AgroSmart Precision Farming Dashboard - Database Schema

Overview

The AgroSmart database is designed for a precision farming dashboard system that manages users, farms, fields, crops, sensors, and related agricultural data. The schema supports role-based access control and comprehensive farm management functionality.

Database Structure

Entity Relationship Summary

- **Users** manage **Farms**
- **Farms** contain **Fields**
- **Fields** have **Sensors** and grow **Crops** (via FieldWiseCrops)
- **Fields** receive **Recommendations** and have **Schedules**
- **WeatherData** provides environmental context

Table Definitions

1. Users Table

Manages user accounts with role-based access control.

Column Name	Data Type	Constraints	Description
UserId	INT	PRIMARY KEY, IDENTITY(1,1)	Unique identifier for each user
FullName	NVARCHAR(100)	NOT NULL	User's full name
Email	NVARCHAR(100)	NOT NULL, UNIQUE	User's email address (must be unique)
PasswordHash	NVARCHAR(255)	NOT NULL	Hashed password for security

Column Name	Data Type	Constraints	Description
Role	NVARCHAR(20)	NOT NULL, CHECK (Role IN ('Farmer', 'Expert', 'Admin'))	User role determining access level
Phone	NVARCHAR(15)	NULL	Optional phone number
Address	NVARCHAR(255)	NULL	Optional address
IsActive	BIT	NOT NULL, DEFAULT 1	Account status (active/inactive)
CreatedAt	DATETIME2	NOT NULL, DEFAULT GETDATE()	Account creation timestamp
UpdatedAt	DATETIME2	NOT NULL, DEFAULT GETDATE()	Last update timestamp

2. Farms Table

Stores farm information linked to users.

Column Name	Data Type	Constraints	Description
FarmId	INT	PRIMARY KEY, IDENTITY(1,1)	Unique identifier for each farm
FarmName	NVARCHAR(100)	NOT NULL	Name of the farm
Location	NVARCHAR(255)	NOT NULL	Farm location description
Latitude	DECIMAL(9,6)	NULL	GPS latitude coordinate
Longitude	DECIMAL(9,6)	NULL	GPS longitude coordinate
TotalAcres	DECIMAL(10,2)	NULL	Total farm size in acres
UserId	INT	NOT NULL, FK → Users(UserId)	Owner of the farm
IsActive	BIT	NOT NULL, DEFAULT 1	Farm status (active/inactive)
CreatedAt	DATETIME2	NOT NULL, DEFAULT GETDATE()	Farm creation timestamp
UpdatedAt	DATETIME2	NOT NULL, DEFAULT GETDATE()	Last update timestamp

3. Crops Table

Master data for different crop types and their optimal growing conditions.

Column Name	Data Type	Constraints	Description
CropId	INT	PRIMARY KEY, IDENTITY(1,1)	Unique identifier for each crop type

Column Name	Data Type	Constraints	Description
CropName	NVARCHAR(100)	NOT NULL, UNIQUE	Name of the crop
OptimalSoilpHMin	DECIMAL(4,2)	CHECK (BETWEEN 0 AND 14)	Minimum optimal soil pH
OptimalSoilpHMax	DECIMAL(4,2)	CHECK (BETWEEN 0 AND 14)	Maximum optimal soil pH
OptimalTempMin	DECIMAL(5,2)	NULL	Minimum optimal temperature
OptimalTempMax	DECIMAL(5,2)	NULL	Maximum optimal temperature
AvgWaterReqmm	DECIMAL(10,2)	NULL	Average water requirement in mm
GrowthDurationDays	INT	CHECK (> 0)	Growth duration in days
SeedingDepthCm	DECIMAL(5,2)	NULL	Recommended seeding depth in cm
HarvestSeason	NVARCHAR(20)	NULL	Optimal harvest season
Description	NVARCHAR(MAX)	NULL	Additional crop information
IsActive	BIT	NOT NULL, DEFAULT 1	Crop status (active/inactive)
CreatedAt	DATETIME2	NOT NULL, DEFAULT GETDATE()	Record creation timestamp

Additional Constraints:

- CHECK (OptimalSoilpHMin <= OptimalSoilpHMax AND OptimalTempMin <= OptimalTempMax)

4. Fields Table

Individual field units within farms.

Column Name	Data Type	Constraints	Description
FieldId	INT	PRIMARY KEY, IDENTITY(1,1)	Unique identifier for each field
FieldName	NVARCHAR(100)	NOT NULL	Name of the field
SizeAcres	DECIMAL(10,2)	NOT NULL, CHECK (> 0)	Field size in acres
SoilType	NVARCHAR(50)	NULL	Type of soil in the field
IrrigationType	NVARCHAR(30)	NULL	Irrigation method used
FarmId	INT	NOT NULL, FK → Farms(FarmId)	Parent farm reference

Column Name	Data Type	Constraints	Description
IsActive	BIT	NOT NULL, DEFAULT 1	Field status (active/inactive)
CreatedAt	DATETIME2	NOT NULL, DEFAULT GETDATE()	Field creation timestamp
UpdatedAt	DATETIME2	NOT NULL, DEFAULT GETDATE()	Last update timestamp

Additional Constraints:

- UNIQUE (FieldName, FarmId) - Field names must be unique within each farm

5. Sensors Table

IoT sensors deployed in fields for data collection.

Column Name	Data Type	Constraints	Description
SensorId	INT	PRIMARY KEY, IDENTITY(1,1)	Unique identifier for each sensor
SensorType	NVARCHAR(50)	NOT NULL	Type of sensor (temperature, humidity, etc.)
Manufacturer	NVARCHAR(100)	NULL	Sensor manufacturer
Model	NVARCHAR(100)	NULL	Sensor model
SerialNumber	NVARCHAR(100)	NULL	Unique serial number
FieldId	INT	NOT NULL, FK → Fields(FieldId)	Field where sensor is installed
InstallationDate	DATETIME2	NULL	When sensor was installed
LastCalibrated	DATETIME2	NULL	Last calibration date
CalibrationInterval	INT	NULL	Days between calibrations
LatestValue	DECIMAL(15,4)	NULL	Most recent sensor reading
LatestUnit	NVARCHAR(20)	NULL	Unit of measurement
LatestQualityScore	DECIMAL(3,2)	CHECK (BETWEEN 0 AND 1)	Data quality score (0-1)
LastReadingTime	DATETIME2	NULL	Timestamp of latest reading
IsActive	BIT	NOT NULL, DEFAULT 1	Sensor status (active/inactive)
CreatedAt	DATETIME2	NOT NULL, DEFAULT GETDATE()	Sensor registration timestamp

6. FieldWiseCrops Table

Bridge table linking fields to crops with planting details.

Column Name	Data Type	Constraints	Description
FieldWiseCropId	INT	PRIMARY KEY, IDENTITY(1,1)	Unique identifier for field-crop relationship
FieldId	INT	NOT NULL, FK → Fields(FieldId)	Reference to field
CropId	INT	NOT NULL, FK → Crops(CropId)	Reference to crop type
PlantedDate	DATE	NOT NULL	Date when crop was planted
ExpectedHarvestDate	DATE	NULL	Expected harvest date
ActualHarvestDate	DATE	NULL	Actual harvest date
CurrentGrowthStage	NVARCHAR(50)	NULL	Current stage of crop growth
PlantedArea	DECIMAL(10,2)	NULL	Area planted with this crop
Status	NVARCHAR(20)	NOT NULL, DEFAULT 'Active', CHECK (IN ('Active', 'Harvested', 'Failed'))	Crop status
Notes	NVARCHAR(MAX)	NULL	Additional notes
CreatedAt	DATETIME2	NOT NULL, DEFAULT GETDATE()	Record creation timestamp
UpdatedAt	DATETIME2	NOT NULL, DEFAULT GETDATE()	Last update timestamp

Additional Constraints:

- CHECK (ExpectedHarvestDate IS NULL OR ExpectedHarvestDate >= PlantedDate)

7. Recommendations Table

AI-generated or expert recommendations for field management.

Column Name	Data Type	Constraints	Description

Column Name	Data Type	Constraints	Description
RecommendationId	INT	PRIMARY KEY, IDENTITY(1,1)	Unique identifier for each recommendation
FieldId	INT	NOT NULL, FK → Fields(FieldId)	Target field for recommendation
RecommendationType	NVARCHAR(50)	NOT NULL	Type of recommendation
Title	NVARCHAR(200)	NOT NULL	Brief title of recommendation
Description	NVARCHAR(MAX)	NOT NULL	Detailed recommendation description
Priority	NVARCHAR(20)	NOT NULL, DEFAULT 'Medium', CHECK (IN ('High', 'Medium', 'Low'))	Recommendation priority
EstimatedCost	DECIMAL(10,2)	NULL	Estimated implementation cost
EstimatedBenefit	DECIMAL(10,2)	NULL	Estimated benefit/ROI
ValidUntil	DATETIME2	NULL	Recommendation expiry date
GeneratedAt	DATETIME2	NOT NULL, DEFAULT GETDATE()	When recommendation was generated

8. Schedules Table

Planned activities and tasks for field management.

Column Name	Data Type	Constraints	Description
ScheduleId	INT	PRIMARY KEY, IDENTITY(1,1)	Unique identifier for each schedule
FieldId	INT	NOT NULL, FK → Fields(FieldId)	Target field for scheduled activity
ScheduleType	NVARCHAR(50)	NOT NULL	Type of scheduled activity

Column Name	Data Type	Constraints	Description
Title	NVARCHAR(200)	NOT NULL	Brief title of scheduled task
Description	NVARCHAR(MAX)	NULL	Detailed task description
ScheduledDate	DATETIME2	NOT NULL	When task is scheduled
Duration	DECIMAL(5,2)	NULL	Expected duration in hours
EstimatedCost	DECIMAL(10,2)	NULL	Estimated cost of activity
Priority	NVARCHAR(20)	NOT NULL, DEFAULT 'Medium', CHECK (IN ('High', 'Medium', 'Low'))	Task priority
Status	NVARCHAR(20)	NOT NULL, DEFAULT 'Scheduled', CHECK (IN ('Scheduled', 'InProgress', 'Completed', 'Cancelled'))	Current status
IsCompleted	BIT	NOT NULL, DEFAULT 0	Completion flag
CreatedBy	INT	NOT NULL, FK → Users(UserId)	User who created the schedule
CreatedAt	DATETIME2	NOT NULL, DEFAULT GETDATE()	Schedule creation timestamp
UpdatedAt	DATETIME2	NOT NULL, DEFAULT GETDATE()	Last update timestamp

9. WeatherData Table

Weather information for location-based farming decisions.

Column Name	Data Type	Constraints	Description
WeatherId	BIGINT	PRIMARY KEY, IDENTITY(1,1)	Unique identifier for weather record
Location	NVARCHAR(255)	NOT NULL	Location description
Latitude	DECIMAL(9,6)	NOT NULL	GPS latitude coordinate
Longitude	DECIMAL(9,6)	NOT NULL	GPS longitude coordinate

Column Name	Data Type	Constraints	Description
Temperature	DECIMAL(5,2)	NULL	Temperature reading
Humidity	DECIMAL(5,2)	NULL	Humidity percentage
Pressure	DECIMAL(7,2)	NULL	Atmospheric pressure
WindSpeed	DECIMAL(5,2)	NULL	Wind speed measurement
WeatherDescription	NVARCHAR(200)	NULL	Weather condition description
ForecastDate	DATETIME2	NOT NULL	Date/time for weather data
DataType	NVARCHAR(20)	NOT NULL, CHECK (IN ('Current', 'Hourly', 'Daily'))	Type of weather data
RetrievedAt	DATETIME2	NOT NULL, DEFAULT GETDATE()	When data was retrieved

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Schema Validation

Schema Strengths

1. **Proper Normalization**: Well-structured with appropriate relationships
2. **Data Integrity**: Comprehensive constraints and foreign keys
3. **Audit Trail**: CreatedAt/UpdatedAt timestamps on key tables
4. **Flexibility**: Support for multiple farms, fields, and crop rotations
5. **Scalability**: BIGINT for high-volume WeatherData table
6. **Data Quality**: Quality scores for sensor data

Potential Improvements

1. **Missing Indexes**: Consider adding indexes on frequently queried columns
2. **Sensor Data History**: Current schema only stores latest sensor values
3. **User Authentication**: Consider adding password reset tokens, login attempts
4. **Soft Deletes**: IsActive flags present but consider adding DeletedAt timestamps
5. **Data Archiving**: Strategy needed for historical weather and sensor data

Recommended Additions

```
-- Performance Indexes
CREATE INDEX IX_Farms_UserId ON Farms(UserId);
CREATE INDEX IX_Fields_FarmId ON Fields(FarmId);
CREATE INDEX IX_Sensors_FieldId ON Sensors(FieldId);
CREATE INDEX IX_WeatherData_Location_Date ON WeatherData(Location, Foreca

-- Historical sensor data table
CREATE TABLE SensorReadings (
    ReadingId BIGINT PRIMARY KEY IDENTITY(1,1),
    SensorId INT NOT NULL,
    Value DECIMAL(15,4),
    Unit NVARCHAR(20),
    QualityScore DECIMAL(3,2),
    ReadingTime DATETIME2 NOT NULL,
    FOREIGN KEY (SensorId) REFERENCES Sensors(SensorId)
);
```

This schema provides a solid foundation for a comprehensive precision farming management system with room for future enhancements.