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

## 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 |

## 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 |

## 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 | **'Spring', 'Summer', 'Fall', 'Winter', 'Year-round'** |
| 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)

## 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

## 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 | **'Temperature', 'Humidity', 'Soil\_Moisture', 'pH', 'Light', 'Pressure', 'Wind', 'Rain'** |
| 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 |

## 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 | **'Germination', 'Seedling', 'Vegetative', 'Flowering', 'Fruiting', 'Maturity'** |
| PlantedArea | DECIMAL(10,2) | NULL | Area planted with this crop |
| Status | NVARCHAR(20) | NOT NULL, DEFAULT 'Active',  CHECK (IN ('Active', 'Harvested', 'Failed')) | **'Active', 'Harvested', 'Failed'** |
| 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)

## Recommendations Table

AI-generated or expert recommendations for field management.

|  |  |  |  |
| --- | --- | --- | --- |
| **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')) | '**High', 'Medium', 'Low'** |
| 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 |

## 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 |

|  |  |  |  |
| --- | --- | --- | --- |
| 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')) | **'High', 'Medium', 'Low'** |
| Status | NVARCHAR(20) | NOT NULL, DEFAULT 'Scheduled', CHECK (IN  ('Scheduled', 'InProgress', 'Completed', 'Cancelled')) | **'Scheduled', 'InProgress', 'Completed', 'Cancelled'** |
| 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 |

## 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 |

|  |  |  |  |
| --- | --- | --- | --- |
| 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')) | **'Current', 'Hourly', 'Daily'** |
| RetrievedAt | DATETIME2 | NOT NULL, DEFAULT GETDATE() | When data was retrieved |

* CONSTRAINT CK\_WeatherData\_Location\_NotEmpty CHECK (LEN(LTRIM(RTRIM(Location))) > 0),
* CONSTRAINT CK\_WeatherData\_Latitude CHECK (Latitude BETWEEN -90 AND 90),
* CONSTRAINT CK\_WeatherData\_Longitude CHECK (Longitude BETWEEN -180 AND 180),
* CONSTRAINT CK\_WeatherData\_Temperature CHECK (Temperature IS NULL OR Temperature BETWEEN -100 AND 70),
* CONSTRAINT CK\_WeatherData\_Humidity CHECK (Humidity IS NULL OR Humidity BETWEEN 0 AND 100),
* CONSTRAINT CK\_WeatherData\_Pressure CHECK (Pressure IS NULL OR Pressure BETWEEN 800 AND 1200),
* CONSTRAINT CK\_WeatherData\_WindSpeed CHECK (WindSpeed IS NULL OR WindSpeed >= 0),
* CONSTRAINT CK\_WeatherData\_DataType CHECK (DataType IN ('Current', 'Hourly', 'Daily'))

# 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

N. **Flexibility**: Support for multiple farms, fields, and crop rotations

U. **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

N. **Soft Deletes**: IsActive flags present but consider adding DeletedAt timestamps

U. **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.