

Smart Agriculture Database

Schema Documentation

Overview

This database schema is designed for an agricultural IoT monitoring system that tracks sensor readings, equipment status, crop management, and environmental conditions across multiple farms and zones.

Enumerations

Equipment Status

Status indicators for equipment:

- **Active:** Equipment is operational
- **Inactive:** Equipment is not currently in use
- **Fault:** Equipment has malfunctioned

Reading Type

Types of sensor readings available:

- **SoilTemperature:** Temperature measurements in soil
- **SoilMoisture:** Soil moisture content
- **SoilPH:** Soil acidity/alkalinity level
- **SoilEC:** Soil electrical conductivity
- **SoilOxygen:** Oxygen levels in soil
- **AmbientTemperature:** Air temperature
- **AmbientHumidity:** Air humidity
- **PAR:** Photosynthetically Active Radiation
- **Rainfall:** Precipitation measurements
- **LeafWetness:** Moisture on plant leaves
- **WindSpeed:** Wind velocity

Threshold Type

Alert threshold categories:

- **BelowMin:** Reading is below minimum threshold
 - **AboveMax:** Reading exceeds maximum threshold
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Database Tables

Farms

Primary entity representing agricultural facilities.

Column	Type	Constraints	Description
Id	int	PK, AUTO_INCREMENT, NOT NULL, UNIQUE	Unique farm identifier
Name	varchar	NOT NULL	Farm name
Code	varchar	NOT NULL	Farm code reference
Lat	float	NOT NULL	Latitude coordinate
Lon	float	NOT NULL	Longitude coordinate
Address	varchar	NOT NULL	Physical address

Zones

Subdivisions within farms for granular monitoring.

Column	Type	Constraints	Description
Id	int	PK, AUTO_INCREMENT, NOT NULL, UNIQUE	Unique zone identifier
Name	varchar	NOT NULL	Zone name
Area	float	No Constraints	Zone area in square meters
SoilType	varchar(100)	No Constraints	Soil type for agricultural analysis
FarmId	int	FK → Farms.Id, NOT NULL	Parent farm reference

Crops

Master list of crop types.

Column	Type	Constraints	Description
Id	int	PK, AUTO_INCREMENT, NOT NULL, UNIQUE	Unique crop identifier
Name	varchar	NOT NULL	Crop name

Reading Types

Defines measurement types and their properties.

Column	Type	Constraints	Description
Id	int	PK, AUTO_INCREMENT, NOT NULL, UNIQUE	Unique reading type identifier
Code	varchar(50)	NOT NULL, UNIQUE	Reading type code (e.g., "SoilTemperature")
Category	varchar(50)	No Constraint	Category: Soil / Weather / Plant
DisplayName	varchar(100)	NOT NULL	Human-readable name
Unit	varchar(20)	NOT NULL	Measurement unit (°C, %, pH, mS/cm, etc.)

Equipments

IoT devices and sensors deployed in zones.

Column	Type	Constraints	Description
Id	int	PK, AUTO_INCREMENT, NOT NULL, UNIQUE	Unique equipment identifier
ZoneId	int	FK → Zones.Id, NOT NULL	Deployment zone
SerialNumber	varchar(100)	No Constraint	Device serial number
EquipmentModel	varchar(100)	No Constraint	Equipment model number
ReadingTypeId	int	FK → ReadingTypes.Id, NOT NULL	Type of reading this equipment provides
Status	EquipmentsStatus	NOT NULL	Current operational status
InstalledAt	datetime	No Constraint	Installation timestamp
LastReadingAt	datetime	No Constraint	Most recent reading timestamp

Sensor Readings

Time-series data from sensors.

Column	Type	Constraints	Description
Id	bigint	PK, AUTO_INCREMENT, NOT NULL, UNIQUE	Unique reading identifier
EquipmentId	int	FK → Equipments.Id, NOT NULL	Source equipment
ReadingTypeId	int	FK → ReadingTypes.Id, NOT NULL	Type of measurement
Value	float	NOT NULL	Measured value
TimestampUtc	datetime	NOT NULL	Reading timestamp (UTC)
IsAnomaly	bool	DEFAULT: false	Flag for unusual readings

Alerts

System-generated notifications for threshold violations.

Column	Type	Constraints	Description
Id	bigint	PK, AUTO_INCREMENT, NOT NULL, UNIQUE	Unique alert identifier
EquipmentId	int	FK → Equipments.Id	Related equipment
ZoneId	int	FK → Zones.Id	Related zone
ReadingTypeId	int	FK → ReadingTypes.Id	Reading type that triggered alert
CropId	int	FK → Crops.Id	Related crop
Value	float	No Constraint	Reading value that triggered alert
ThresholdType	ThresholdType	No Constraint	Type of threshold violation
Message	varchar(1000)	NOT NULL	Alert description
CreatedAt	datetime	NOT NULL	Alert creation timestamp
IsAcknowledged	bool	NOT NULL, DEFAULT: false	Acknowledgment status
AcknowledgedAt	datetime	No Constraint	Acknowledgment timestamp
StageId	int	FK → CropGrowthStages.Id	Related growth stage

Crop Seasons

Seasonal planting and harvesting schedules.

Column	Type	Constraints	Description
Id	int	PK, AUTO_INCREMENT	Unique season identifier
CropId	int	FK → Crops.Id	Related crop
SeasonName	varchar	NOT NULL	Season name (e.g., "Winter", "Summer")
PlantingStartMonth	int	NOT NULL	Planting start month (1-12)
PlantingEndMonth	int	NOT NULL	Planting end month (1-12)
HarvestStartMonth	int	NOT NULL	Harvest start month (1-12)
HarvestEndMonth	int	NOT NULL	Harvest end month (1-12)
ExpectedRangeDays	varchar(20)	No Constraint	Expected duration (e.g., "10-15 days")
Notes	text	No Constraint	Additional notes

Crop Growth Stages

Growth phases for crop lifecycle management.

Column	Type	Constraints	Description
Id	int	PK, AUTO_INCREMENT	Unique stage identifier
CropId	int	FK → Crops.Id	Related crop
StageName	varchar	NOT NULL	Stage name (Germination, Vegetative, Flowering, etc.)
Order	int	NOT NULL	Sequential order of stage
DurationDays	int	NOT NULL	Days since planting
Description	text	No Constraint	Stage description

Crop Stage Requirements

Environmental requirements for each growth stage.

Column	Type	Constraints	Description
Id	int	PK, AUTO_INCREMENT	Unique requirement identifier
CropGrowthStageId	int	FK → CropGrowthStages.Id	Related growth stage
ReadingTypeId	int	FK → ReadingTypes.Id	Type of measurement
MinValue	float	No Constraint	Minimum acceptable value
MaxValue	float	No Constraint	Maximum acceptable value
OptimalMin	float	No Constraint	Optimal range minimum
OptimalMax	float	No Constraint	Optimal range maximum

Zone Crops

Tracks active and historical crop plantings in zones.

Column	Type	Constraints	Description
Id	int	PK, AUTO_INCREMENT	Unique planting identifier
ZoneId	int	FK → Zones.Id	Planting zone
CropId	int	FK → Crops.Id	Planted crop
PlantedAt	date	NOT NULL	Planting date
ExpectedHarvestAt	date	No Constraint	Expected harvest date
CurrentStageId	int	FK → CropGrowthStages.Id	Current growth stage
Notes	text	No Constraint	Additional notes
ActualHarvestAt	date	No Constraint	Actual harvest date
YieldWeightKg	float	No Constraint	Harvest yield in kilograms
IsActive	bool	DEFAULT: true	Active/completed status

Entity Relationships

Farm Hierarchy

- **Farms → Zones (1:N)**: A farm contains multiple zones
- **Zones → Equipments (1:N)**: Each zone has multiple sensors/equipment

Crop Management

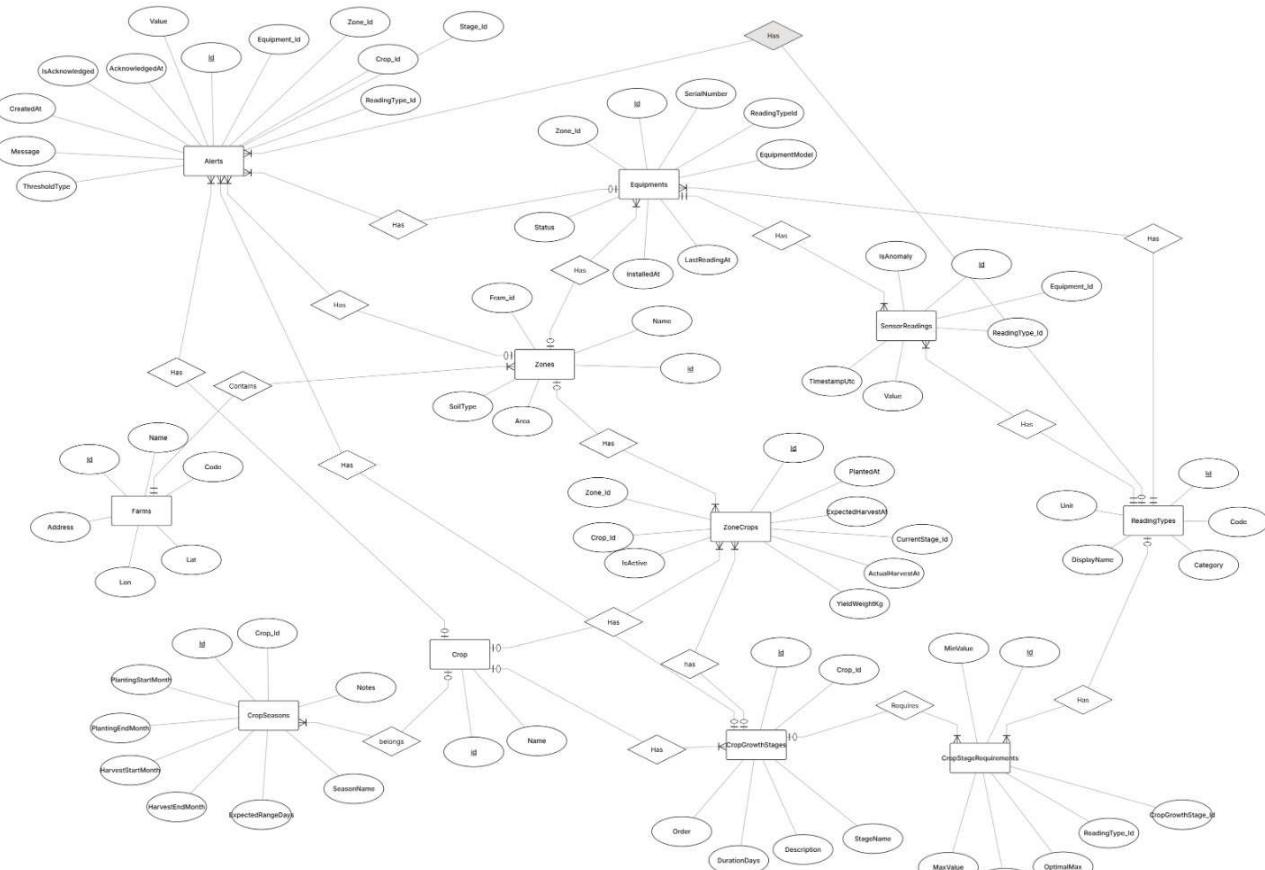
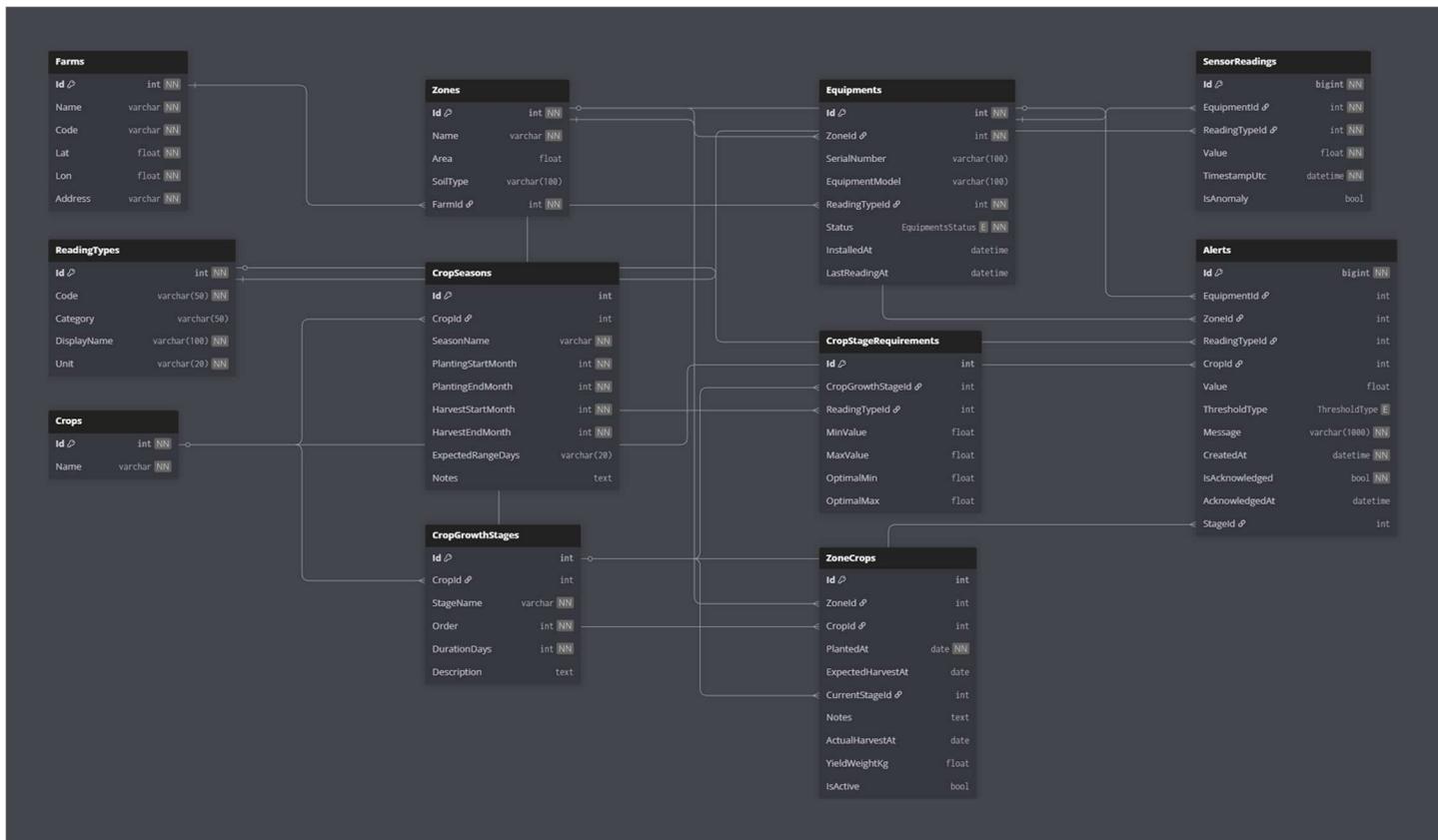
- **Crops → CropSeasons (1:N)**: Crops have multiple planting seasons
- **Crops → CropGrowthStages (1:N)**: Crops progress through defined growth stages
- **CropGrowthStages → CropStageRequirements (1:N)**: Each stage has specific environmental requirements
- **Zones → ZoneCrops (1:N)**: Tracks what crops are planted in each zone
- **Crops → ZoneCrops (1:N)**: Historical record of crop plantings

Monitoring System

- **ReadingTypes → Equipments (1:N)**: Defines what each equipment measures
- **Equipments → SensorReadings (1:N)**: Equipment generates readings over time
- **ReadingTypes → SensorReadings (1:N)**: Categorizes each reading

Alert System

- **Equipments → Alerts (1:N)**: Equipment can trigger alerts
 - **Zones → Alerts (1:N)**: Alerts are associated with zones
 - **ReadingTypes → Alerts (1:N)**: Specifies what type of reading triggered the alert
 - **Crops → Alerts (1:N)**: Alerts can be crop-specific
 - **CropGrowthStages → Alerts (1:N)**: Alerts linked to specific growth stages
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Key Features

Time-Series Data Management

The **SensorReadings** table stores all sensor data with timestamps, supporting historical analysis and trend detection. The **IsAnomaly** flag helps identify outlier readings.

Threshold-Based Alerting

The **Alerts** table integrates with **CropStageRequirements** to automatically generate notifications when sensor readings fall outside acceptable ranges for the current growth stage.

Crop Lifecycle Tracking

The system tracks crops from planting through harvest, monitoring environmental conditions against stage-specific requirements and providing yield data for analysis.

Multi-Level Organization

The hierarchical structure (Farms → Zones → Equipment) enables granular monitoring while maintaining organizational context.

Use Cases

1. **Real-time Monitoring:** Track current sensor readings across all farm zones
2. **Predictive Analytics:** Analyze historical data to predict optimal planting times and yields
3. **Alert Management:** Respond to threshold violations during critical growth stages
4. **Yield Optimization:** Compare environmental conditions with harvest yields to identify best practices
5. **Equipment Maintenance:** Track equipment status and last reading times to schedule maintenance
6. **Seasonal Planning:** Use historical season data to plan crop rotations and planting schedules