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VASANTDADA PATIL PRATISHTHAN'S
COLLEGE OF ENGINEERING & VISUAL ARTS

Problem Statement: PS04 College

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Team Name: BitBuilders

Team Members:

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AUTONOMOUS SMART IRRIGATION SYSTEM

The Core Concept - Autonomous Closed-Loop System

Real-Time Sensing

Utilizes a network of ***field sensors*** to continuously monitor soil moisture, temperature, and critical ***NPK*** nutrient levels.

Automated Actuation

A completely autonomous feedback loop where sensor data directly triggers ***solenoid valves*** and ***pumps*** for precise irrigation and fertilization cycles without human intervention.

Key Innovation — Weather-Aware Predictive Alutonomous Closed-Loop System

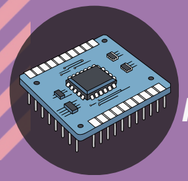
Beyond Thresholds

Shifts from simple reactive "***if/then***" logic to predictive modeling that anticipates crop needs based on growth stages.

Forecast Integration

AI engine integrates real-time weather forecasts (rain/heat) to proactively delay watering or fertilization, preventing resource wastage and chemical runoff.

Technical Execution — Robust Full-Stack IoT



Edge Hardware

Built on the versatile ***ESP32 microcontroller*** using corrosion-resistant capacitive soil sensors for reliable, long-term field deployment.

Resilient Connectivity

Uses the lightweight ***MQTT protocol*** to ensure reliable data transmission even in rural areas with low-bandwidth or unstable internet.

Unique Value Prop — Blockchain-Based Trust & Audit

Immutable Logging

Every irrigation event and fertilizer application is permanently recorded on the ***Polygon blockchain***, creating an unalterable audit trail

Verifiable Certification

Provides farmers with irrefutable digital proof of resource usage, streamlining "***Organic Certification***" and enabling premium pricing.

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TECHINCAL APPROACH

On the Screen

Real-time dashboard streams live farm data via WebSockets and overlays AI predictions with actual sensor readings.

Transparent monitoring enables farmers to instantly verify and understand automated system decisions.

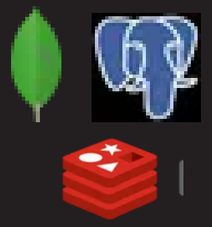
Analyse& Action

AI predictions are converted into validated action plans using rule and safety checks. Approved decisions are immutably logged on the blockchain for audit and compliance.

Cloud Layer

AI / ML Layer

Database



Ai & Audit

An AI engine predicts water needs 24 hours in advance. An LSTM model analyzes sensor trends and weather forecasts to conserve water.

All farming actions are recorded on a blockchain. This creates a tamper-proof audit trail, verifying organic certification standards.

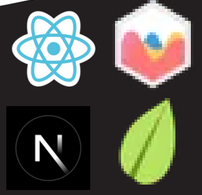
On the Field

Smart Sensor gathers soil information, ESP32 microcontrollers.

Data is transmitted efficiently via MQTT protocol.

Backend

Frontend

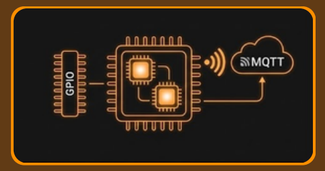


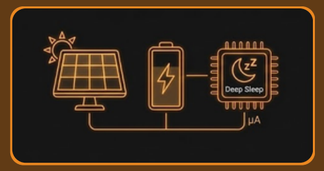
FEASIBILITY & VIABILITY

Technical Feasibility

Scaling Smart Agriculture with Precision & Trust

The Edge-to-Cloud Continuum





Low-Power Wide-Area Network (LPWAN) Compatibility:

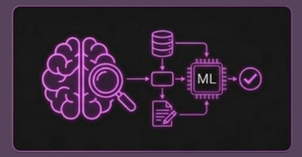
- Leveraging dual cores, the system handles real-time GPIO polling and asynchronous MQTT telemetry simultaneously.

Hardware Durability & Signal Integrity

Energy Autonomy

- Utilizes oxidation-resistant capacitive sensing to ensure high-fidelity data retention over extended deployment cycles.
- Implements hardware deep sleep states to reduce current draw to microamperes, facilitating indefinite solar-powered operation.

Risk Matrix: Critical System Vulnerabilities



Environmental & Infrastructural Volatility

System precision is threatened by unreliable rural backhaul introducing latency into the cloud-to-edge control loop, compounded by complex soil matrices inducing sensor drift that degrades long-term fertigation accuracy.

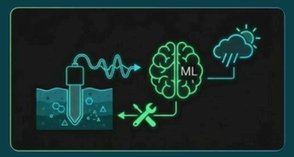
Endpoint Security

Vulnerabilities in MQTT brokers or local microcontrollers could expose the irrigation infrastructure to unauthorized actuation.

Mitigation & Strategic Viability: The Self-Healing Grid

Deterministic Edge Logic

- To counter connectivity loss, the ESP32 maintains a local fail-safe state machine that reverts to threshold-based irrigation if the cloud-based AI heartbeat is lost.



ML-Driven Calibration (Auto-Correction)

- The backend employs an LSTM-based anomaly detection layer that flags sensor deviation by cross-referencing multi-node data points against localized weather API telemetry

Cryptographic Audit Trails

- Every actuation command is validated via a hash-linked record on the Polygon Blockchain, creating a tamper-proof "Proof of Action" that streamlines regulatory compliance for organic certification.

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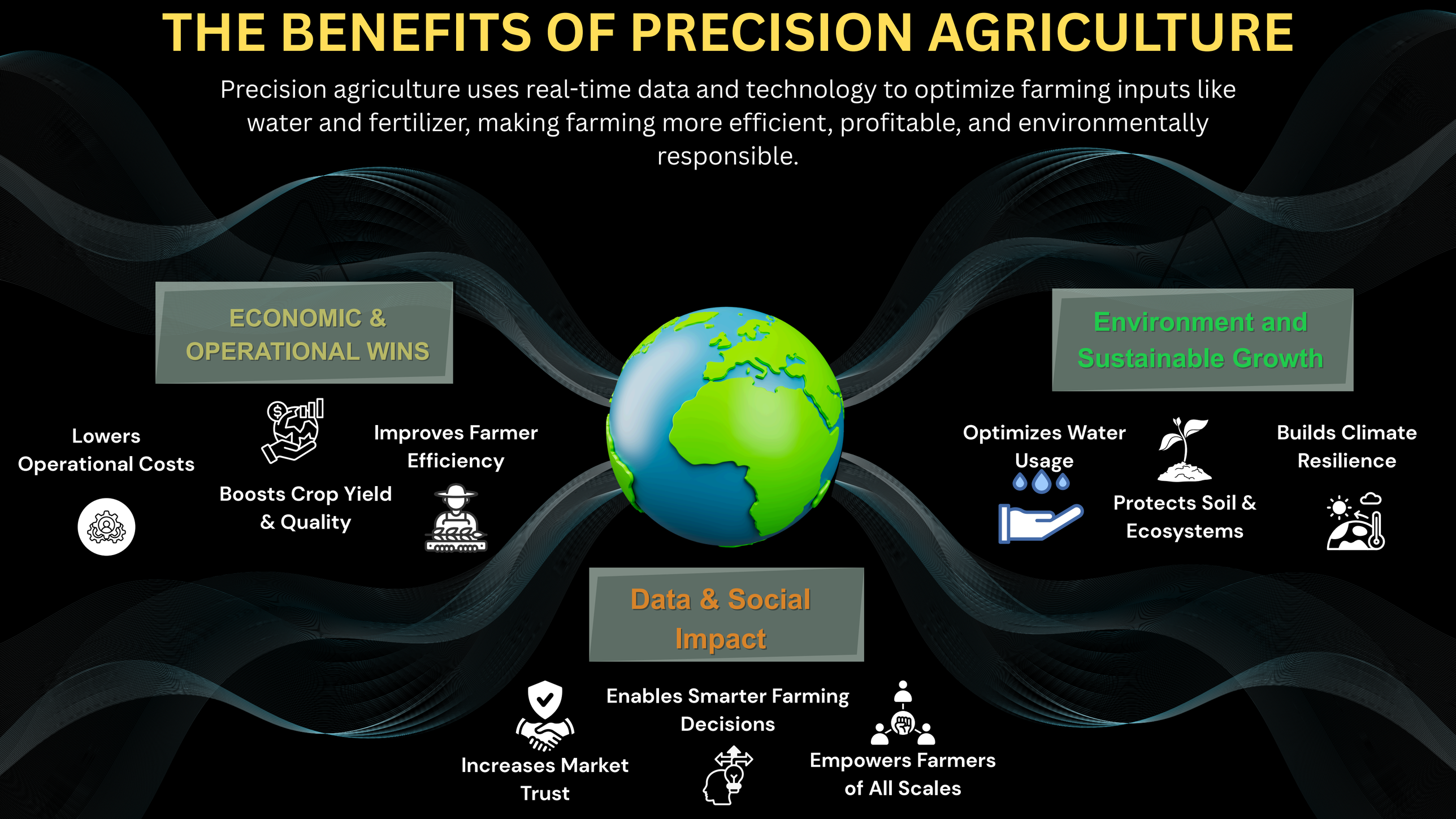
THE BENEFITS OF PRECISION AGRICULTURE

Precision agriculture uses real-time data and technology to optimize farming inputs like water and fertilizer, making farming more efficient, profitable, and environmentally responsible.

ECONOMIC & OPERATIONAL WINS

- Lowers Operational Costs
- Boosts Crop Yield & Quality
- Improves Farmer Efficiency



Environment and Sustainable Growth

- Optimizes Water Usage
- Protects Soil & Ecosystems
- Builds Climate Resilience

Data & Social Impact

- Increases Market Trust
- Enables Smarter Farming Decisions
- Empowers Farmers of All Scales

RESEARCH & REFERENCES

Cloud Infrastructure and APIs

- **NASA Earthdata (SMAP & HLS)**

https://www.earthdata.nasa.gov/engage/open- data-services-software/earthdata-developer-portal

- **OpenWeather API**

https://openweathermap.org/api

- **Farmonaut API**

https://farmonaut.com/

- **Sentinel Hub API**

https://www.sentinel-hub.com/develop /api/

Datasets

- **Crop Recommendation Dataset (Kaggle)**

https://www.earthdata.nasa.gov/engage/open- data-services-software/earthdata-developer-portal

- **Fertilizer Recommendation (GitHub)**

https://www.earthdata.nasa.gov/engage/open- data-services-software/earthdata-developer-portal

- **Smart Agriculture Dataset (Kaggle)**

https://www.sentinel-hub.com/develop /api/

Tech Tools

Hardware Platforms and Tools

- Espressif ESP32-WROOM-32
- Arduino IDE / PlatformIO
- RS485/Modbus Protocol

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