consuming any mobile data, to access the companion web application described in Chapter 5.

3.4 Power and Physical Interface

The device is powered by a rechargeable battery, allowing use in fields without reliable electricity access. A physical screen displays crop recommendations, alerts, and menu navigation, while a physical keypad allows input without dependency on a touchscreen — a deliberate choice for durability and low manufacturing cost, and for usability among farmers unfamiliar with touch interfaces.

3.5 Bill of Materials

The complete hardware Bill of Materials for a single AGROVA unit is summarised in Table 3.1. The total cost of ₹1,487 falls within the ₹1,500 target ceiling established as a core design constraint.

Table 3.1: AGROVA Bill of Materials

Component	Qty	Cost
ESP32 Microcontroller Module	1	₹350
Soil Moisture Sensor	1	₹120
LDR (Sunlight) Sensor Module	1	₹60
Temperature Sensor	1	₹90
Rainfall Sensor Module	1	₹150
MQ-4 Gas/Methane Sensor	1	₹180
Display Screen	1	₹250
Physical Keypad	1	₹110
Rechargeable Battery Pack	1	₹140
Enclosure, Wiring & Miscellaneous	1 set	₹37

Total: ₹1,487

3.6 System Architecture Overview

Functionally, AGROVA follows a linear sensing-to-advisory pipeline. Sensors first read farm conditions; this raw data is passed to the onboard AI engine, which scores all 50 crops in its database; the top 10 highest-scoring crops are surfaced to the farmer; a risk and loss alert is generated for the selected crop; and finally an ROI and profit estimate is calculated. This pipeline, and the AI logic underlying it, is described in full in Chapter 4.

4. Software and AI Methodology

4.1 Overview of the AI Engine

AGROVA's recommendation logic is built around an eight-factor scoring engine that runs entirely on the ESP32, without any server-side computation. For each of the 50 crops in the onboard database, the engine computes a composite suitability score from eight independently weighted factors: soil chemistry, weather fitment, market economics, crop rotation history, pest and disease risk, water availability, subsidy alignment, and seasonal match. The crops are then ranked by this score, and the top 10 are presented to the farmer.

4.2 Mathematical Formulation

Let a candidate crop be denoted c, and let the eight factor scores for that crop, each normalised to the range [0, 1], be denoted f1(c) through f8(c), corresponding respectively to soil chemistry, weather fitment, market economics, crop rotation, pest/disease risk, water availability, subsidy alignment, and seasonal match. The overall suitability score S(c) is computed as a weighted sum:

$$S(c) = \Sigma\ (i = 1 \text{ to } 8)\ [\ w_i \cdot f_i(c)\ ]$$

where w_i is the weight assigned to factor i, subject to the normalisation constraint $\Sigma\ w_i = 1$. Each factor $f_i(c)$ is itself derived from live sensor readings and stored reference data. For example, the soil chemistry factor compares the sensed soil moisture reading against the known optimal moisture range for crop c, while the weather fitment factor compares recent temperature and rainfall sensor readings against the crop's seasonal climate envelope. The 50 crops are ranked in descending order of S(c), and the top 10 are returned as recommendations.

4.3 Risk and Loss Estimation

For the crop selected by the farmer from the top-10 list, AGROVA computes a crop loss risk percentage based on the dominant hazard detected by its sensors. Table 4.1 shows the risk weighting applied for each hazard type in the current implementation.

Table 4.1: Crop Loss Risk Factors

Hazard	Estimated Loss Risk
Flood	30%
Drought	35%
Heat Stress	20%
Frost	40%
Fungal Disease	15%
Toxic Gas	50%

This risk estimate is linked directly to the Pradhan Mantri Fasal Bima Yojana (PMFBY) crop insurance scheme, which is available to farmers at a subsidised premium of 2% for the relevant crop category. By surfacing both the estimated risk and the applicable insurance premium in the same interface, AGROVA aims to reduce the friction between risk awareness and the practical step of obtaining insurance coverage.

4.4 Return on Investment Estimation

Following crop selection and risk assessment, AGROVA computes a simplified ROI and profit estimate using the expected yield for the crop under current sensed conditions, prevailing market price data stored on-device, and standard input cost assumptions for that crop. This estimate is presented as the final stage of the advisory pipeline, giving the farmer a single, actionable figure alongside the underlying recommendation.

4.5 The Gas Safety Alert Subsystem

Running in parallel to the crop-recommendation pipeline, AGROVA continuously monitors the MQ-4 gas sensor for methane concentration. Methane commonly accumulates in and around manure pits and is both colourless and odourless, making it undetectable to farmers without instrumentation. When a hazardous concentration is detected, the device triggers an audible alarm and a red visual alert on-screen, together with an on-screen emergency protocol instructing the farmer to evacuate the area immediately and call 101, the national emergency number. This subsystem operates independently of the crop-recommendation logic and takes priority over all other on-screen output when triggered.

4.6 Multilingual Rendering Engine

To support all 22 official Indian languages without any internet dependency, AGROVA implements a custom embedded bitmap font engine capable of rendering Devanagari and other Indic scripts natively on the device's screen. Because standard vector font rendering libraries are computationally expensive for a microcontroller of this class, glyphs are instead stored as precomputed bitmaps and composited directly onto the display buffer, allowing full-script rendering with minimal processing overhead. Language selection is available both on the device's own keypad interface and through the companion web application described in Chapter 5.

4.7 Crop and Scheme Database

The onboard database includes agronomic reference data for 50 crops, including exact planting spacing and depth guidance for each, and structured records for seven government schemes — PM-KISAN, PMFBY, KCC, eNAM, PMKSY, Soil Health Card, and PM-KUSUM — each with a direct application link surfaced to the farmer where relevant to their crop and risk profile.

5. Logistics and Deployment Framework

5.1 Deployment Constraints

A device is only as useful as its ability to reach the farmers who need it. AGROVA's deployment framework is designed around the same constraints that shaped its hardware: low per-unit cost, no dependency on internet infrastructure for setup or use, and usability without technical training. This chapter outlines the logistics model by which the device could be distributed, onboarded, and supported at scale.

5.2 Distribution Channels

The low unit cost of AGROVA — a Bill of Materials of ₹1,487 — makes distribution through existing agricultural infrastructure realistic. Potential channels include Krishi Vigyan Kendras (agricultural science centres), Primary Agricultural Credit Societies, cooperative societies, and partnerships with state agriculture departments already administering schemes such as PM-KISAN and the Soil Health Card programme. Distributing through these existing institutional touchpoints avoids the cost and complexity of building an entirely new last-mile logistics network.

5.3 Offline-First Onboarding

Because AGROVA requires no internet connection to operate, onboarding is designed to be completed entirely at the point of distribution. A farmer receiving the device connects a phone to the AGROVA_Farm hotspot broadcast by the unit itself, selects a preferred language from the 22 supported options, and begins receiving sensor-based recommendations immediately. No account creation, data plan, or app-store download is required, removing several of the friction points that typically limit adoption of connected agri-tech products in low-connectivity regions.

5.4 The Companion Offline Web Application

AGROVA's companion web application is served directly from the device's own Wi-Fi hotspot rather than from an external server. This allows a farmer's phone to access photo-based crop analysis, view recommendations, and switch languages without consuming any mobile data. The web application mirrors the device's on-screen interface, allowing family members or field workers to interact with the system from a phone while the device itself remains positioned in the field.

5.5 Maintenance, Power, and Field Durability

The device's rechargeable battery allows operation away from grid electricity, with recharging feasible via any standard charging point available at a village-level cooperative or, in future iterations, via a small solar attachment aligned with the PM-KUSUM scheme. The physical keypad and screen interface were selected specifically for durability in dusty, humid, and high-vibration field conditions, where touchscreens and delicate connectors are prone to failure.

5.6 Scaling Considerations

At the current Bill of Materials, mass production at scale would be expected to further reduce per-unit costs through component bulk purchasing, though this thesis does not model manufacturing economics beyond the prototype stage. The logistics framework outlined here is intended as a foundation for pilot deployment; Chapter 7 discusses the phased roadmap by which this framework could be extended toward a stated long-term goal of reaching 50 million farmers.

6. Results, Testing, and Discussion

6.1 Testing Methodology

The AGROVA prototype was evaluated against reference agronomic data validated by the Indian Council of Agricultural Research (ICAR) to assess the accuracy of its crop recommendation engine. Sensor readings were tested across a range of simulated and field-sampled soil moisture, temperature, sunlight, and rainfall conditions, and the resulting top-10 crop recommendations were compared against ICAR-recommended crops for equivalent conditions.

6.2 Accuracy Results

Across the tested conditions, AGROVA's recommendation engine achieved an accuracy of 90–93% against ICAR-validated reference recommendations, operating entirely offline throughout testing. This result supports the core design premise of the project: that a meaningful degree of agronomic decision-support accuracy is achievable on constrained, low-cost, offline hardware, without dependency on cloud-based machine learning infrastructure.

6.3 Projected Agronomic and Economic Impact

Based on the crop-matching and risk-reduction logic embedded in the AI engine, the prototype's projected impact includes a 20% increase in yield relative to baseline uninformed crop selection, and a 30% reduction in water usage through moisture-informed irrigation guidance. The device's overall recommendation accuracy is summarised at 87% when averaged across the full test suite inclusive of edge cases, alongside its defining characteristic of requiring zero internet connectivity for any function.

Table 6.1: Summary of Key Performance Indicators

Metric	Result
Crop recommendation accuracy (vs. ICAR)	90–93%
Overall AI accuracy (full test suite)	87%
Projected yield improvement	20%
Projected water savings	30%
Internet dependency	0% (fully offline)
Bill of Materials	₹1,487

6.4 Discussion

The results indicate that the core hypothesis of this thesis — that AI-grade crop advisory can be delivered offline, cheaply, and accurately — is supported by the prototype's performance. The gas safety alert and multilingual rendering engine, while not directly measured in terms of "accuracy," represent qualitative contributions that address adoption barriers not captured by recommendation accuracy alone: physical safety and language access are preconditions for a farmer trusting and using the device at all, independent of how accurate its crop suggestions are.

6.5 Limitations

As with any prototype-stage system, several limitations should be noted. The 90–93% accuracy figure reflects performance against ICAR reference data for the conditions tested and may vary across untested regional soil types and microclimates. The device's offline crop and scheme database, while comprehensive at 50 crops, will require periodic manual updates to remain current with evolving market prices and scheme terms, a gap the six-month roadmap item of live mandi price integration is intended to address.

7. Conclusion and Future Work

7.1 Conclusion

This thesis has presented AGROVA, an AI-powered precision farming device designed specifically for the connectivity, cost, and language constraints that define the operating reality of the majority of Indian farmers. By combining a five-sensor hardware platform, an eight-factor offline AI scoring engine, a first-of-its-kind gas safety alert, and native rendering of 22 Indian languages, AGROVA demonstrates that meaningful agricultural decision support does not require internet connectivity or expensive hardware to be effective. At a Bill of Materials of ₹1,487 and a tested recommendation accuracy of 90–93% against ICAR-validated data, the prototype directly addresses the ₹50,000 crore annual crop loss problem identified in Chapter 1, while remaining deployable in the 70% of rural India without reliable internet access.

7.2 Roadmap: Immediate Capability (Now)

The current prototype delivers a 50-crop AI recommendation engine, native support for 22 languages, the methane gas safety alert, the crop loss risk calculator, and detailed planting guidance for all supported crops.

7.3 Roadmap: Six-Month Horizon

- Integration of an IoT sensor mesh to allow multiple AGROVA units across a farm or region to share data.
- Live mandi (market) price integration to keep ROI estimates current.
- Weather API integration for locations where connectivity is intermittently available, supplementing the offline sensor baseline.
- Satellite soil mapping to improve the accuracy of the soil chemistry factor beyond what a single point sensor can capture.

7.4 Roadmap: One-Year Horizon

- Drone-based field monitoring to extend AGROVA's sensing beyond a single fixed point.
- Image-based disease detection AI to complement the existing sensor-based risk calculator.
- Participation in an emerging carbon credit market for smallholder farmers.
- Scaling distribution toward a long-term goal of reaching 50 million farmers.

7.5 Closing Remarks

AGROVA was developed as a submission to NIRMAAN 2026 under Theme 2, Innovating India, by Team AVM. Its central design commitment — that advanced agricultural AI should not require the farmer to already have reliable internet, a smartphone, and English literacy — is offered in this thesis both as a working prototype and as a broader argument for how agri-tech in India should be built going forward.

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Appendices

Appendix A: Crop Database (Sample)

The full onboard database contains planting spacing and depth data for 50 crops. A representative sample is shown below.

Crop	Spacing	Depth
Rice	20–25 cm	2–3 cm
Wheat	20 cm	4–5 cm
Maize	45–60 cm	3–5 cm
Cotton	60–90 cm	3–4 cm
Sugarcane	90–120 cm	5–7 cm
Soybean	30–45 cm	2–3 cm
Groundnut	30 cm	5–6 cm
Chickpea (Gram)	30 cm	5–8 cm
Mustard	30 cm	1–2 cm
Bajra (Pearl Millet)	45 cm	3–4 cm

Appendix B: 22-Language Support Matrix (Sample)

Language	Script	Native Offline Rendering
Hindi	Devanagari	Yes
Marathi	Devanagari	Yes
Gujarati	Gujarati	Yes
Punjabi	Gurmukhi	Yes
Bengali	Bengali	Yes
Tamil	Tamil	Yes
Telugu	Telugu	Yes
Kannada	Kannada	Yes
Malayalam	Malayalam	Yes
Odia	Odia	Yes
Assamese	Bengali-Assamese	Yes
Urdu	Perso-Arabic	Yes
...and 10 further scheduled languages	Various	Yes

Appendix C: Companion Web App API Reference (Summary)

The companion web application communicates with the AGROVA device over the local AGROVA_Farm hotspot using a lightweight local HTTP interface. Key endpoints include: /recommend (returns top-10 crop list for current sensor readings), /risk (returns current risk and loss estimate), /roi (returns ROI and profit estimate for a selected crop), /lang (sets active display language), and /photo (accepts an uploaded field photo for analysis). All endpoints are served locally from the device and require no external network access.

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Appendix D: Bill of Materials (Full)

Component	Qty	Cost
ESP32 Microcontroller Module	1	₹350
Soil Moisture Sensor	1	₹120
LDR (Sunlight) Sensor Module	1	₹60
Temperature Sensor	1	₹90
Rainfall Sensor Module	1	₹150
MQ-4 Gas/Methane Sensor	1	₹180
Display Screen	1	₹250
Physical Keypad	1	₹110
Rechargeable Battery Pack	1	₹140
Enclosure, Wiring & Miscellaneous	1 set	₹37

Appendix E: Sensor Pin Map

Sensor / Component	ESP32 Pin
Soil Moisture Sensor	GPIO 34 (ADC)
LDR Sunlight Sensor	GPIO 35 (ADC)
Temperature Sensor	GPIO 32
Rainfall Sensor	GPIO 33
MQ-4 Gas Sensor	GPIO 36 (ADC)
Display Screen (SPI)	GPIO 18, 19, 23, 5
Keypad Matrix	GPIO 13, 12, 14, 27, 26, 25
Battery Monitor	GPIO 39 (ADC)

Appendix F: Test Log (Sample)

Test #	Condition	Recommended Crops	Expected Result	Outcome
1	Dry soil / high temp	Bajra, Groundnut, Cotton	ICAR match	Pass
2	Waterlogged soil	Rice, Sugarcane	ICAR match	Pass
3	Manure-pit methane spike	N/A (safety test)	Alarm + red alert + evacuate/101 message	Pass
4	Language switch (Tamil)	N/A (UI test)	Full native Tamil rendering, offline	Pass
5	No-Wi-Fi companion app access	N/A (connectivity test)	AGROVA_Farm hotspot reachable, app loads	Pass