DBMS Project Report

Sustainable Agriculture Resource Management

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Chapter 1: Software Requirements Specification (SRS)

Problem Description

Detailed Explanation of the Case Study

What Is Sustainable Agriculture?

Sustainable agriculture is a method of farming that focuses on long-term crop and livestock production and minimization of environmental harms. It is about meeting the needs of the present without compromising the needs of future generations. It can have a number of objectives, including water conservation, minimising the use of chemical fertilisers and pesticides, and promoting biodiversity in crops and ecosystems. It also helps producers improve their practices and sustain the economic viability of their farms.

- Tracks farm ownership, farm size, and crop production.

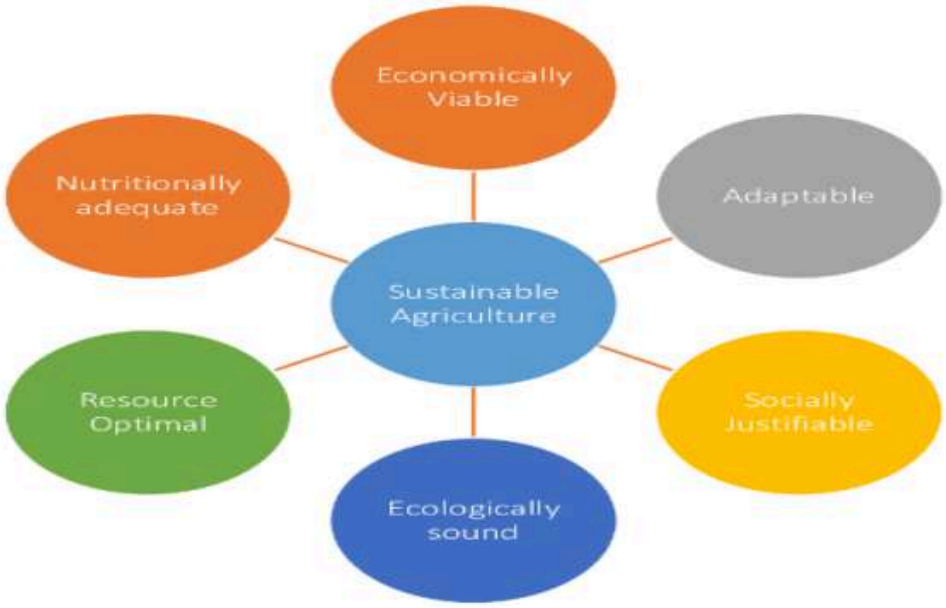
- Gathers essential crop dates, weather data, and soil conditions supporting effective management decisions.

- Saves time calculating the correct fertiliser and agricultural inputs with maximum productivity.

Purpose of Sustainable Agriculture :
The primary aim of the database is to assist farmers in farm management

by monitoring essential aspects such as crops, soil conditions, weather and resource utilisation. Therefore, it will facilitate better decision making by farmers aimed at increasing productivity and sustainable farming practice.

This model supports farmers making work more productive, more environmentally responsive, and enhancing systems to improve productivity.



The Future Usability of Sustainable Agriculture For Farmers:

1. Improved Yield and Efficiency:

- Farmers will grow more crops by using natural resources efficiently, which means using less water and fewer chemical fertilizers.

2. Soil Health:

- Sustainable agriculture maintains healthy soil with adequate nutrients, allowing farmers to grow crops on the same land without exhausting its fertility.

3. Water Conservation:

- Sustainable agriculture promotes water conservation by integrating efficient irrigation practices, especially important for farmers in areas facing water shortages.

4. Climate Change Adaptation:

- Sustainable farming practices like crop rotation and soil conservation help farms cope better with extreme weather and adapt to changing climate conditions.

5. Environmental and Economic Security:

- By lowering input costs and preventing environmental degradation, sustainable agriculture ensures that farms remain economically stable and ecosystems can be restored for future generations.

By implementing sustainable farming practices, farmers will have options for continuing to be productive, conserve their land, and have the choice to continue farming in the future.

Problems Farmers in Sustainable Agriculture Face:

1. Resource Use:

- As water, fertilizers, and energy are critical for farming, farmers often struggle to use them effectively. Overuse can lead to waste, increased costs, and negative environmental impacts, while underuse can reduce crop yield. Effective resource management is essential in sustainable agriculture, but many farmers do not identify inefficiencies without proper tools.

2. Lack of Real-Time Information Regarding Soil Health:

- Soil health is the foundation of productive farming, but many farmers lack easy access to real-time information about their soil. Without tracking critical elements like nutrient levels, organic matter, and pH, it is challenging to maintain healthy soils that support good crop yields. Poor soil leads to reduced yields and land degradation.

3. Unpredictable and Changing Weather Conditions:

- Climate change has altered weather patterns in unpredictable ways, making it difficult for farmers to plan. Sudden droughts and unseasonal heavy rains can severely affect crop development and yields. Many farmers lack resources to anticipate these changes and do not know when to adjust their practices.

4. Access to Comprehensive Data for Decision-Making:

- Many farmers rely on partial or outdated information for decisions related to planting, resource use, and crop management. Without a system to capture and process comprehensive information, they may miss critical inputs that could enhance their practices, leading to inefficiencies and increased costs.

5. Lack of Long-Term Planning and Forecasting:

- Sustainable farming requires long-term planning, but many farmers struggle to predict future needs such as water availability, nutrient requirements, and crop performance. Without appropriate forecasting tools, they find it challenging to prepare for future sustainability and respond to regulatory or environmental demands.

Why Use a Database Management System for Sustainable Agriculture?

A Sustainable Agriculture Resource Management Database provides the technological support needed to overcome these issues. It centralizes critical farm data, enabling farmers to make informed decisions that can boost efficiency, sustainability, and productivity.

1. Optimised Resource Management:

- The database monitors water usage, fertilizer application, and energy consumption in real time. This helps farmers apply the right amount of resources, reducing waste and saving money. By minimizing the overuse of inputs, the environmental footprint of the farm decreases, enhancing sustainability.

2. Real-Time Monitoring of Soil Health:

- Key parameters such as nutrients, moisture content, pH balance, and organic matter are monitored continuously. This ongoing assessment allows farmers to detect nutrient deficiencies or soil degradation early and take corrective action to maintain soil fertility.

3. Integration of Weather Data for Better Adaptation:

- The system integrates historical weather data and real-time forecasts, helping farmers adapt to unpredictable conditions. This enables them to adjust planting schedules, irrigation systems, and crop protection strategies based on expected weather patterns.

4. Comprehensive Decisions:

- The database provides a complete view of the farm by integrating data on soil conditions, crop performance, resource use, and weather patterns. This comprehensive perspective allows farmers to make informed decisions that improve productivity. Trends can be analyzed over time to adapt practices for optimal yields.

5. Predictive Analytics for Future Planning:

- Predictive analytics help farmers forecast yield potential, resource needs, and potential risks. This enhances their ability to prepare for future growing seasons and make proactive decisions, allowing them to respond effectively to challenges like water shortages or crop failures.

How the Database Solves Challenges: Resource Optimization: The system tracks resource usage, facilitating optimal allocation of water, fertilizers, and energy to each crop without overusing them, thereby minimising ecological impact.

- Soil Health: Continuous monitoring of soil quality ensures fertile land for harvests while preventing soil degradation.

- Adaptation to Climate Change: Integrating weather data enables farmers to adjust to changing conditions, enhancing resilience against adverse weather.

- Informed Decisions: Comprehensive data aids decision-making in crop management, improving yields and reducing unnecessary inputs.

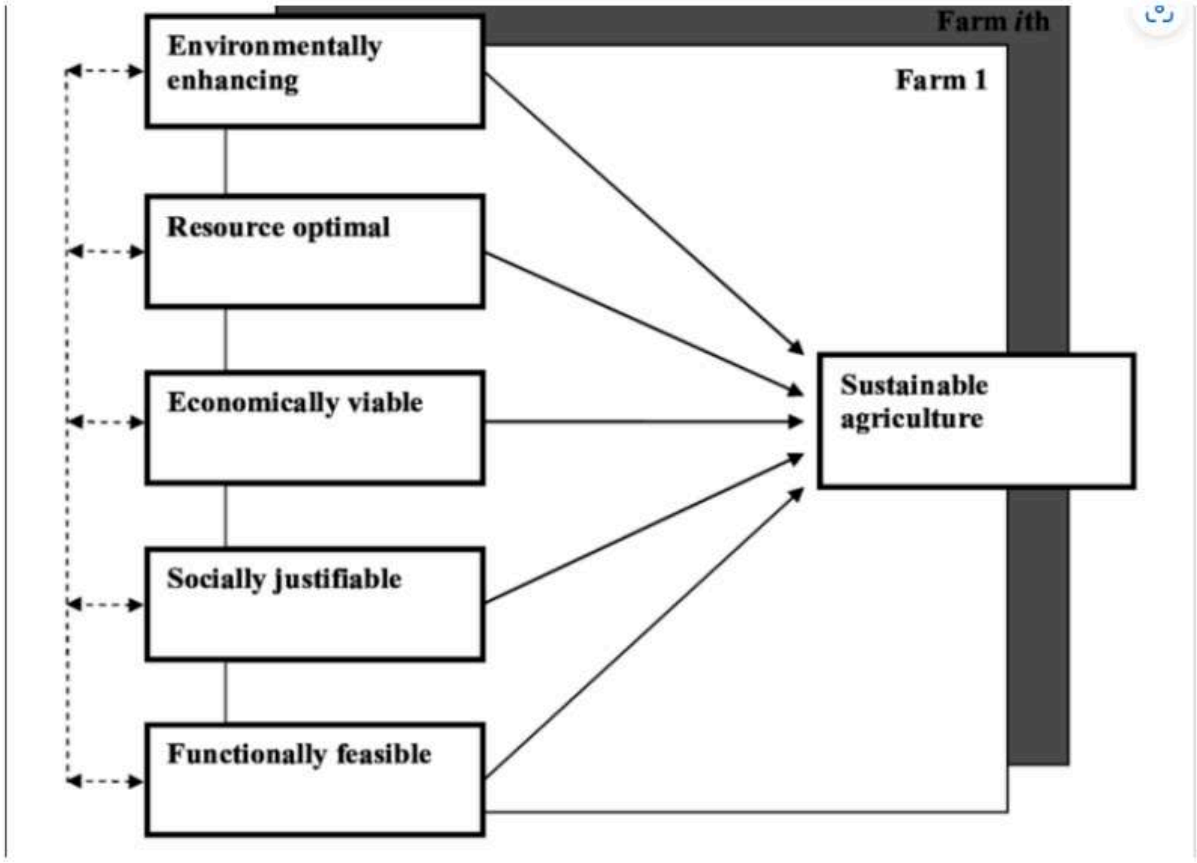
- Long-Term Sustainability: Predictive analytics support preparation for future challenges, helping farmers adopt practices that ensure sustainability for both their farms and the environment.
A specific database management system for sustainable agriculture will address farmers' concerns regarding resource use, soil health, climatic uncertainty, and long-term sustainability.

Sustainable Agriculture Resource Management Database: To facilitate the transition toward sustainability, the Sustainable Agriculture Resource Management Database serves as a centralized data repository designed to support farmers in adopting eco-friendly practices. The database provides a range of tools and insights that empower farmers to make informed decisions aimed at optimizing resource use, enhancing crop yields, and improving sustainability metrics.

Purpose of the Database:- Centralised Data Hub: It stores crucial farm data, offering farmers a single point of access for managing various aspects of their operations.

- Decision Support: By analyzing data trends, the database helps farmers make well-informed choices that support sustainability.

- Sustainability Enhancement: It promotes sustainable farming practices by optimizing the use of water, soil, fertilizers, and energy, reducing the overall environmental impact.



Key Features:

1. Farm Profile Management:

- Provides detailed records of farm attributes like location, size, and ownership.
- Facilitates better management of diverse farming operations.

2. Crop Management: - Tracks planting schedules, harvest outcomes, and crop types, offering insights into yield trends and crop performance over time.

- Enables farmers to monitor productivity and make adjustments for future planting cycles.

3. Soil Health Monitoring: - Measures essential soil parameters such as nutrient levels, pH, and organic matter, which are critical for sustainable crop production.

- Provides actionable insights to enhance soil health and optimize fertility.

4. Weather Data Integration:

- Incorporates historical and real-time weather information to assist in climate smart planning.

- Supports farmers in adapting to weather changes, improving resilience to climate variability.

5. Resource Usage Management:

- Tracks the use of water, fertilisers, and energy, enabling farmers to optimise inputs and reduce waste.

- Helps minimise the environmental footprint of farming practices.

6. Predictive Analytics: - Uses data-driven models to forecast crop yields and optimise resource allocation.

- Identifies potential risks, offering farmers foresight to avoid problems before they escalate.

7. Sustainability Metrics:

- Assesses farms' sustainability performance by evaluating environmental, economic, and social factors.

- Encourages continuous improvement in sustainable practices by providing benchmarks and actionable insights.

By equipping farmers with this integrated resource management tool, the Sustainable Agriculture Resource Management Database will empower them to make informed choices that not only increase productivity but also align with sustainable agricultural practices. This holistic approach is essential for fostering an environmentally responsible and economically stable agricultural sector.

Requirement Collection

Background Reading

The main goal of sustainable agriculture is to meet the world's food requirements without depleting the earth's natural resources. It addresses all three major components:
1.Economic The sustainable farming system should be profitable. Farmers can have a good living for themselves and also for their families.

2.Environment Sustainable agriculture for maintaining the environment, conservation of all natural resources is made like water bodies systems, healthy soil, quality of air etc.

3. Neighbourhood Sustainable agriculture improves the quality of life for farming and ranching communities and contributes to a more productive countryside with wealthy open countryside and fair treatment of farm workers along with good employment.

➔ https://www.agrivi.com/blog/sustainable-agriculture/

It is based on the three pillars of the sustainable agriculture in the economic, social, and environmental dimensions. The agri-ecological scale ensures environmental consideration and friendliness in farming, hence

assuring the least pollution, and use of non-renewable resources. The social, or social-territorial scale, addresses how people can appropriately feed the population of our planet and provide fair employment and development. For local communities. It is here that the economic scale secures the viability, efficiency, and profitability of the farming business.

➔ https://eos.com/blog/sustainable-agriculture/

According to Anibaldi et al. (2021), various factors across disciplines influence farmers' decisions to adopt sustainable agriculture. While many studies were conducted on the subject, several believe that the progress of sustainable agriculture is at a standstill. In practice, too, many farmers face an intentionbehavior gap in conducting sustainable agriculture (Nguyen et al. 2019). Further investigation into this issue should be necessary in the interest of policy recommendations.

➔https://www.researchgate.net/publication/359211371_Sustainable_agricultural_pra ctices_adoption

The growth in the adoption of smart farming technologies increased the level of data creation and consumption for agricultural purposes and automatically attracted questions about the management of such important data. A study of the responses from federal agencies showed that better practices in data management should be encouraged. The DART project, standing for Data Management Plans as a Research Tool, is on its quest to bring about more transparency and efficiency in the usage of data but still faces challenges due to the inconsistency of discipline-specific repositories.

➔ https://acsess.onlinelibrary.wiley.com/doi/10.1002/agj2.20639

Smallholder farmers produce 70% of the world’s food but face challenges with sustainable digital services. Improved data management and sharing

among agricultural stakeholders can help address these issues. This paper proposes a comprehensive digital framework for managing agricultural data to support smallholder farmers in Tanzania and beyond. The framework's effectiveness is demonstrated through case studies in Tanzania.

➔https://www.researchgate.net/publication/371173421_Data_management_system_for_sustainable_agriculture_among_smallholder_farmers_in_Tanzania_research-inprogress

It is different from conventional farming because it is practiced without harmful methods such as excessive pesticides, superfluous irrigation, or monoculture plantations. Industrialized farming demands extensive use of chemicals and fossil fuels, thereby reducing natural resources, increasing CO2 emissions, and threatening biodiversity through replacement of traditional crops with fast-growing varieties. Sustainable farming, on its part, strives to reduce these environmental pressures.

➔ https://study.com/learn/lesson/what-is-sustainable-agriculture.html

In order to practice agriculture successfully and ensure its effectiveness in various locations and changing conditions a mix of expertise technical know how and a competent workforce is necessary Scientific research and the knowledge gained from local farmers are crucial for attaining sustainability Schools and other social institutions have an important role in educating both farmers and scientists Collaborative efforts between farmers researchers are vital, for enhancing productivity and upholding sustainable farming methods

➔https://www.nature.com/scitable/knowledge/library/sustainable-agriculture23562787/

By 2050 the world population is projected to reach 9. With a 70 percent increase in food demand ahead. Agriculture faces challenges such as

pesticide use, Fertilizer runoff and monoculture farming complicating the task at hand. Concerns arise over farmers depleting resources, Which could impact future farming practices negatively. Agroecology presents an approach by balancing food security and environmental conservation. Modern farming practices often strain soils But adopting renewable methods, like crop rotation and reducing chemical usage can help alleviate these issues. Embracing knowledge and technology will propel us towards more efficient and environmentally friendly agricultural techniques.

➔ https://youtu.be/X4DZLtdSeCM?si=u1Jx4FsR3S8eZKfg

Developing practices that improve farm sustainability — profitability, quality of life and environmental care. Sustainable agriculture seek to meet the present food necessities without compromising on future resources. Key points include:

>Productivity & Profitability

>Whole-Farm Approach: Using practices such as rotational grazing and disc reduction to lessen their impact.
>Marketing Mix: Customer-added value and social contract.
>People and Future Generations: Promote farmer health and encourage good farming practices for present needs as well as future generations.
>Resilience It means bringing people together and learning as a collaborative effort to build robust systems.

➔ https://www.youtube.com/watch?v=iloAQmroRK0&t=61s

Technological Innovations: Precision agriculture, remote sensing, and data analytics are enhancing farming by optimizing resource use, boosting yields, and reducing environmental impact Sustainable Practices: These technologies promote sustainability through efficient resource use, reduced chemical inputs, and improved farm management. Future Prospects: The technologies have potential to tackle global challenges like food security

and environmental sustainability, with a call for ongoing research and development.

➔https://www.igi-global.com/chapter/emerging-technological-model-to-sustainableagriculture/26803

1.2.2 Interviews

Interview Plan:

System : Sustainable Agriculture

Project Reference : Group 1

Participants :Aarti Bodani
Bhakti Khokhani

Date: 10/9/2024 **Time**: 15:14

Duration: 45 minutes **Place**: Farm

Purpose of Interview:
Preliminary meeting to gain knowledge of the current various agriculture scenarios from the farmers

Agenda:
Current farming practices Resource
management by farmers Problems
faced by the farmers
Future sustainable agricultural plans/goals

Interview Summary: System :

Sustainable Agriculture **Project**

Reference : Group 1

Participants :Aarti Bodani
Bhakti Khokhani

Date: 10/9/2024 **Time**: 15:14
Duration: 45 minutes **Place**: Farm

Purpose of Interview:

Preliminary meeting to gain knowledge of the current various agriculture scenarios from the farmers

Questions to discuss:

1.What are the different farming practices currently on board?
2.What is the profit of farmers and how the current technique affects the environment?
3.What tools and technology do you currently use?
4.What future plans do you have regarding the sustainability of the agriculture?
5.How frequently the tools are used for the farming?
6.How and in how much quantity are the resources used?
(resources eg. water ,land ,seeds ,waste management)
7.Which government policy/schemes do you think will affect or improve your farming?
8.What are the current major problems are you facing now?
9.With which method will you go if you face the minor or major

problems?

Summary of the given questions solution:

- Combining traditional methods and modern methods.
- Profits are stable but fluctuate;depends on the crops.
- Use tractors, automated irrigation, pesticides tools. Use limited technology which stops the growth.
- Plans include expanding organic practices and investing

in solar energy.

- Tools like tractors and irrigation systems are used frequently; drones and sensors are used periodically.
- Efficient use of water with drip irrigation, land managed with crop rotation, optimized seed usage, and composting for waste management.
- Have less knowledge about the government schemes and policies. And if have the information then dont know how to implement it.
- Issues include fluctuating market prices, pest management, unpredictable weather, soil degradation, and water scarcity.
- Minor issues are handled with practice adjustments; major issues involve seeking expert advice, investing in technology, and exploring government support.So sometimes it takes time to solve and face the major problems.

Combined Requirements:

• 1. Farming Practices
- A list of traditional and modern farming methods.
- Information connecting specific methods to different crops and farming conditions.
- Details on how effective each method is and how often it's used.

• 2. Farmer Profitability and Environmental Impact
- Records of profit, costs, and earnings for each crop.
- Data on how farming affects the environment, such as soil health, water use, and pollution.

• 3. Tools and Technology Usage
- A list of farming tools and technologies like tractors, irrigation systems, drones, and sensors.
- Information on how often tools are used, how they are maintained, and how they impact farming efficiency.

• 4. Sustainability Plans
- Plans for future sustainability efforts like organic farming and

using solar energy.
- Progress updates on sustainability goals and the steps taken to reach them.

• 5. Resource Management
  - Information on how water, land, seeds, and waste are used.
  - Historical data to help improve resource usage and reduce waste.

• 6. Government Policies and Schemes
  - Details on government policies and schemes, including eligibility and how to apply.
  - Tracking farmers' knowledge and use of these policies.
• 7. Market Trends and Environmental Challenges
  - Information on changing market prices, pest problems, unpredictable weather, soil issues, and water shortages.
  - Suggestions for handling these challenges based on past data.

• 8. Problem-Solving Methods
  - Ways to solve both minor and major farming problems, including advice from experts and new technology.
- Information on how long it takes to fix issues and what resources are used

Key Insights from Interviews

The interviews conducted shed light on the current state of sustainable agriculture, covering the methods, issues, and aspirations of farmers. The main insights are summarized as follows:

1.Farming Methods:
Farmers are employing a mix of traditional and modern methods. While they maintain some conventional practices, they have also integrated basic machinery like tractors, automated irrigation systems, and pesticides to improve productivity. However, limited adoption of advanced technologies has been a noted challenge.

2.Profitability and Environmental Considerations:

Farmers' profits fluctuate due to crop yields and market conditions. They are conscious of the environmental effects of their practices and are interested in expanding organic farming and using renewable energy, such as solar power, to promote sustainability.

3.Tools and Technology Use:

Essential machinery like tractors and irrigation systems are frequently used, while tools like drones and sensors are occasionally employed for specific tasks. Farmers recognize that more advanced technology could boost efficiency but need support for its full adoption.

4.Resource Management Practices:

Water and land management practices are being optimized, with methods like drip irrigation for efficient water use and crop rotation for soil conservation. Composting is also used for waste management, with opportunities to enhance these practices further.

5.Awareness of Government Schemes:

Many farmers are either unaware of beneficial government schemes or lack the resources and knowledge to implement them effectively. This highlights a need for better access to information and assistance.

6.Primary Challenges:

Key issues include fluctuating prices, pest control, unpredictable weather, soil erosion, and limited water availability. Minor issues are generally addressed through small adjustments, while larger issues require expert intervention, technological investment, and sometimes government assistance.

7.Goals for Sustainable Growth:

Farmers aim to adopt more sustainable practices, such as organic methods and renewable energy sources, to promote long-term productivity and environmental conservation.

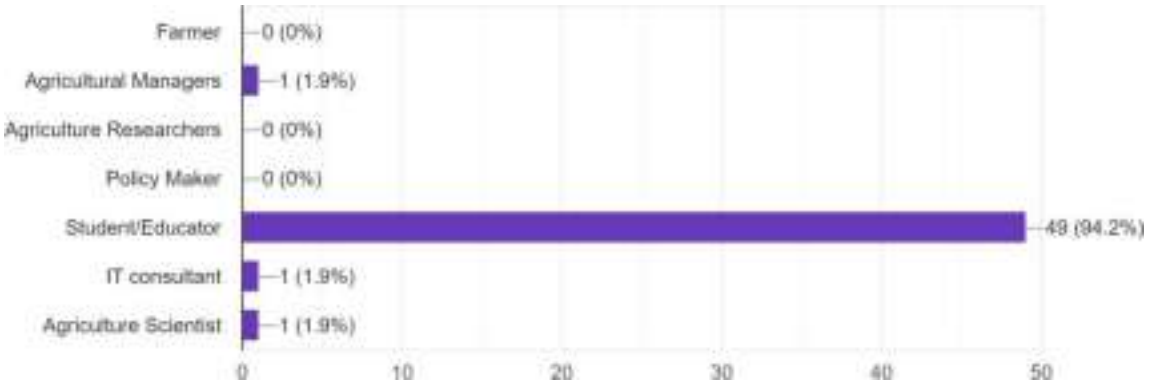
These findings have informed the project's requirements, leading to solutions focused on enhanced resource management, improved government policy awareness, and tracking systems for profitability and environmental sustainability.

Questionnaires/Surveys

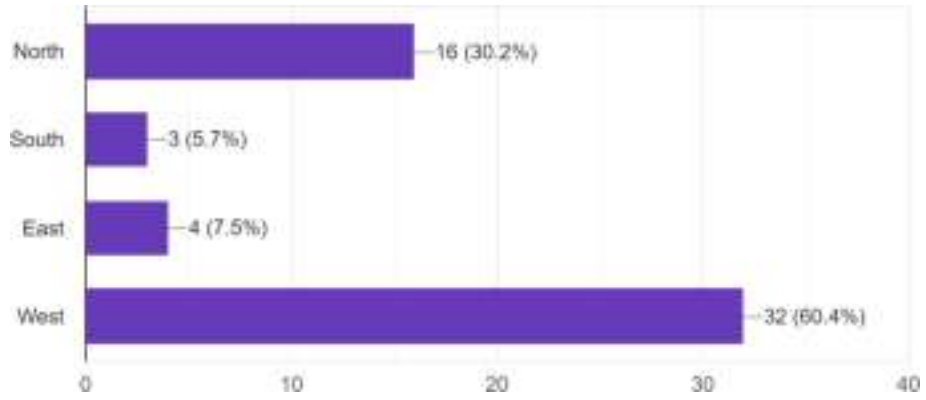
Summary of Questions, Issues, and Responses from Questionnaires

Summary:-

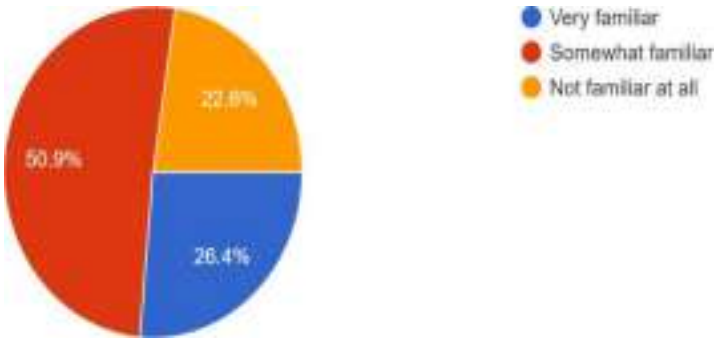
1. Role:-



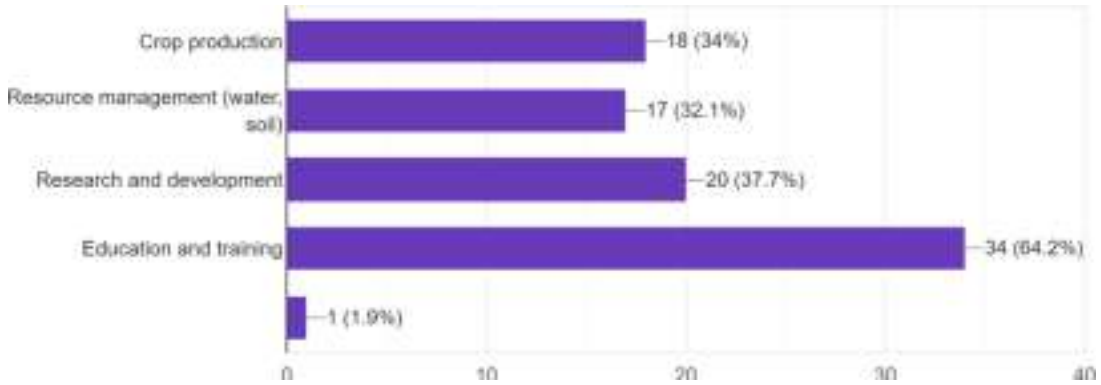
2. Region of Agriculture



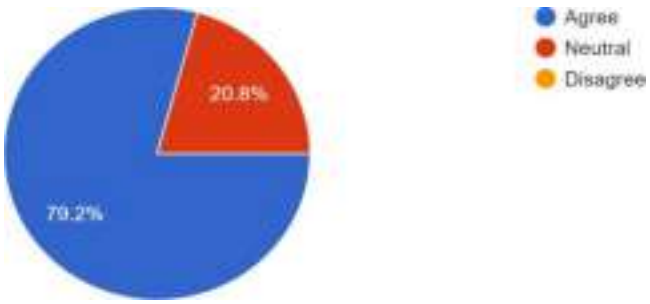
3. How familiar are you with sustainable agriculture?



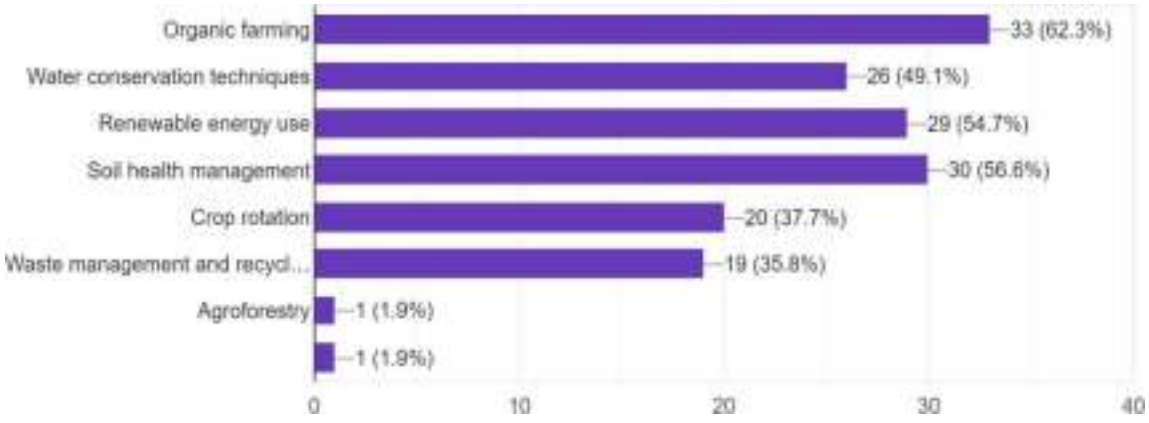
4.What type of agricultural practices are you most involved in or have knowledge about



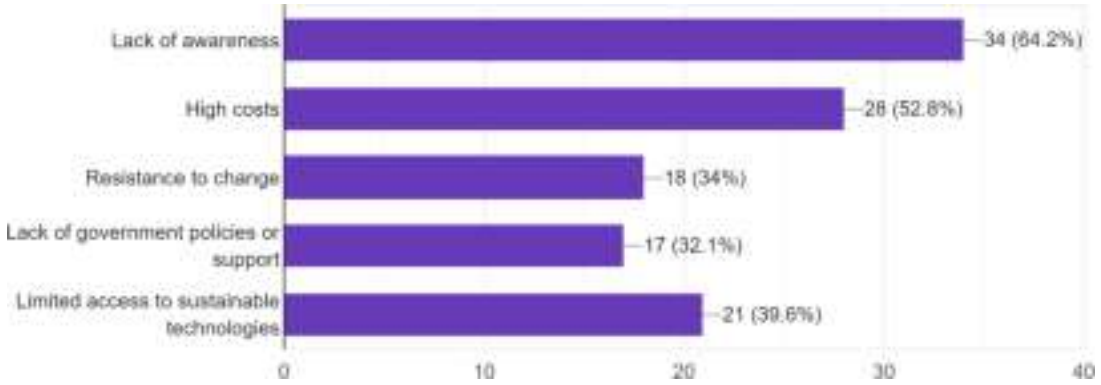
5.Do you believe that sustainable agriculture practices are important for long-term food security?



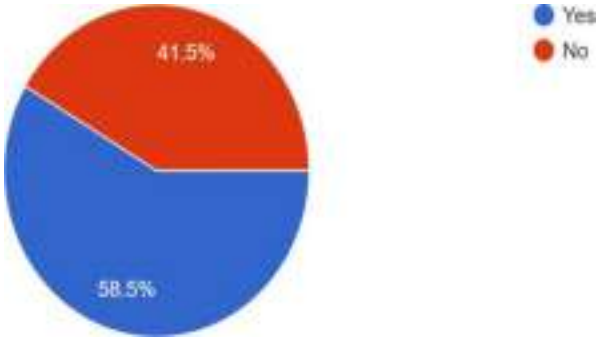
6.What sustainability practices do you think are most important for agriculture?



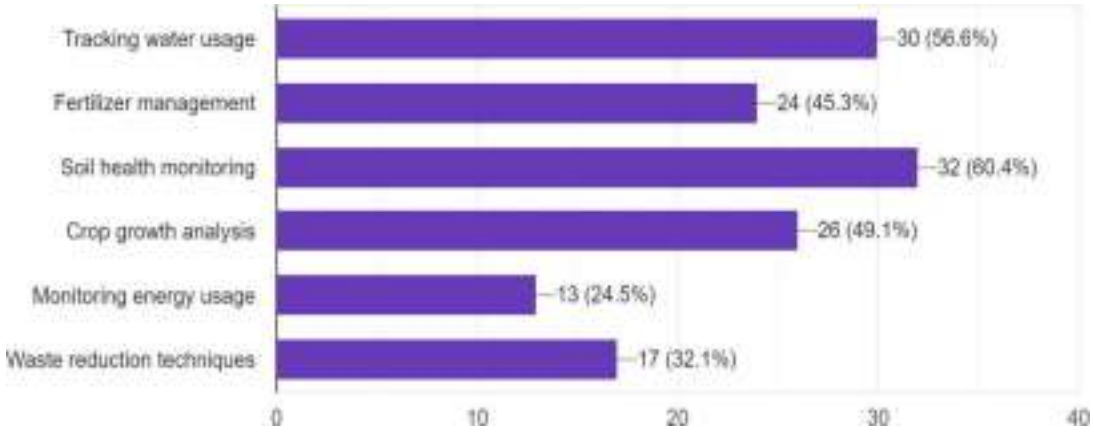
7.According to you what could be the key problems in implementing sustainable agriculture practices?



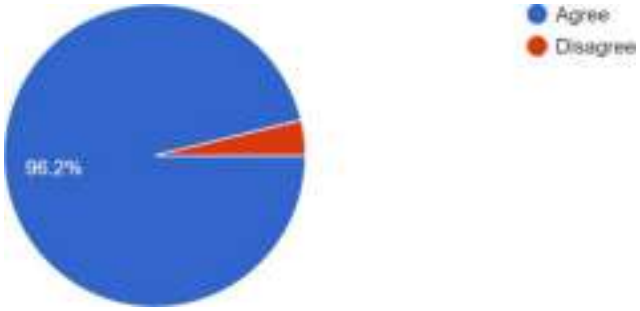
8.Do you know about the use of tools for managing agricultural resources (i.e, databases ,etc)?



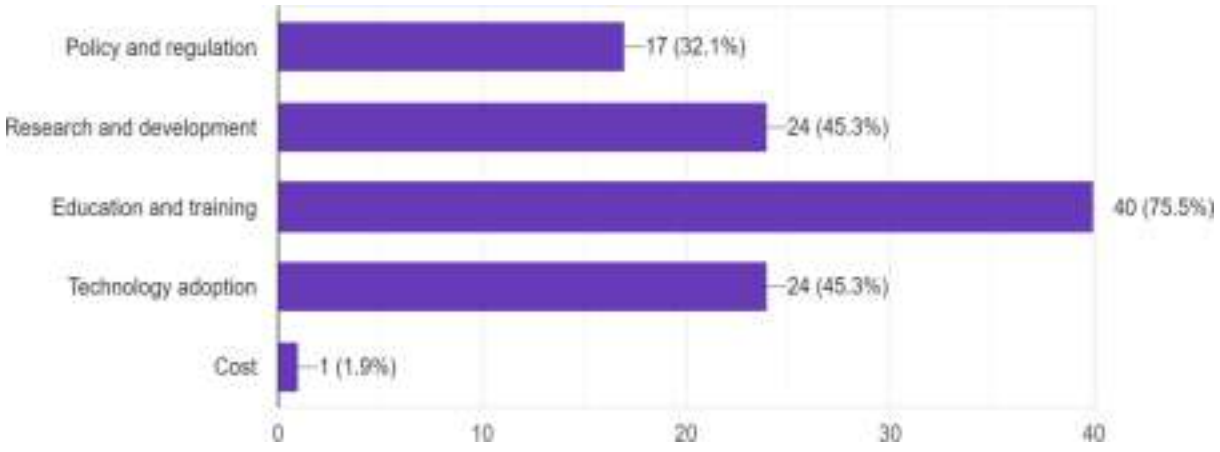
9.Which resource management techniques do you think are most effective in improving sustainability



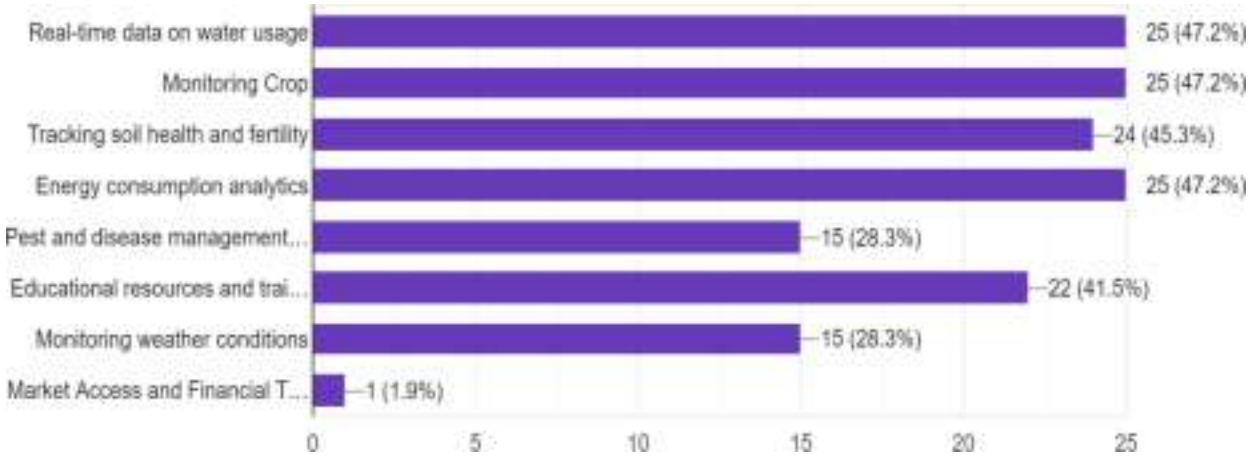
10. Do you believe that technology can play an important role in advancing sustainable agriculture?



11. According to you what should be the key areas for improving sustainable agriculture?



12. What features would you like to see in a sustainable agriculture resource management system?



The questionnaire responses provided valuable insights into the participants' views on sustainable agriculture, preferred practices, and challenges. Here is a summary of the main questions, common issues, and responses:

1.Awareness of Sustainable Agriculture:

Respondents varied in their knowledge of sustainable agriculture. Some participants were more familiar with sustainable methods, while others were less informed. Overall, there was agreement on the importance of sustainable practices for ensuring long-term food security.

2.Primary Agricultural Practices:

Participants highlighted various farming practices, emphasizing soil conservation, water management, and crop rotation. Drip irrigation and composting were commonly cited as effective methods for optimizing resource use.

3.Value of Sustainability:

Most respondents recognized the critical role of sustainable practices in maintaining productivity and preserving resources. Organic farming and renewable energy sources were identified as important for future resilience.

4.Challenges in Adopting Sustainable Methods:

Respondents pointed out barriers such as limited resources, high costs, and a lack of knowledge, which hinder the adoption of sustainable techniques. Additional challenges included market price fluctuations, water shortages, and soil degradation.

5.Technology's Role in Sustainability:
Participants generally agreed that technology could enhance sustainability, though they expressed concerns about the costs and skills required to implement advanced tools like drones and data systems.

6.Desired Features in a Resource Management System:
Respondents showed interest in features to track water usage, soil health, crop rotation schedules, and energy consumption. User-friendly interfaces and real-time data access were highlighted as key components to support effective resource management.

These findings have informed the design requirements for an agricultural management system, emphasizing features for resource tracking, technology accessibility, and support for sustainable practices.

Real-World Observations of Processes in the Agricultural Domain

To create an effective database for sustainable agriculture resource management, it's crucial to understand how various agricultural activities function in real-world settings. Through field visits, interviews, and data collection with farmers, agricultural managers, and researchers, we observed the following processes:

1. Crop Selection and Cultivation

- **Observation**: Farmers plan crop selection based on seasonal patterns, soil conditions, and weather forecasts. This planning phase often involves reviewing past yields, soil test results, and current market needs.

- **Database Application**: The **Crops** table in the database records details such as crop type, planting season, and soil requirements, linking each crop entry to its specific **Farm_ID**.

2. Farm Operations and Resource Allocation

- **Observation**: Common farming operations like soil preparation, planting, irrigation, and fertilization rely on specific resources (e.g., seeds, water, fertilizers), with resource use adjusted based on crop type and farm conditions.
- **Database Application**: The **Farm_Activities** table stores data on these activities, helping track resource usage and support sustainable resource management.

3. Weather-Dependent Farming Decisions

- **Observation**: Weather significantly impacts farm productivity. Farmers adapt schedules for irrigation and harvesting based on both current weather and forecast data.
- **Database Application**: The **Weather_Data** table collects historical and real-time weather information, enabling farmers to make data-driven decisions and track trends over time.

4. Sustainability and Carbon Management

- **Observation**: Increasingly, farms incorporate sustainable practices like crop rotation, reduced chemical usage, and carbon offset strategies, aimed at both environmental compliance and soil health.
- **Database Application**: **Sustainability_Measures** and **Carbon_Tracking** tables document these sustainable practices and track carbon output, providing data for assessing environmental performance.

5. Research and Data Collection for Improvement

- **Observation**: Researchers collect extensive data on crop growth, soil health, and resource use to identify best practices and drive innovation in sustainable farming.

- **Database Application**: The **Research_Data** table organizes data from these studies, allowing structured analysis of agricultural methods and their impacts.

6. Policy Development and Data-Driven Decisions

- **Observation**: Agricultural policy makers rely on collected farm data to craft guidelines that promote sustainable farming, such as regulations on water usage or fertilizer application.
- **Database Application**: Data related to policies is stored and linked to relevant farm activities and sustainability measures, allowing stakeholders to monitor policy effectiveness and make adjustments as necessary.

Fact-Finding Chart

Table/Chart of Findings from Requirement Collection

Objective	Technique	Time commitment
Defining primary goal of the database	Background reading	1 Day
For understanding current agricultural challenges	Interviews, background reading	2 Days
for identifying data source and requirement for the system	Interview	1 Day
for identifying scope for improvement in resource usage	Interview	1 Day
To get the opinions from farmers,managers,students,researchers	Interview Questionnaire survey	4-5 hours
To understand the preference of users of database	Questionnaire survey	4-5 hours
To establish key features and functionalities for the system	Interview Questionnaire	4-5 hours

Requirements List

Consolidated List of Requirements

Based on insights gathered through interviews, surveys, and observations, the following requirements have been identified for a sustainable agriculture resource management system:

1.Management of Farming Practices
- Develop a database to store comprehensive details on various farming practices, including names, descriptions, and related crop types.
- Link practices to specific conditions to facilitate effective categorization and analysis.

2.Profit and Environmental Impact Tracking
- Implement a system to record financial information, such as revenue, expenses, and profit margins associated with each crop and farming method.
- Include fields to assess environmental impact, tracking metrics like soil quality, water usage, and pollution levels to evaluate sustainability.

3.Inventory of Tools and Technology
- Set up tables to log all farming tools and technologies, detailing tool types, usage frequency, and maintenance schedules.
- Track the impact of each tool on productivity, aiming to optimize tool deployment.

4.Sustainability Initiatives and Future Plans
- Develop a module to document and track sustainability goals, including descriptions, objectives, and implementation progress.
- Record milestones and results to assess the impact of these efforts over time.

5.Resource Management
- Track usage of key resources like water, land, and seeds, aiming to maximize efficiency and conservation.
- Add fields to monitor quantities used, conservation techniques (e.g., drip irrigation), and adjustments over time.

6.Tracking of Government Programs and Policies
- Create a database of government programs relevant to sustainable agriculture, including policy names, descriptions, eligibility criteria, and farmers' application statuses.
- Record farmer awareness and engagement to improve access to support.

7.Issue Management and Problem Resolution
- Include tables for tracking issues in farming, detailing descriptions, severity, and impacts of various challenges.
- Log problem-solving methods, noting time taken and effectiveness, to improve responses to recurring issues.

8.Water Usage Monitoring
- Record water usage precisely, detailing quantities used, conservation practices, and adjustments over time for better resource management.

9.Land Utilization Tracking
- Keep detailed records of land usage, including area, crop types, and rotation practices, to ensure efficient land management.

10.Soil Health Data
- Track soil health metrics, such as fertility indicators (e.g., phosphorus, potassium), pH, and nutrient levels, to maintain and improve soil quality.

11.Energy Use and Pest Management
- Monitor energy consumption by farm equipment to assess energy efficiency.
- Log pest management efforts, including pest types, affected crops, and control methods, for improved pest control strategies.

This consolidated list provides a structured framework for designing a sustainable agriculture management system, enabling better resource

tracking, enhanced program support, and informed decision-making for sustainability.

User Roles and Privileges within the System

In the **Sustainable Agriculture Resource Management System**, different roles are defined to manage access based on each user's responsibilities. Below are the roles and their respective privileges:

1. Administrator

- **Role**: Manages the entire system, including user roles and database settings.
- **Privileges**:
    - Full access to all system data and functionalities.
    - Ability to create, edit, and delete user accounts and assign roles.
    - Manage database backups, system settings, and monitor performance.
    - Oversee data usage across the platform.

2. Agriculture Manager

- **Role**: Oversees farm data, tracks farm activities, and manages resources.
- **Privileges**:
    - View, add, modify, and delete entries in **Farm_Activities** and **Farms** tables.
    - Access and edit data on crops, sustainability, and farm characteristics.
    - Generate reports on resource usage, crop performance, and farm metrics.

3. Farmer

- **Role**: Associated with one or more farms; responsible for farm activity records and using sustainable practices.
- **Privileges**:
    - View and update personal entries in **Farm_Activities** and **Crops**.
    - Access personal contact information and manage farm-specific data.
    - Limited read-only access to sustainability measures applicable to their farm.

4. Researcher

- **Role**: Utilizes system data to improve agricultural methods and sustainability practices.
- **Privileges**:
    - Read-only access to **Farm_Activities**, **Crops**, and **Weather_Data**.
    - Contribute research results to **Research_Data**.
    - Access **Sustainability_Measures** and **Carbon_Tracking** data for research.
    - Can submit data requests for specific farms or activities, pending approval.

5. Policy Maker

- **Role**: Analyzes data to help develop policies supporting sustainable agriculture.
- **Privileges**:
    - Read-only access to **Farm_Activities**, **Crops**, **Weather_Data**, and **Carbon_Tracking**.
    - Access to various system reports and sustainability assessments.
    - Limited data export for policy development purposes.

6. Student/Teacher

- **Role**: Users with an educational focus, studying system data for learning purposes.
- **Privileges**:
    - Read-only access to certain tables like **Research_Data** and **Sustainability_Measures**.
    - View-only access to anonymized data in **Farm_Activities**.

Privilege Levels and Access Control

Each role is assigned a privilege level to manage data access as required by their responsibilities:

Privilege Level	Description
Read-Only	View data without making changes
Read-Write	View and modify data, excluding deletions
Full Control	Complete access to view, edit, and delete records

---

Summary of User Roles and Access Levels

Role	Privilege Level	Accessible Tables	Actions Allowed
Administrator	Full Control	All Tables	View, Add, Edit, Delete, User and System Management

Agriculture Manager	Read-Write	Farms, Farm_Activities, Crops, Sustainability_Measures	View, Add, Edit, Delete
Farmer	Read-Write (Own Data)	Farm_Activities, Crops	View, Edit (Own Records Only)
Researcher	Read-Only	Farm_Activities, Crops, Weather_Data, Sustainability_Measures, Research_Data	View, Submit Research Findings
Policy Maker	Read-Only	Farm_Activities, Crops, Weather_Data, Carbon_Tracking	View, Data Export (Limited)
Student/Teacher	Read-Only	Research_Data, Sustainability_Measures, Farm_Activities (Anonymized)	View Only

Chapter 2: Database Design

1. Noun Analysis:

Table 1 : All Extracted Nouns & Verbs from Problem Description

Noun	Verb
Agriculture	Manages
Resources	Allocates
Farmers	Cultivates
Crop	Grows
Management	Optimises
System	Tracks
Information	Collects
Data	Analyses
Soil	Measures
Water	Conserves
Policy	Develops
Survey	Conducts
Techniques	Implements

Database	Stores
Inputs	Monitors
Outputs	Evaluates
Sustainability	Promotes
Ecosystem	Supports
Environment	Protects
Technology	Integrates
Tools	Utilizes
Research	Conducts
Climate	Adapts
Seeds	Plants
Pesticides	Uses
Fertilizers	Applies
Yield	Increases
Production	Enhances

Cost	Reduces
Techniques	Improves
Results	Analyses

Stakeholders	Involves
Students	Educates
Teachers	Guides
Government	Regulates
Reports	Generates
Experts	Advises
Land	Cultivates
Livelihoods	Improves
Crops	Harvests
Knowledge	Shares
Communities	Engages
Feedback	Receives
Decision	Makes
Opportunities	Creates
Strategies	Develops
Inputs	Supplies

Outputs	Delivers
Market	Connects

Resources	Provides
Productivity	Increases
Quality	Enhances
Waste	Minimises
Goals	Sets
Systems	Establishes
Policies	Implements
Initiatives	Launches
Farmers	Engages
Communities	Builds
Action	Takes
Impact	Assesses
Livelihoods	Enhances
Strategies	Proposes
Programs	Executes
Infrastructure	Develops
Support	Provides

Food	Grows

Regions	Includes
Rainfall	Affects
Projects	Designs
Issues	Identifies
Energy	Consumes
Solutions	Proposes
Team	Forms
Farmers	Consults
Experts	Collaborates
Challenges	Faces
Problems	Solves
Solutions	Implements
Farms	Supports
Collaboration	Encourages
Policies	Influences
Soil	Enriches
Agriculture	Enhances
Discussions	Leads

Reports	Provides
Markets	Links
Profitability	Enhances
Partnerships	Develops
Farmers	Supports
Goals	Achieves
Impact	Measures
Engagement	Encourages
Results	Reports
Land	Utilises
Inputs	Increases
Data	Gathers
Technology	Adopts
Communication	Facilitates
Outputs	Processes
Equipment	Uses
Land	Acquires
Projects	Coordinates
Reports	Summarizes

Technology	Automates
Systems	Evaluates
Frameworks	Develops
Soil	Analyses
Partnerships	Encourages
Communities	Supports
Strategies	Formulates
Models	Simulates
Databases	Integrates
Fields	Cultivates
Fertilisers	Distributes
Insects	Controls
Pest	Mitigates
Programs	Manages
Reports	Verifies
Sensors	Monitors
Projects	Tests
Energy	Consumes

Sustainability	Promotes

Techniques	Demonstrates
Innovations	Introduces
Harvest	Collects
Feedback	Analyses
Algorithms	Executes
Investments	Expands
Reports	Details
Tools	Measures
Applications	Manages
Software	Develops
Techniques	Models
Practices	Enhances
Agriculture	Improves
Yields	Measures
Farmers	Invests
Projects	Plans
Workshops	Conducts

Research	Expands
Labs	Tests

Technology	Creates
Resources	Maximises
Markets	Supports
Data	Automates
Crops	Improves
Plants	Enhances
Feedback	Captures
Research	Designs

Table 2 : Accepted Noun & Verbs list

Candidate Entity Set	Candidate Attributes Set	Candidate Relationship Set
Agriculture	Agriculture ID, Practices, Economic Viability	Agriculture-Implements Policies
Sustainability	Sustainability ID, Practices	Sustainability-Supports Community
Farmers	Farmer ID, Name, Practices	Farmers-Engages-Community

Inputs	Input ID, Type, Quantity	Inputs-Supports-Resources
Resources	Resource ID, Type, Availability	Resources-Manages-Inputs
Outputs	Output ID, Type, Quantity	Outputs-Monitors-Performance
Data	Data ID, Type, Collection Method	Data-Analyzes-Effectiveness
Environment	Environment ID, Quality	Environment-Protects Biodiversity
Water	Water ID, Quality, Source	Water-Conserves-Soil
Crop	Crop ID, Type, Yield	Crop-Improves-Productivity
Technology	Technology ID, Type, Application	Technology-Optimizes Management
Community	Community ID, Name, Engagement Level	Community-Engagement Facilitates
Ecosystem	Ecosystem ID, Health Status	Ecosystem-Supports Environmental Quality
Impact	Impact ID, Description, Assessment	Impact-Evaluates Performance
Biodiversity	Biodiversity ID, Species Count	Biodiversity-Monitoring Effectiveness
Policies	Policy ID, Description, Implementation	Policies-Guide-Management

Development	Development ID, Type, Goals	Development-Conducts Research
Soil	Soil ID, Type, Health Status	Soil-Measures-Quality
Water Quality	Water Quality ID, Parameters	Water Quality-Monitors Effectiveness

Table 3 : Rejected Noun & Verbs list

Rejected Noun	Rejection Reason
Agriculture	General: Too broad
Resources	Vague: Lacks context
Farmers	Irrelevant: Too generic; lacks specificity
Management	General: Needs definition
System	General: Lacks context
Information	Vague: Not clearly defined
Data	Irrelevant: Too broad
Water	General: Needs specificity
Policy	Vague: Lacks context
Survey	Irrelevant: Needs context
Techniques	Irrelevant: Already included
Inputs	General: Needs context
Outputs	General: Needs context
Sustainability	Vague: Lacks specificity

Ecosystem	General: Too abstract; lacks context
Environment	Vague: Needs specificity
Technology	General: Too broad; lacks clarity
Tools	General: Needs context
Research	General: Needs context
Climate	Irrelevant: Lacks specificity
Seeds	General: Needs context

Pesticides	General: Needs context
Fertilizers	General: Needs context
Yield	General: Lacks context
Production	General: Needs context
Cost	Irrelevant: Too broad
Results	Vague: Not clearly defined
Stakeholders	Irrelevant: Too broad
Students	General: Needs context
Teachers	General: Needs context
Government	Irrelevant: Too broad
Land	General: Needs specificity
Livelihoods	General: Needs context
Knowledge	General: Not clearly defined

Feedback	General: Lacks context
Decision	General: Needs context
Opportunities	Irrelevant: Too broad
Strategies	General: Lacks specificity
Market	General: Needs context
Productivity	Irrelevant: Too broad
Waste	General: Needs specificity
Action	General: Not clearly defined
Impact	General: Not clearly defined

Infrastructure	General: Needs context
Food	Irrelevant: Too broad
Regions	General: Needs specificity
Rainfall	General: Needs context
Issues	General: Not clearly defined
Energy	Irrelevant: Too broad
Solutions	General: Needs context
Team	General: Needs context
Challenges	General: Not clearly defined
Problems	Irrelevant: Too broad
Collaboration	General: Needs context

Discussions	General: Not clearly defined
Profitability	Irrelevant: Lacks context
Partnerships	General: Needs context
Engagement	General: Lacks context
Communication	General: Needs specificity
Equipment	Irrelevant: Needs context
Fields	General: Needs specificity
Fertilisers	General: Needs context
Insects	General: Needs context
Pest	General: Needs specificity
Sensors	General: Needs context

Frameworks	General: Needs context

Table 4: Final list of Entities

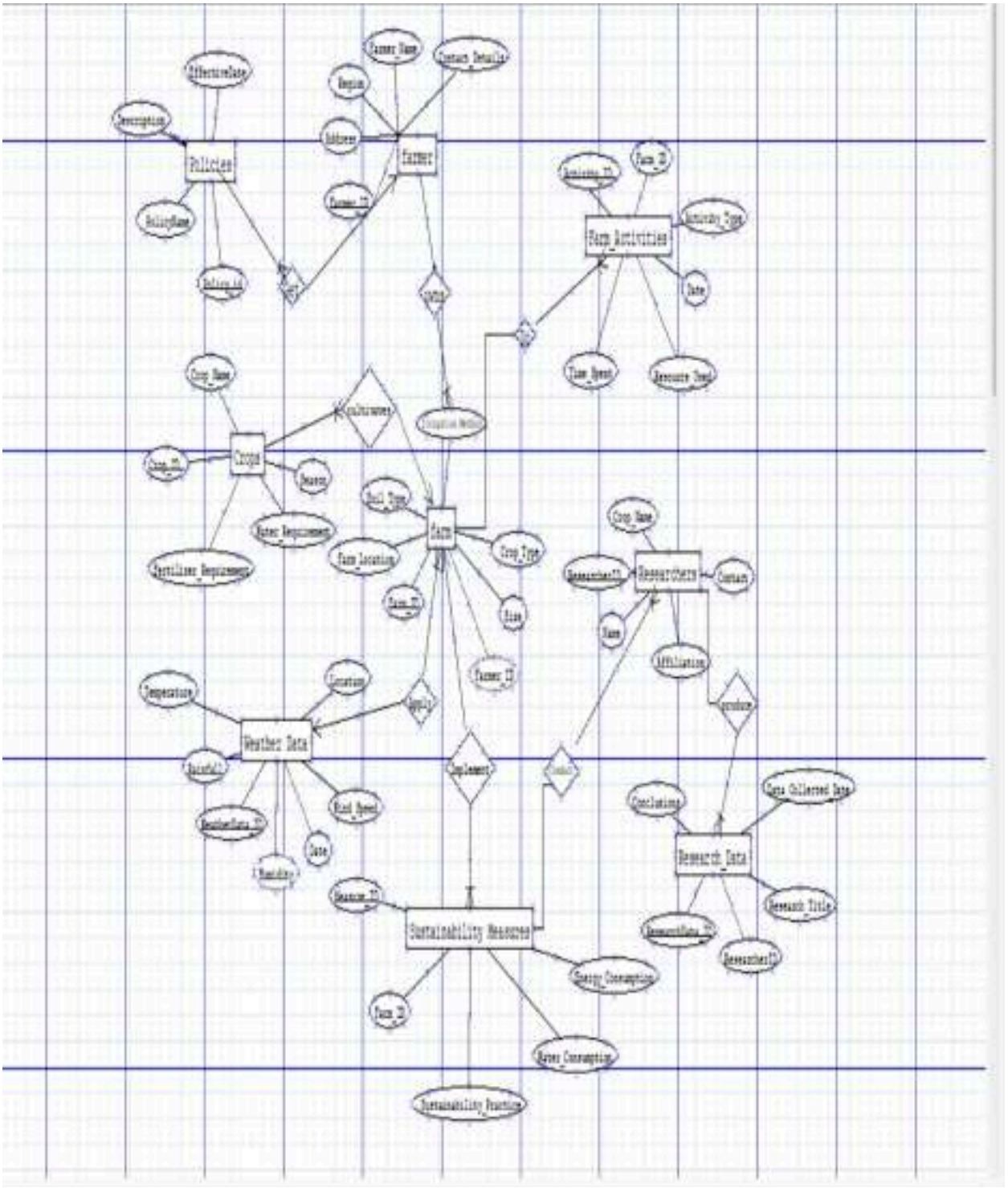
Entity	Attributes	Relations
Farmers	Farmer_ID (PK), Farmer_Name, Contact_Details, Address, Region	One-to-Many (Farmers → Farms)

Farms	Farm_ID (PK), Farmer_ID (FK),size, Farm_Location, Soil_Type, Crop_Type, Irrigation_Method	Many-to-One (Farms → Farmers)
Crops	Crop_ID (PK), Crop_Name	One-to-Many (Farms → Crops)
Weather_Data	WeatherData_ID (PK), Date, Location, Temperature, Rainfall, Humidity, Wind_Speed	One-to-Many (Weather_Data→ Farms)
Farm_Activities	Activity_ID (PK), Farm_ID (FK), Activity_Type, Date, Resource_Used	One-to-Many (Farms →

		Farm_Activities):
Sustainability_Measures	Measure_ID (PK), Farm_ID (FK), Sustainability_Practice, Energy_Consumption, Water_Consumption	One-to-Many (Farms → Sustainability _Measures

Researchers	ResearcherID (PK), Name, Affiliation, Contact	One-to-Many (Researchers → Research Data)
Research_Data	ResearchData_ID (PK), Research Title, ResearcherID (FK), Data_Collected_Date, Conclusions	Many-to-One (Research data → Researchers)
Policies	PolicyID (PK), PolicyName, Description, EffectiveDate	One-to-Many (Farmers->policy)

ER diagram :-


Farmer
Policies
Farm Activities
Crops
Farm
Researchers
Weather Data
Research Data
Sustainability Measures

Entity Types

1. Strong Entities: Entities that exist independently with unique identifiers (primary keys).
    - Farmers
        - Entity Type: Strong Entity
        - Identifier: Farmer_ID
    - Farms
        - Entity Type: Strong Entity
        - Identifier: Farm_ID
    - Crops
        - Entity Type: Strong Entity
        - Identifier: Crop_ID
    - Weather_Data
        - Entity Type: Strong Entity
        - Identifier: WeatherData_ID
    - Researchers
        - Entity Type: Strong Entity
        - Identifier: ResearcherID
    - Research_Data
        - Entity Type: Strong Entity
        - Identifier: ResearchData_ID
    - Policies
        - Entity Type: Strong Entity
        - Identifier: PolicyID
2. Weak Entities: Entities that depend on strong entities for their identification and require foreign keys from those entities to create a composite primary key.
    - Farm_Activities
        - Entity Type: Weak Entity (dependent on Farms)
        - Identifier: {Farm_ID, Activity_ID}
    - Sustainability_Measures
        - Entity Type: Weak Entity (dependent on Farms)
        - Identifier: {Farm_ID, Measure_ID}

Relationship Types

1. One-to-One (1:1) Relationships:
    - Farmers to Contact_Details: Each farmer has a unique set of contact details, and each set of contact details is associated with only one farmer.
2. One-to-Many (1
) Relationships:
    - Farmers to Farms: One farmer can own or manage multiple farms, but each farm is associated with a single farmer.
    - Farms to Crops: A single farm can grow multiple crops, but each crop record is linked to one farm.
    - Farms to Farm_Activities: One farm can have multiple activities, but each activity is specific to a single farm.
    - Sustainability_Measures to Farms: Each sustainability measure can be applied to multiple farms, but each farm is linked to one specific sustainability measure.
3. Many-to-Many (M
) Relationships:
    - Researchers to Research_Data: Multiple researchers can contribute to multiple research data sets, and each data set can involve multiple researchers.
    - Farms to Carbon_Footprint_Tracking: Many farms can have carbon footprint data records, and each record can pertain to multiple farms (if managed collectively in the analysis).
    - Crops to Farm_Activities: Multiple crops can be involved in multiple activities, and each activity can affect multiple crops.

Mapping E-R Model to Relational Model

1. Farmers
 - Relation: Farmers(**Farmer_ID**, Farmer_Name, Contact_Details, Address, Region)

2. Farms
 - Relation: Farms(**Farm_ID**, Farmer_ID, Size, Farm_Location, Soil_Type, Crop_Type, Irrigation_Method)
 - Primary Key: Farm_ID
 - Foreign Key: Farmer_ID (references Farmers)

3. Crops
 - Relation: Crops(**Crop_ID**, Crop_Name, Season, Water_Requirement, Fertilizer_Requirement)
 - Primary Key: Crop_ID

4. Weather_Data
 - Relation: Weather_Data(**WeatherData_ID**, Date, Location, Temperature, Rainfall, Humidity, Wind_Speed, _Farm_ID_) - Primary Key: WeatherData_ID
 - Foreign Key: Farm_ID(references Farms)

5. Farm_Activities
 - Relation: Farm_Activities(**Activity_ID**, Farm_ID, Activity_Type, Date, Resource_Used, Time_Spent)
 - Primary Key: Activity_ID
 - Foreign Key: Farm_ID (references Farms)

6. Sustainability_Measures
 - Relation: Sustainability_Measures(**Measure_ID**, Farm_ID, Sustainability_Practice, Energy_Consumption, Water_Consumption) - Primary Key: Measure_ID
 - Foreign Key: Farm_ID (references Farms)
7. Researchers
 - Relation: Researchers(**ResearcherID**, Name, Affiliation,

Contact)** - Primary Key: ResearcherID

8. Research_Data
- Relation: Research_Data(**ResearchData_ID**, Research_Title, _ResearcherID_, Data_Collected_Date, Conclusions)
- Primary Key: ResearchData_ID
- Foreign Key: ResearcherID (references Researchers)

9. Policies
- Relation: Policies(**PolicyID**, PolicyName, Description, EffectiveDate) - Primary Key: PolicyID

10. Farmers_Policies (Associative Entity for the Many-to-Many relationship) - Relation: Farmers_Policies(Farmer_ID, PolicyID)
- Primary Key: (Farmer_ID, PolicyID) (composite key)
- Foreign Key: Farmer_ID(references Farmers)
- Foreign Key: PolicyID (references Policies)

11. Carbon_Tracking
- (**Tracking_ID**, Farm_ID, Researcher_ID, Total_Carbon_Emissions, Measurement_Period, Reduction_Strategies)
- Primary Key: Tracking_ID
- Foreign Key: Farm_ID (references Farms)
- Foreign Key: Researcher_ID (references Researchers)

12.Contact_Details (**Contact_ID**, Farmer_ID, Phone_Number, Email_Address ,Address)
- Primary Key: Contact_ID
- Foreign Key: Farmer_ID (references Farmers)

2. Create DDL Scripts

1. Farmers:-

```
CREATE TABLE Farmers (
```

```
Farmer_ID INT PRIMARY KEY,
Farmer_Name VARCHAR(100) NOT NULL,
Contact_Details VARCHAR(255),
Address VARCHAR(255) NOT NULL,
Region VARCHAR(100) NOT NULL
);
```

2. Farm:-

```
CREATE TABLE Farms (
Farm_ID INT PRIMARY KEY,
Farmer_ID INT,
Size DECIMAL(10, 2),
Farm_Location VARCHAR(255),
Soil_Type VARCHAR(100),
Crop_Type VARCHAR(100),
Irrigation_Method VARCHAR(100),
FOREIGN KEY (Farmer_ID) REFERENCES
Farmers(Farmer_ID) );
```

3. Crops:-

```
CREATE TABLE Crops (
Crop_ID INT PRIMARY KEY,
Crop_Name VARCHAR(100) NOT NULL,
Season VARCHAR(50),
Water_Requirement DECIMAL(10, 2),
Fertilizer_Requirement DECIMAL(10, 2)
);
```

4. Weather_Data:-

```
CREATE TABLE Weather_Data (
WeatherData_ID INT PRIMARY KEY,
Date DATE NOT NULL,
Location VARCHAR(255),
Temperature DECIMAL(5, 2),
Rainfall DECIMAL(5, 2),
```

```
Humidity DECIMAL(5, 2),
Wind_Speed DECIMAL(5, 2),
Farm_ID INT,
FOREIGN KEY (Farm_ID) REFERENCES
Farms(Farm_ID) );
```

5. Farm_Activities:-

```
CREATE TABLE Farm_Activities (
Activity_ID INT PRIMARY KEY,
Farm_ID INT,
Activity_Type VARCHAR(100),
Date DATE NOT NULL,
Resource_Used VARCHAR(100),
Time_Spent DECIMAL(5, 2),
FOREIGN KEY (Farm_ID) REFERENCES
Farms(Farm_ID) );
```

6. Sustainability_Measures:-

```
CREATE TABLE Sustainability_Measures (
Measure_ID INT PRIMARY KEY,
Farm_ID INT,
Sustainability_Practice VARCHAR(100),
Energy_Consumption DECIMAL(10, 2),
Water_Consumption DECIMAL(10, 2),
FOREIGN KEY (Farm_ID) REFERENCES
Farms(Farm_ID) );
```

7. Researchers:-

```
CREATE TABLE Researchers (
ResearcherID INT PRIMARY KEY,
Name VARCHAR(100) NOT NULL,
Affiliation VARCHAR(100),
Contact VARCHAR(100)
);
```

8. Research_Data:-

```
CREATE TABLE Research_Data (
 ResearchData_ID INT PRIMARY KEY,
 Research_Title VARCHAR(255) NOT NULL,
 ResearcherID INT,
 Data_Collected_Date DATE NOT NULL,
 Conclusions TEXT,
 FOREIGN KEY (ResearcherID)
REFERENCES
Researchers(ResearcherID)
);
```

9. Policies

```
CREATE TABLE Policies (
 PolicyID INT PRIMARY KEY,
 PolicyName VARCHAR(100) NOT NULL,
 Description TEXT,
 EffectiveDate DATE
);
```

10. Carbon_Tracking:-

```
CREATE TABLE Carbon_Tracking (
 Tracking_ID INT PRIMARY KEY,
 Farm_ID INT,
 Researcher_ID INT,
 Total_Carbon_Emissions DECIMAL(10, 2)
CHECK  (Total_Carbon_Emissions >= 0),
 Measurement_Period DATE NOT NULL,
 Reduction_Strategies TEXT,
 FOREIGN KEY (Farm_ID) REFERENCES
Farms(Farm_ID),  FOREIGN KEY (Researcher_ID)
REFERENCES  Researchers(ResearcherID)
);
```

11. Contact_Details:-

```
CREATE TABLE Contact_Details (
```

```
Contact_ID INT PRIMARY KEY,
Farmer_ID INT,
Phone_Number VARCHAR(15),
Email_Address VARCHAR(100) UNIQUE,
Address VARCHAR(255),
FOREIGN KEY (Farmer_ID) REFERENCES
Farmers(Farmer_ID) );
```

12. Farmers_Policies:

```
CREATE TABLE Farmers_Policies (
Farmer_ID INT,
PolicyID INT,
PRIMARY KEY (Farmer_ID, PolicyID),
FOREIGN KEY (Farmer_ID) REFERENCES
Farmers(Farmer_ID),  FOREIGN KEY (PolicyID)
REFERENCES Policies(PolicyID) );
```

Chapter 3: Normalization of Database

Normalization and Schema Refinement
In this section, we discuss the process of normalization applied to the database to eliminate redundancy and improve data integrity. We also review the original database design and schemas before the normalization process, highlighting the improvements made during schema refinement.

Original Database

Relations

1. Each farmer can manage multiple farms, but each farm is managed by a single farmer.

2. Each farm can grow multiple types of crops, and each crop can be grown on multiple farms.

3. Each farm can have multiple weather data records, but each record is associated with one specific farm.

4. Each activity is specific to a farm, but a farm can have multiple activities.

5. Multiple resources may be used in a single farm activity, and each resource may be used across multiple activities.

6. Each farm can adopt multiple sustainability measures, but each measure is linked to one specific farm.

7. Each researcher can produce multiple research data records, but each record is authored by one researcher.

8. Policies can apply to multiple farms, and each farm may adhere to multiple policies.

9. Each carbon tracking record pertains to a specific farm, but a farm may have multiple tracking records.

10. Each farmer can have multiple contact details (phone numbers, email, address), but each contact detail is associated with one farmer.

Here's a list of relations and descriptions for your sustainable agriculture resource management system database project, following the provided format:

1. Farmers

   - Related Table: Farms

   - Relation: `Farmer_ID` in Farms references `Farmers(Farmer_ID)`. This indicates that each farm is managed by a specific farmer.

2. Farms

   - Related Table: Crops

   - Relation: `Farm_ID` in a linking table references both `Farms(Farm_ID)` and `Crops(Crop_ID)`. This indicates that each farm can grow multiple crops, and each crop can be grown on multiple farms.

3. Weather_Data

   - Related Table: Farms

   - Relation: `Farm_ID` in Weather_Data references `Farms(Farm_ID)`. This shows that each weather data entry is associated with a specific farm.

4. Farm_Activities

- Related Table: Farms

- Relation: `Farm_ID` in Farm_Activities references `Farms(Farm_ID)`. This establishes that each activity is specific to a particular farm.

5. Farm_Activities

- Related Table: Resources_Usage (via a linking table or separate rows in Farm_Activities)

- Relation: Each activity can have multiple resources used, represented by a linking structure to accommodate the many-to-many relationship.

6. Sustainability_Measures

- Related Table: Farms

- Relation: `Farm_ID` in Sustainability_Measures references `Farms(Farm_ID)`. This associates each sustainability measure with a specific farm.

7. Researchers

- Related Table: Research_Data

- Relation: `Researcher_ID` in Research_Data references `Researchers(Researcher_ID)`. This indicates that each research data entry is linked to a specific researcher.

8. Research_Data

- Related Table:Researcher

- Relation: `Researcher_ID` in Research_Data references `Researcher(Researcher_ID)`.

9. Policies

- Related Table: Farms

- Relation: Each policy can apply to multiple farms, and each farm may adhere to multiple policies.

10. Carbon_Tracking

- Related Table: Farms

- Relation: `Farm_ID` in Carbon_Tracking references `Farms(Farm_ID)`. This indicates that each carbon tracking record pertains to a specific farm.

Dependencies Analysis

Farmers Table

- **Primary Key Dependency**:
  - Farmer_ID
- **Foreign Key Dependency**:
  - None
- **Functional Dependencies**:
  - Farmer_ID → Name, Contact_Details, Address, Farm_ID

Farms Table

- **Primary Key Dependency**:
  - Farm_ID

- **Foreign Key Dependency**:
  - Farmer_ID references Farmers(Farmer_ID)
- **Functional Dependencies**:
  - Farm_ID → Location, Size, Soil_Type, Farmer_ID

Crops Table

- **Primary Key Dependency**:
  - Crop_ID
- **Foreign Key Dependency**:
  - None
- **Functional Dependencies**:
  - Crop_ID → Name, Season, Yield, Farm_ID

Weather_Data Table

- **Primary Key Dependency**:
  - Weather_Data_ID
- **Foreign Key Dependency**:
  - Farm_ID references Farms(Farm_ID)
- **Functional Dependencies**:
  - Weather_Data_ID → Temperature, Rainfall, Humidity, Date, Farm_ID

Farm_Activities Table

- **Primary Key Dependency**:
  - Activity_ID
- **Foreign Key Dependency**:
  - Farm_ID references Farms(Farm_ID)
- **Functional Dependencies**:
  - Activity_ID → Activity_Type, Date, Resource_Used, Farm_ID

Sustainability_Measures Table

- **Primary Key Dependency**:
  - Measure_ID

- **Foreign Key Dependency**:
  - Farm_ID references Farms(Farm_ID)
- **Functional Dependencies**:
  - Measure_ID → Description, effectiveness, Farm_ID

Researchers Table

- **Primary Key Dependency**:
  - Researcher_ID
- **Foreign Key Dependency**:
  - None
- **Functional Dependencies**:
  - Researcher_ID → Name, Specialty, Contact_Info

Research_Data Table

- **Primary Key Dependency**:
  - Research_Data_ID
- **Foreign Key Dependency**:
  - Researcher_ID references Researchers(Researcher_ID)
- **Functional Dependencies**:
  - Research_Data_ID → Findings, Date, Researcher_ID,conclusion

Policies Table

- **Primary Key Dependency**:
  - Policy_ID
- **Foreign Key Dependency**:
  - None
- **Functional Dependencies**:
  - Policy_ID → Policy_Name, description ,effective_date,expiry_date

Carbon_Tracking Table

- **Primary Key Dependency**:

    - Tracking_ID
- **Foreign Key Dependency**:
    - Farm_ID references Farms(Farm_ID)
- **Functional Dependencies**:
    - Tracking_ID → Total_Carbon_Emissions, Measurement_Period, Reduction_Strategies, Farm_ID

Contact_Details Table

- **Primary Key Dependency**:
    - Contact_ID
- **Foreign Key Dependency**:
    - Farmer_ID references Farmers(Farmer_ID)
- **Functional Dependencies**:
    - Contact_ID → Phone_Number, Email_Address, Address, Farmer_ID

Redundancy and Anomalies Documentation

Redundancies:

Farmers Table

- **Potential Redundancy**:
    - If multiple farmers have the same contact details or address, the same information will be repeated for each farmer.
- **How to Avoid**:
    - Create a separate Contact_Details table with a unique Contact_ID and reference it in the Farmers table to store contact information once and link it using a foreign key.

Farms Table

- **Potential Redundancy**:

    - If multiple farms are located in the same area or share similar characteristics (e.g., soil type, size), these details might repeat across several farm records.
- **How to Avoid**:
    - Normalize farm data further by creating a Farm_Location table to store location-specific details, and reference this table in the Farms table.

Crops Table

- **Potential Redundancy**:
    - If multiple farms grow the same crop, the crop details (name, yield, season, etc.) might repeat for each farm.
- **How to Avoid**:
    - Create a Crop_Farm_Link table that links crops to farms, ensuring crop details are stored once and referenced by multiple farms.

Weather_Data Table

- **Potential Redundancy**:
    - If weather data is collected for the same farm multiple times (e.g., for each day or month), farm information (Farm_ID) will repeat.
- **How to Avoid**:
    - Normalize by storing weather data separately and linking it to the Farms table through the Farm_ID. If needed, separate daily or monthly weather data into different tables.

Farm_Activities Table

- **Potential Redundancy**:
    - If multiple farm activities use the same resources (e.g., machinery, labor), the resource details may repeat for each activity record.
- **How to Avoid**:

    - Use a separate Resource_Used table that links resources to activities and ensure that resource details are stored once, referencing the table via a foreign key.

Sustainability_Measures Table

- **Potential Redundancy**:
    - If multiple sustainability measures apply to the same farm or activity, the same measure data might repeat.
- **How to Avoid**:
    - Create a Farm_Sustainability_Link table that associates farms with sustainability measures, avoiding the repetition of measure details.

Researchers Table

- **Potential Redundancy**:
    - If researchers are working on multiple research projects or data entries, their details (name, specialty, contact) may repeat.
- **How to Avoid**:
    - Link researchers to research data through a Researcher_Data_Link table to ensure that researcher information is stored once.

Research_Data Table

- **Potential Redundancy**:
    - If multiple research entries are associated with the same researcher or sustainability measure, the same researcher and measure details may repeat.
- **How to Avoid**:
    - Normalize the data by separating research findings from the researcher and sustainability measure data. Use a Researcher_Research_Link and a Measure_Research_Link table.

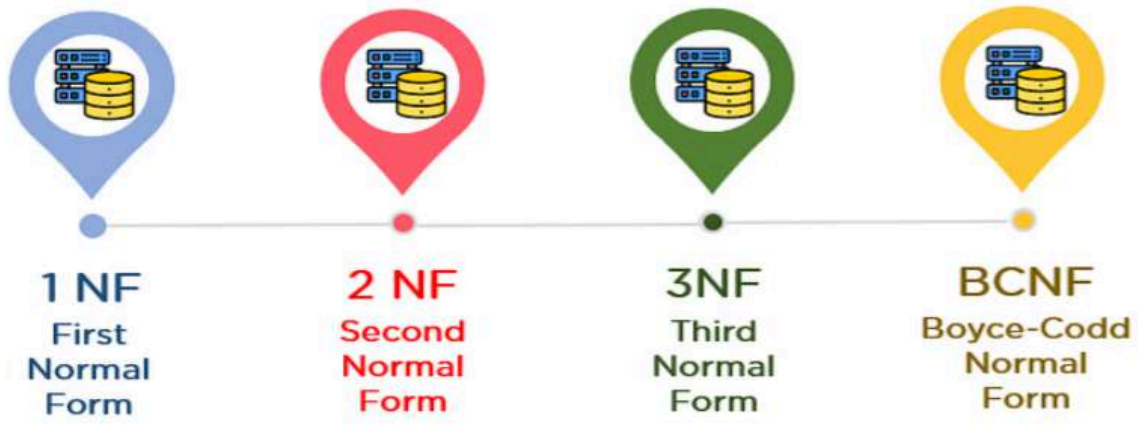
Policies Table

- **Potential Redundancy**:
    - If multiple policies cover the same topic or have similar descriptions, these details could be repeated.
- **How to Avoid**:
    - Use a Policy_Type table to categorize policies by topic or area, and reference this table in the Policies table to avoid repeating similar policy details.

Contact_Details Table

- **Potential Redundancy**:
    - If a farmer has multiple contact details (e.g., phone numbers, email addresses), those details could be repeated across multiple contact records.
- **How to Avoid**:
    - Normalize the contact data by creating a unique Contact_Type column in the Contact_Details table, allowing multiple contact details for each farmer without redundancy.

Normalization Process



1NF – Enforcing Scalar Values

Conditions for 1NF:

1. Ensure that each table has a primary key.
2. Each field contains only atomic (indivisible) values. No lists or sets are allowed in a single column.
3. No repeating groups or arrays.

Step 1: Apply 1NF (First Normal Form)

- Farmers table has contact detail.To normalize database to 1NF we need to ensure a single Value per Column,but contact detail can have multiple values as a single person can own multiple contact numbers. contact detail attributes can be taken out of farmers relation and new relation can be formed of contact detail

  Contact_Details (Contact_ID, Farmer_ID, Phone_Number, Email_Address ,Address)

  Primary Key: Contact_ID - Foreign Key: Farmer_ID (references Farmers)
- In table Farms , their is a attributed name Crop_Type and it should only have one type of crop per entry .if more crop_type for a single farm in the same field ,then this could be done by making it separate rows or a new table,but the point is we already have a crop table which has all this attributes so we can just put this crop type in crop table . And in case multiple crop are grown in a single farm then we can make a separate table to store farm_id with respective crop grown in them
- In table Farm_Activities we need to ensure that attribute Resource_Used should have single value ,but in case of multiple resources used in a single farm_activity ,we need to create separate rows or a new table

  Resoursces_used(Resource_ID ,resource_name) Modifying farm_activties:- Activity_ID, Farm_ID, Activity_Type, Date, Resource_ID, Time_Spent)

Here is the complete list of all tables in sustainable agriculture resource management system database, including their attributes after applying

1NF:

- Farmers(**Farmer_ID**, Farmer_Name, Age, address)

- Farms(**Farm_ID**, Farmer_ID, Farm_Name,Location, Size, Soil_Type, Water_Source)

- Crops(**Crop_ID**, Crop_Name)

- Farm_crops(**Link_ID**, Farm_ID, Crop_ID)

- Weather_Data(**Weather_ID**, Farm_ID, Date, Temperature, Rainfall, Humidity,wind_speed)

-Farm_Activities(**Activity_ID**,Farm_ID,Activity_type)

-Sustainability_Measures(**Measure_ID**, Farm_ID, Measure_Type, Implementation_Date, effectiveness)

-Researchers(**Researcher_ID**, Name, Field_of_Study, Affiliation, Contact_Info)

-Research_Data(**Research_ID**, Researcher_ID, Title, conclusion, Date_Conducted)

-Policies(**Policy_ID**, Policy_Name, Description, Effective_Date, Expiry_date)

- Carbon_Tracking(**Tracking_ID**, Farm_ID, Total_Carbon_Emissions, Measurement_Period, Reduction_Strategies)

-Resource_Usage(**Resource_Usage_ID**,Activity_ID, Resource_Type)

-Contact_Details(**Contact_ID**, Farmer_ID, Phone_Number, Email_Address, Address)

2NF – Eliminating Partial Dependencies & Redundancy Analysis

Conditions for 2NF:

1. The table must be in 1NF.
2. Remove partial dependencies (non-key attributes should depend on the whole primary key, not just part of it).

Step 2: Apply 2NF (Second Normal Form)

1. Farmers Table

Attributes
Farmer_ID (PK), Farmer_Name, Age, Address

- Primary Key: Farmer_ID.
- Dependencies:
    - Farmer_Name, Age, and Address all depend fully on Farmer_ID (which is the primary key).
    - Since Farmer_ID is a single attribute (not a composite key), there is no possibility of partial dependency.

Conclusion: This table is in 2NF because all non-key attributes (Farmer_Name, Age, Address) depend on the entire primary key (Farmer_ID), and there is no partial dependency.

2. Crops Table

Attributes

Crop_ID (PK), Crop_Type

- Primary Key: Crop_ID.
- Dependencies:
    - Crop_Type fully depends on Crop_ID.
    - Again, since the primary key is a single attribute, there are no partial dependencies.

Conclusion: This table is in 2NF because all non-key attributes depend fully on the single primary key (Crop_ID).

3. Farm_Activities

Attributes
Activity_ID (PK), Farm_ID (FK), Activity_Type

- Primary Key: Activity_ID.
- Foreign Key: Farm_ID.
- Dependencies:
    - Activity_Type depends entirely on Activity_ID.
    - Farm_ID is a foreign key and does not cause any partial dependency.

Conclusion: This table is in 2NF because all non-key attributes (Activity_Type, Farm_ID) depend fully on the primary key (Activity_ID). There are no partial dependencies.

4. Resource_Usage Table

Attributes
Resource_Usage_ID (PK), Activity_ID (FK), Resource_Type

- Primary Key: Resource_Usage_ID.
- Foreign Key: Activity_ID.
- Dependencies:
    - Resource_Type depends fully on Resource_Usage_ID, the primary key.

Conclusion: This table is in 2NF because all non-key attributes (Resource_Type, Activity_ID) depend on the whole primary key, and there are no partial dependencies.

5. Carbon_Tracking Table

Attributes
Tracking_ID (PK), Farm_ID (FK), Total_Carbon_Emissions, Measurement_Period, Reduction_Strategies

- Primary Key: Tracking_ID.
- Foreign Key: Farm_ID.
- Dependencies:
    - Total_Carbon_Emissions, Measurement_Period, and Reduction_Strategies all depend fully on Tracking_ID.
    - There are no partial dependencies as Tracking_ID is a single primary key.

Conclusion: This table is in 2NF because there are no partial dependencies. All attributes depend fully on the primary key, Tracking_ID.

6. Contact_Details Table

Attributes
Contact_ID (PK), Farmer_ID (FK), Phone_Number, Email_Address, Address

- Primary Key: Contact_ID.
- Foreign Key: Farmer_ID.
- Dependencies:
    - Phone_Number, Email_Address, and Address depend fully on Contact_ID.
    - Farmer_ID is a foreign key and not part of the primary key. There are no partial dependencies here.

Conclusion: This table is in 2NF because all non-key attributes (Phone_Number, Email_Address, Address) depend fully on the primary key, Contact_ID.

---

7. Farm_Crops Table

Attributes
Farm_Crop_ID (PK), Farm_ID (FK), Crop_ID (FK)

- Primary Key: Farm_Crop_ID.
- Foreign Keys: Farm_ID, Crop_ID.
- Dependencies:
    - Farm_Crop_ID is the only primary key, and no non-key attributes are dependent on only part of a composite key.

    - Both Farm_ID and Crop_ID are foreign keys that define the relationship between farms and crops.

Conclusion: This table is in 2NF because all non-key attributes (none in this case) depend fully on the primary key, Farm_Crop_ID. There are no partial dependencies.

8. Weather_Data Table

Attributes
Weather_ID (PK), Farm_ID (FK), Temperature, Rainfall, Humidity, Wind_Speed, Observation_Date

- Primary Key: Weather_ID.
- Foreign Key: Farm_ID.
- Dependencies:
    - Temperature, Rainfall, Humidity, Wind_Speed, and Observation_Date all depend fully on Weather_ID.

Conclusion: This table is in 2NF because all attributes depend fully on the primary key, Weather_ID. There are no partial dependencies.

9. Sustainability_Measures Table

Attributes
Measure_ID (PK), Farm_ID (FK), Sustainability_Type, Implementation_Date, Effectiveness

- Primary Key: Measure_ID.
- Foreign Key: Farm_ID.
- Dependencies:
    - Sustainability_Type, Implementation_Date, and Effectiveness all depend fully on Measure_ID.

Conclusion: This table is in 2NF because all non-key attributes (Sustainability_Type, Implementation_Date, Effectiveness) depend fully on the primary key, Measure_ID.

10. Researchers Table

Attributes
Researcher_ID, Name, Field_of_Study, Affiliation, Contact_Info

- Primary Key: Researcher_ID.
- Dependencies:
    - Researcher_Name and Institution both depend fully on Researcher_ID.

Conclusion: This table is in 2NF because all attributes depend fully on the primary key, Researcher_ID.

11. Research_Data Table

Attributes
Research_ID (PK), Researcher_ID (FK), Farm_ID (FK), Research_Title,conclusion, Date_Conducted

- Primary Key: Research_ID.
- Foreign Keys: Researcher_ID, Farm_ID,
- Dependencies:
    - Research_Title, Findings, and Date_Conducted depend fully on Research_ID.

Conclusion: This table is in 2NF because all attributes depend fully on the primary key (Research_ID), and there are no partial dependencies.

---

12. Policies Table

Attributes
Policy_ID (PK), Policy_Name, Description, Effective_Date, Expiry_Date

- Primary Key: Policy_ID.
- Dependencies:
    - Policy_Name, Description, Effective_Date, and Expiry_Date depend fully on Policy_ID.

Conclusion: This table is in 2NF because all non-key attributes depend on the entire primary key (Policy_ID).

3NF/BCNF – Removing Transitive Dependencies

1. The table must be in 2NF.
2. Remove transitive dependencies (non-key attributes should depend only on the primary key, not on other non-key attributes).

1. Farmers Table

Attributes
Farmer_ID (PK), Farmer_Name, Age, Address

- Primary Key: Farmer_ID.

- There are no transitive dependencies since Farmer_Name, Age, and Address all depend directly on Farmer_ID.

2. Crops Table

Attributes
Crop_ID (PK), Crop_Type

- Primary Key: Crop_ID.
- There are no transitive dependencies since `Crop_Type` depends directly on Crop_ID.

3. Farm_Activities Table

Attributes
Activity_ID (PK), Farm_ID (FK), Activity_Type

- Primary Key: Activity_ID.
- There are no transitive dependencies as `Activity_Type` depends directly on `Activity_ID` and not on any non-key attribute.

4. Resource_Usage Table

Attributes
Resource_Usage_ID (PK), Activity_ID (FK), Resource_Type

-Primary Key: Resource_Usage_ID.
- No transitive dependencies exist since `Resource_Type` depends directly on `Resource_Usage_ID`.

5. Carbon_Tracking Table

Attributes
Tracking_ID (PK), Farm_ID (FK), Total_Carbon_Emissions, Measurement_Period, Reduction_Strategies

- Primary Key: Tracking_ID.
- There are no transitive dependencies here. All non-key attributes (Total_Carbon_Emissions, Measurement_Period, Reduction_Strategies) depend only on the primary key (Tracking_ID).

6. Contact_Details Table

Attributes
Contact_ID (PK), Farmer_ID (FK), Phone_Number, Email_Address, Address

-Primary Key: Contact_ID.
- There are no transitive dependencies. All non-key attributes depend directly on `Contact_ID.

7. Farm_Crops Table

Attributes
Farm_Crop_ID (PK), Farm_ID (FK), Crop_ID (FK)

- Primary Key: Farm_Crop_ID.
- No transitive dependencies exist as Farm_ID and Crop_ID are foreign keys, and there are no other non-key attributes to introduce a transitive dependency.

8. Weather_Data Table

Attributes

Weather_ID (PK), Farm_ID (FK), Temperature, Rainfall, Humidity, Wind_Speed, Observation_Date

- Primary Key: Weather_ID.
- There are no transitive dependencies since Temperature, Rainfall, Humidity, Wind_Speed, and Observation_Date all depend directly on Weather_ID.

9. Sustainability_Measures Table

Attributes
Measure_ID (PK), Farm_ID (FK), Sustainability_Type, Implementation_Date, Effectiveness

Primary Key: Measure_ID.
- There are no transitive dependencies. Sustainability_Type, Implementation_Date, and Effectiveness depend directly on Measure_ID.

10. Researchers Table

Attributes

Researcher_ID, Name, Field_of_Study, Affiliation, Contact_Info

Primary Key: Researcher_ID.
- There are no transitive dependencies. Both Researcher_Name and Institution depend on the primary key.

11. Research_Data Table

Attributes
Research_ID (PK), Researcher_ID (FK), Farm_ID (FK), Research_Title, Findings, Date_Conducted

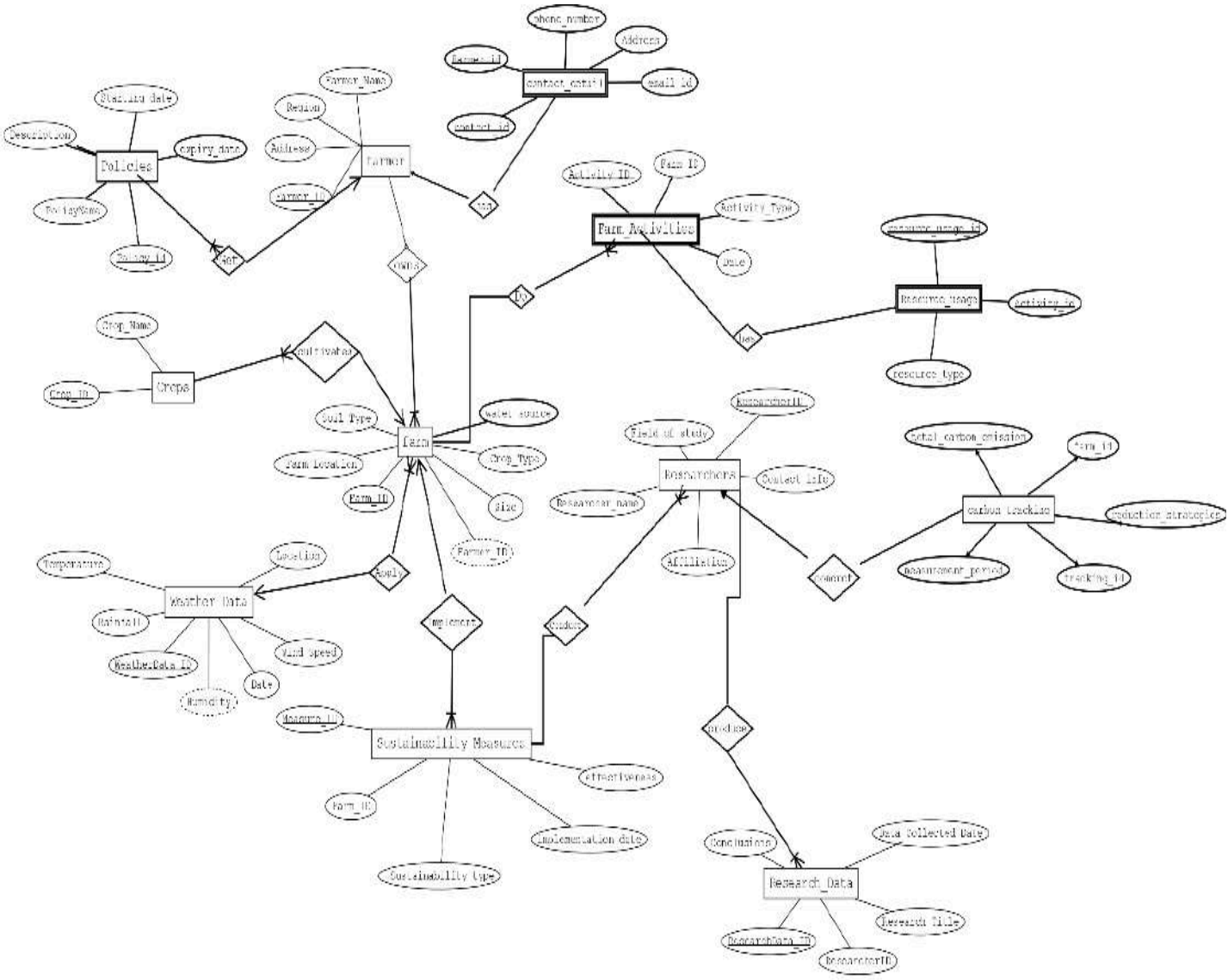
- Primary Key: Research_ID.
- There are no transitive dependencies as all attributes depend directly on Research_ID.

12. Policies Table

Attributes
Policy_ID (PK), Policy_Name, Description, Effective_Date, Expiry_Date

- Primary Key: Policy_ID.

- No transitive dependencies exist, as all attributes depend directly on Policy_ID.



Chapter 4: Implementation of Database

4.1 Revised DDL Scripts

In this section, we provide the revised Data Definition Language (DDL) scripts used to create the database schema. These scripts define the structure of the database, including tables, columns, constraints, and relationships. The changes and improvements made to the initial scripts are also discussed here.

1. Farmers Table

```
CREATE TABLE Farmers (
    Farmer_ID INT PRIMARY KEY,
    Farmer_Name VARCHAR(100),
    Age INT,
    Address TEXT
);
```

2. Crops Table

```
CREATE TABLE Crops (
    Crop_ID INT PRIMARY KEY,
    Crop_Type VARCHAR(50)
);
```

3. Farm_Activities Table

```
CREATE TABLE Farm_Activities (
    Activity_ID INT PRIMARY KEY,
    Farm_ID INT,
    Activity_Type VARCHAR(100),
    FOREIGN KEY (Farm_ID) REFERENCES Farms(Farm_ID)
```

```
);

4.Resource_Usage Table
CREATE TABLE Resource_Usage (
    Resource_Usage_ID INT PRIMARY KEY,
    Activity_ID INT,
    Resource_Type VARCHAR(100),
    FOREIGN KEY (Activity_ID) REFERENCES Farm_Activities(Activity_ID)
);

5.Carbon_Tracking Table
CREATE TABLE Carbon_Tracking (
    Tracking_ID INT PRIMARY KEY,
    Farm_ID INT,
    Total_Carbon_Emissions DECIMAL(10, 2),
    Measurement_Period VARCHAR(50)
    Reduction_Strategies TEXT,
    FOREIGN KEY (Farm_ID) REFERENCES Farms(Farm_ID)
)

6.Contact_Details Table

CREATE TABLE Contact_Details (
    Contact_ID INT PRIMARY KEY,
    Farmer_ID INT,
    Phone_Number VARCHAR(15),
    Email_Address VARCHAR(100),
    Address TEXT,
    FOREIGN KEY (Farmer_ID) REFERENCES Farmers(Farmer_ID)
);

7.Farm_Crops Table
CREATE TABLE Farm_Crops (
    Farm_Crop_ID INT PRIMARY KEY,
```

```
    Farm_ID INT,
    Crop_ID INT,
    FOREIGN KEY (Farm_ID) REFERENCES Farms(Farm_ID),
    FOREIGN KEY (Crop_ID) REFERENCES Crops(Crop_ID)
);

8. Weather_Data Table
CREATE TABLE Weather_Data (
    Weather_ID INT PRIMARY KEY,
    Farm_ID INT,
    Temperature DECIMAL(5, 2),
    Rainfall DECIMAL(5, 2),
    Humidity DECIMAL(5, 2),
    Wind_Speed DECIMAL(5, 2),
    Observation_Date DATE,
    FOREIGN KEY (Farm_ID) REFERENCES Farms(Farm_ID)
);

9. Sustainability_Measures Table
CREATE TABLE Sustainability_Measures (
    Measure_ID INT PRIMARY KEY,
    Farm_ID INT,
    Sustainability_Type VARCHAR(100),
    Implementation_Date DATE,
    Effectiveness TEXT,
    FOREIGN KEY (Farm_ID) REFERENCES Farms(Farm_ID)
);

10. Researchers Table
CREATE TABLE Researchers (
    researcher_ID varchar(255) PRIMARY KEY,
    researcher_Name VARCHAR(100),
    field_of_study VARCHAR(100),
        affiliation VARCHAR(100),
        contact_info VARCHAR(100)
```

```
);

11. Research_Data Table
CREATE TABLE Research_Data (
 ResearchData_ID INT PRIMARY KEY,
 Research_Title VARCHAR(255) NOT NULL,
 Researcher_ID VARCHAR(255),
 Data_Collected_Date DATE NOT NULL,
 Conclusions TEXT,
 FOREIGN KEY (Researcher_ID) REFERENCES
Researchers(Researcher_ID)
);

12. Policies Table
CREATE TABLE Policies (
    Policy_ID INT PRIMARY KEY,
    Policy_Name VARCHAR(100),
    Description TEXT,
    Effective_Date DATE,
    Expiry_Date DATE
);

13 Farm Table
CREATE TABLE Farms (
    Farm_ID INT PRIMARY KEY,
    Farmer_ID INT,
    Farm_Name VARCHAR(100),
    Location VARCHAR(255),
    Size DECIMAL(10, 2),
    Soil_Type VARCHAR(50),
    Water_Source VARCHAR(100),
    FOREIGN KEY (Farmer_ID) REFERENCES Farmers(Farmer_ID)
);
```

4.2 Database Population INSERT Statements

Farmers table
INSERT INTO farmers (Farmer_id, Farmer_name, age, address) VALUES
(1, 'Rajesh Kumar', 45, 'Billaspur, Rampur, Uttar Pradesh'),
(2, 'Aarti Sharma', 37, 'Billaspur, Rampur, Uttar Pradesh'),
(3, 'Vikram Singh', 50, 'Billaspur, Rampur, Uttar Pradesh'),
(4, 'Priya Patel', 29, 'Sitapur, Uttar Pradesh'),
(5, 'Amit Chauhan', 40, 'Sitapur, Uttar Pradesh'),
(6, 'Sunita Devi', 55, 'Mau, Azamgarh, Uttar Pradesh'),
(7, 'Rahul Mehta', 33, 'Mau, Azamgarh, Uttar Pradesh'),
(8, 'Kiran Bhatt', 42, 'Chhatarpur, Madhya Pradesh'),
(9, 'Suresh Yadav', 47, 'Chhatarpur, Madhya Pradesh'),
(10, 'Neha Singh', 31, 'Hapur, Uttar Pradesh'),
(11, 'Mohammed Ali', 38, 'Hapur, Uttar Pradesh'),
(12, 'Sita Verma', 41, 'Khandwa, Madhya Pradesh'),
(13, 'Gopal Tiwari', 49, 'Khandwa, Madhya Pradesh'),
(14, 'Deepa Nair', 36, 'Deoria, Uttar Pradesh'),
(15, 'Ramesh Gupta', 48, 'Deoria, Uttar Pradesh'),
(16, 'Kavita Rao', 34, 'Saharanpur, Uttar Pradesh'),
(17, 'Prakash Joshi', 53, 'Shivpuri, Madhya Pradesh'),
(18, 'Anjali Sharma', 26, 'Bulandshahr, Uttar Pradesh'),
(19, 'Arvind Mehta', 44, 'Bulandshahr, Uttar Pradesh'),
(20, 'Poonam Desai', 32, 'Morena, Madhya Pradesh'),
(21, 'Vijay Patil', 39, 'Morena, Madhya Pradesh'),
(22, 'Nisha Rani', 46, 'Faizabad, Uttar Pradesh'),
(23, 'Suraj Singh', 30, 'Faizabad, Uttar Pradesh'),
(24, 'Shalini Agarwal', 51, 'Dhar, Madhya Pradesh'),
(25, 'Ashok Choudhary', 43, 'Dhar, Madhya Pradesh'),
(26, 'Geeta Iyer', 35, 'Banda, Uttar Pradesh'),
(27, 'Kiran Kapadia', 52, 'Chhindwara, Madhya Pradesh'),
(28, 'Aditi Kapoor', 27, 'Rewa, Madhya Pradesh'),
(29, 'Rohit Sharma', 54, 'Sagar, Madhya Pradesh'),
(30, 'Neelam Sethi', 41, 'Jalaun, Uttar Pradesh'),
(31, 'Jitendra Verma', 37, 'Jalaun, Uttar Pradesh'),

(32, 'Maya Patel', 48, 'Hardoi, Uttar Pradesh'),
(33, 'Rajesh Yadav', 40, 'Madhubani, Bihar'),
(34, 'Vinita Kumar', 29, 'Madhubani, Bihar'),
(35, 'Anand Rao', 44, 'Gaya, Bihar'),
(36, 'Sonali Deshmukh', 33, 'Purnea, Bihar'),
(37, 'Nitin Joshi', 50, 'Bhagalpur, Bihar'),
(38, 'Nandini Mehta', 39, 'Patna, Bihar'),
(39, 'Sandeep Choudhary', 55, 'Patna, Bihar'),
(40, 'Suman Rani', 34, 'Gorakhpur, Uttar Pradesh'),
(41, 'Kumar Awasthi', 42, 'Gorakhpur, Uttar Pradesh'),
(42, 'Nisha Sharma', 27, 'Siddharth Nagar, Uttar Pradesh'),
(43, 'Ajay Gupta', 49, 'Siddharth Nagar, Uttar Pradesh'),
(44, 'Savita Singh', 36, 'Sonbhadra, Uttar Pradesh'),
(45, 'Raghav Mehta', 46, 'Sonbhadra, Uttar Pradesh'),
(46, 'Preeti Rani', 32, 'Basti, Uttar Pradesh'),
(47, 'Manoj Agarwal', 38, 'Basti, Uttar Pradesh'),
(48, 'Sheetal Desai', 43, 'Lakhimpur Kheri, Uttar Pradesh'),
(49, 'Deepak Sharma', 29, 'Lakhimpur Kheri, Uttar Pradesh'),
(50, 'Kavita Verma', 55, 'Sitapur, Uttar Pradesh'),
(51, 'Suresh Yadav', 41, 'Azamgarh, Uttar Pradesh'),
(52, 'Pooja Sharma', 34, 'Kanpur, Uttar Pradesh'),
(53, 'Vinod Kumar', 39, 'Hathras, Uttar Pradesh'),
(54, 'Sneha Patel', 47, 'Firozabad, Uttar Pradesh'),
(55, 'Nikhil Rao', 50, 'Maharajganj, Uttar Pradesh'),
(56, 'Priyanka Bhattacharya', 26, 'Barabanki, Uttar Pradesh'),
(57, 'Shiv Kumar', 45, 'Aligarh, Uttar Pradesh'),
(58, 'Anjali Iyer', 36, 'Etah, Uttar Pradesh'),
(59, 'Ravi Singh', 52, 'Etawah, Uttar Pradesh'),
(60, 'Sonam Verma', 28, 'Unnao, Uttar Pradesh'),
(61, 'Mohit Joshi', 37, 'Bareilly, Uttar Pradesh'),
(62, 'Tara Devi', 45, 'Kushinagar, Uttar Pradesh'),
(63, 'Rakesh Yadav', 42, 'Bhadohi, Uttar Pradesh'),
(64, 'Leela Sharma', 30, 'Kahna, Madhya Pradesh'),
(65, 'Ajit Kumar', 50, 'Mandla, Madhya Pradesh'),
(66, 'Suman Gupta', 29, 'Chhindwara, Madhya Pradesh'),

(67, 'Jagat Singh', 39, 'Mandla, Madhya Pradesh'),
(68, 'Seema Nair', 45, 'Sagar, Madhya Pradesh'),
(69, 'Deepak Chaudhary', 38, 'Madhya Pradesh, India'),
(70, 'Geeta Patil', 53, 'Uttar Pradesh, India'),
(71, 'Pramod Sharma', 48, 'Morena, Madhya Pradesh'),
(72, 'Nandini Singh', 34, 'Gwalior, Madhya Pradesh'),
(73, 'Karan Yadav', 29, 'Bhind, Madhya Pradesh'),
(74, 'Asha Verma', 40, 'Ashok Nagar, Madhya Pradesh'),
(75, 'Kunal Gupta', 46, 'Datia, Madhya Pradesh'),
(76, 'Neeraj Kumar', 38, 'Chhatarpur, Madhya Pradesh'),
(77, 'Vani Patil', 30, 'Khargone, Madhya Pradesh'),
(78, 'Devendra Chaudhary', 51, 'Jhabua, Madhya Pradesh'),
(79, 'Shweta Desai', 27, 'Bhopal, Madhya Pradesh'),
(80, 'Ranjeet Singh', 42, 'Indore, Madhya Pradesh'),
(81, 'Aman Kumar', 54, 'Mandsaur, Madhya Pradesh'),
(82, 'Rupal Gupta', 33, 'Sagar, Madhya Pradesh'),
(83, 'Siddharth Sharma', 39, 'Sehore, Madhya Pradesh'),
(84, 'Tanya Verma', 41, 'Ujjain, Madhya Pradesh'),
(85, 'Rajendra Yadav', 36, 'Betul, Madhya Pradesh'),
(86, 'Nisha Patel', 45, 'Hoshangabad, Madhya Pradesh'),
(87, 'Vinay Yadav', 30, 'Dhar, Madhya Pradesh'),
(88, 'Deepak Sharma', 48, 'Chhindwara, Madhya Pradesh'),
(89, 'Sheetal Nair', 35, 'Panchgani, Maharashtra'),
(90, 'Vishal Singh', 29, 'Nagpur, Maharashtra'),
(91, 'Gauri Joshi', 37, 'Ahmednagar, Maharashtra'),
(92, 'Ravi Patil', 50, 'Aurangabad, Maharashtra'),
(93, 'Tanvi Sharma', 41, 'Solapur, Maharashtra'),
(94, 'Shubham Singh', 28, 'Satara, Maharashtra'),
(95, 'Anju Chaudhary', 43, 'Thane, Maharashtra'),
(96, 'Deepa Iyer', 32, 'Nashik, Maharashtra'),
(97, 'Rohit Pawar', 39, 'Raigad, Maharashtra'),
(98, 'Sonal Sethi', 45, 'Kolhapur, Maharashtra'),
(99, 'Ketan Joshi', 50, 'Latur, Maharashtra’),
(100,’Priya Verma’,33,’Dhule, Maharashtra’);

Farms table
Insert into farms values
(1200, 1, "Green Acres", "Rampur, Uttar Pradesh", 25.50, "Loamy", "Canal"),
(1201, 2, "Sunny Fields", "Rampur, Uttar Pradesh", 18.75, "Clay", "Well"),
(1202, 3, "Harvest Haven", "Rampur, Uttar Pradesh", 30.00, "Sandy", "River"),
(1203, 4, "Organic Orchards", "Sitapur, Uttar Pradesh", 12.00, "Clay", "Borewell"),
(1204, 5, "Fresh Greens", "Sitapur, Uttar Pradesh", 20.50, "Loamy", "Tank"),
(1205, 6, "Devi Farms", "Azamgarh, Uttar Pradesh", 28.00, "Sandy", "Canal"),
(1206, 7, "Mehta Meadows", "Azamgarh, Uttar Pradesh", 15.00, "Loamy", "Well"),
(1207, 8, "Bhatt Estates", "Chhatarpur, Madhya Pradesh", 22.75, "Clay", "River"),
(1208, 9, "Yadav Fields", "Chhatarpur, Madhya Pradesh", 26.50, "Sandy", "Borewell"),
(1209, 10, "Singh Acres", "Hapur, Uttar Pradesh", 18.00, "Loamy", "Tank"),
(1220, 21, "Patil Farm", "Morena, Madhya Pradesh", 27.00, "Sandy", "Canal"),
(1221, 22, "Rani Fields", "Faizabad, Uttar Pradesh", 22.25, "Loamy", "Well"),
(1222, 23, "Singh Holdings", "Faizabad, Uttar Pradesh", 18.50, "Clay", "River"),
(1223, 24, "Agarwal Estates", "Dhar, Madhya Pradesh", 15.30, "Sandy", "Borewell"),
(1224, 25, "Choudhary Acres", "Dhar, Madhya Pradesh", 19.10, "Loamy", "Tank"),
(1225, 26, "Iyer Farms", "Banda, Uttar Pradesh", 30.00, "Clay", "Canal"),
(1226, 27, "Kapadia Fields", "Chhindwara, Madhya Pradesh", 21.40, "Sandy", "Well"),
(1227, 28, "Kapoor Farm", "Rewa, Madhya Pradesh", 16.00, "Loamy", "River"),

(1228, 29, "Sharma Holdings", "Sagar, Madhya Pradesh", 28.00, "Clay", "Borewell"),
(1229, 30, "Sethi Farm", "Jalaun, Uttar Pradesh", 17.50, "Sandy", "Tank"),
(1230, 31, "Verma Fields", "Jalaun, Uttar Pradesh", 29.75, "Loamy", "Canal"),
(1231, 32, "Patel Estate", "Hardoi, Uttar Pradesh", 15.25, "Clay", "Well"),
(1232, 33, "Yadav Farm", "Madhubani, Bihar", 18.80, "Sandy", "River"),
(1233, 34, "Kumar Orchard", "Madhubani, Bihar", 22.50, "Loamy", "Borewell"),
(1234, 35, "Rao Fields", "Gaya, Bihar", 24.75, "Clay", "Tank"),
(1235, 36, "Deshmukh Farms", "Purnea, Bihar", 19.00, "Sandy", "Canal"),
(1236, 37, "Joshi Estates", "Bhagalpur, Bihar", 20.00, "Loamy", "Well"),
(1237, 38, "Mehta Farm", "Patna, Bihar", 21.50, "Clay", "River"),
(1238, 39, "Choudhary Acres", "Patna, Bihar", 16.00, "Sandy", "Borewell"),
(1239, 40, "Rani Fields", "Gorakhpur, Uttar Pradesh", 28.50, "Loamy", "Tank"),
(1240, 41, "Awasthi Farms", "Gorakhpur, Uttar Pradesh", 23.75, "Clay", "Canal"),
(1241, 42, "Sharma Farms", "Siddharth Nagar, Uttar Pradesh", 15.00, "Sandy", "Well"),
(1242, 43, "Gupta Estate", "Siddharth Nagar, Uttar Pradesh", 19.40, "Loamy", "River"),
(1243, 44, "Singh Holdings", "Sonbhadra, Uttar Pradesh", 17.80, "Clay", "Borewell"),
(1244, 45, "Mehta Meadows", "Sonbhadra, Uttar Pradesh", 20.90, "Sandy", "Tank"),
(1245, 46, "Rani Farm", "Basti, Uttar Pradesh", 25.50, "Loamy", "Canal"),
(1246, 47, "Agarwal Estate", "Basti, Uttar Pradesh", 12.30, "Clay", "Well"),
(1247, 48, "Desai Farms", "Lakhimpur Kheri, Uttar Pradesh", 28.00, "Sandy", "River"),
(1248, 49, "Sharma Fields", "Lakhimpur Kheri, Uttar Pradesh", 22.75, "Loamy", "Borewell"),
(1249, 50, "Verma Estates", "Sitapur, Uttar Pradesh", 15.50, "Clay", "Tank"),
(1250, 51, "Yadav Fields", "Azamgarh, Uttar Pradesh", 26.00, "Sandy", "Canal"),

(1251, 52, "Sharma Farms", "Kanpur, Uttar Pradesh", 29.75, "Loamy", "Well"),
(1252, 53, "Kumar Holdings", "Hathras, Uttar Pradesh", 20.00, "Clay", "River"),
(1253, 54, "Patil Acres", "Firozabad, Uttar Pradesh", 14.00, "Sandy", "Borewell"),
(1254, 55, "Rao Fields", "Maharajganj, Uttar Pradesh", 27.00, "Loamy", "Tank"),
(1255, 56, "Bhattacharya Farms", "Barabanki, Uttar Pradesh", 18.50, "Clay", "Canal"),
(1256, 57, "Kumar Meadows", "Aligarh, Uttar Pradesh", 30.00, "Sandy", "Well"),
(1257, 58, "Iyer Farms", "Etah, Uttar Pradesh", 22.20, "Loamy", "River"),
(1258, 59, "Singh Holdings", "Etawah, Uttar Pradesh", 19.90, "Clay", "Borewell"),
(1259, 60, "Verma Acres", "Unnao, Uttar Pradesh", 16.75, "Sandy", "Tank"),
(1260, 61, "Green Fields", "Bareilly, Uttar Pradesh", 10.00, "Loamy", "Well"),
(1261, 62, "Sunny Orchard", "Kushinagar, Uttar Pradesh", 15.00, "Clay", "River"),
(1262, 63, "Happy Cows Dairy", "Bhadohi, Uttar Pradesh", 8.00, "Sandy", "Borewell"),
(1263, 64, "Golden Grains", "Kahna, Madhya Pradesh", 20.00, "Loamy", "Canal"),
(1264, 65, "Fresh Eggs Farm", "Mandla, Madhya Pradesh", 12.00, "Clay", "Well"),
(1265, 66, "Veggie Delight", "Chhindwara, Madhya Pradesh", 10.00, "Sandy", "River"),
(1266, 67, "Orchard of Fruits", "Mandla, Madhya Pradesh", 13.00, "Loamy", "Borewell"),
(1267, 68, "Sagar Dairy", "Sagar, Madhya Pradesh", 9.00, "Clay", "Canal"),
(1268, 69, "Madhya Pradesh Grains", "Madhya Pradesh, India", 18.00, "Loamy", "Well"),
(1269, 70, "Eggcellent Farm", "Uttar Pradesh, India", 11.00, "Sandy", "River"),

(1270, 71, "Morena Vegetables", "Morena, Madhya Pradesh", 14.00, "Clay", "Borewell"),
(1271, 72, "Gwalior Fruits", "Gwalior, Madhya Pradesh", 16.00, "Loamy", "Canal"),

(1272, 73, "Bhind Dairy Farm", "Bhind, Madhya Pradesh", 7.00, "Sandy", "Well"),
(1273, 74, "Ashok Nagar Grains", "Ashok Nagar, Madhya Pradesh", 22.00, "Clay", "River"),
(1274, 75, "Datia Poultry", "Datia, Madhya Pradesh", 15.00, "Loamy", "Borewell"),
(1275, 76, "Chhatarpur Vegetables", "Chhatarpur, Madhya Pradesh", 19.00, "Sandy", "Canal"),
(1276, 77, "Khargone Fruits", "Khargone, Madhya Pradesh", 10.00, "Clay", "Well"),
(1277, 78, "Jhabua Dairy", "Jhabua, Madhya Pradesh", 8.00, "Loamy", "River"),
(1278, 79, "Bhopal Grains", "Bhopal, Madhya Pradesh", 25.00, "Sandy", "Borewell"),
(1279, 80, "Indore Poultry", "Indore, Madhya Pradesh", 12.00, "Clay", "Canal"),
(1210, 11, "Ali Farms", "Hapur, Uttar Pradesh", 29.00, "Clay", "Canal"),
(1211, 12, "Verma Farm", "Khandwa, Madhya Pradesh", 14.25, "Sandy", "Well"),
(1212, 13, "Tiwari Holdings", "Khandwa, Madhya Pradesh", 31.50, "Loamy", "River"),
(1213, 14, "Deepa Gardens", "Deoria, Uttar Pradesh", 17.80, "Clay", "Borewell"),
(1214, 15, "Gupta Farms", "Deoria, Uttar Pradesh", 19.40, "Sandy", "Tank"),
(1215, 16, "Rao Fields", "Saharanpur, Uttar Pradesh", 23.20, "Loamy", "Canal"),
(1216, 17, "Joshi Estates", "Shivpuri, Madhya Pradesh", 20.00, "Clay", "Well"),
(1217, 18, "Sharma Orchard", "Bulandshahr, Uttar Pradesh", 11.00, "Sandy", "River"),

(1218, 19, "Mehta Meadows", "Bulandshahr, Uttar Pradesh", 24.00, "Loamy", "Borewell"),
(1219, 20, "Desai Farm", "Morena, Madhya Pradesh", 16.75, "Clay", "Tank");

Crop table
Insert into crop values
(300,"Wheat"),
(301, "Rice"),
(302, "Maize"),
(303, "Barley"),
(304, "Sorghum (Jowar)"),
(305, "Pearl Millet (Bajra)"),
(306, "Finger Millet (Ragi)"),
(307, "Pigeon Pea (Arhar)"),
(308, "Green Gram (Moong)"),
(309, "Black Gram (Urad)"),
(310, "Chickpea (Chana)"),
(311, "Lentil (Masoor)"),
(312, "Peas"),
(312, "Peas"),
(313, "Soybean"),
(314, "Groundnut"),
(315, "Cotton"),
(316, "Sugarcane"),
(317, "Mustard"),
(318, "Sunflower"),
(319, "Sesame"),
(320, "Safflower"),
(321, "Tea"),
(322, "Coffee"),
(323, "Cardamom"),
(324, "Turmeric"),
(325, "Ginger"),

(326, "Chili Pepper"),
(327, "Coriander"),
(328, "Cumin"),
(329, "Fennel"),
(330, "Onion"),
(331, "Garlic"),
(332, "Tomato"),
(333, "Potato"),
(334, "Cauliflower"),
(335, "Cabbage"),
(336, "Brinjal (Eggplant)"),
(337, "Spinach"),
(338, "Bitter Gourd"),
(339, "Bottle Gourd"),
(340, "Pumpkin"),
(341, "Cucumber"),
(342, "Radish"),
(343, "Carrot"),
(344, "Mango"),
(345, "Banana"),
(346, "Pomegranate"),
(347, "Guava"),
(348, "Papaya"),
(349, "Coconut"),
(350, "Cluster Bean (Guar)"),
(351, "Cowpea"),
(352, "Black Pepper"),
(353, "Curry Leaves"),
(354, "Betel Leaf"),
(355, "Tapioca"),
(356, "Tamarind"),
(357, "Jute"),
(358, "Areca Nut"),
(359, "Pineapple"),
(360, "Sapota (Chikoo)"),

(361, "Lychee"),
(362, "Jackfruit"),
(363, "Watermelon"),
(364, "Muskmelon"),
(365, "Amla (Indian Gooseberry)"),
(366, "Jamun (Java Plum)"),
(367, "Custard Apple (Sitaphal)"),
(368, "Ber (Indian Jujube)"),
(369, "Pear"),
(370, "Apricot"),
(371, "Peach"),
(372, "Plum"),
(373, "Mulberry"),
(374, "Walnut"),
(375, "Almond"),
(376, "Cashew"),
(377, "Linseed"),
(378, "Castor"),
(379, "Indian Mustard"),
(380, "Henna (Mehndi)"),
(381, "Fenugreek (Methi)"),
(382, "Basil (Tulsi)"),
(383, "Ashwagandha"),
(384, "Bitter Leaf"),
(385, "Neem"),
(386, "Holy Basil"),
(387, "Mint"),
(388, "Mushroom"),
(389, "Lemongrass"),
(390, "Grapes"),
(391, "Strawberry"),
(392, "Kinnow"),
(393, "Lemon"),
(394, "Orange"),
(395, "Curry Plant"),

(396, "Perilla (Bhanjeera)"),
(397, "Bhindi (Okra)"),
(398, "Methi (Fenugreek)"),
(399, "Drumstick (Moringa)");

Policies table
INSERT INTO Policies (Policy_ID, Policy_Name, Description, effective_date, Expiry_Date) VALUES
(1, 'Sustainable Farming Practices', 'Encourages practices that protect the environment while enhancing farm productivity.', '2023-01-01', '2025-01-01'),
(2, 'Organic Certification Policy', 'Regulates the certification of organic agricultural products to ensure quality.', '2023-01-15', '2025-01-15'),
(3, 'Soil Conservation Policy', 'Promotes practices that protect and enhance soil health.', '2023-02-01', '2025-02-01'),
(4, 'Water Management Policy', 'Establishes guidelines for sustainable water use in agriculture.', '2023-02-10', '2025-02-10'),
(5, 'Pesticide Management Policy', 'Regulates the use of pesticides to minimize environmental impact.', '2023-03-01', '2025-03-01'),
(6, 'Crop Rotation Policy', 'Encourages farmers to adopt crop rotation for improved soil fertility.', '2023-03-15', '2025-03-15'),
(7, 'Integrated Pest Management Policy', 'Promotes the use of natural pest control methods alongside chemical treatments.', '2023-04-01', '2025-04-01'),
(8, 'Agroforestry Policy', 'Supports the integration of trees and shrubs into agricultural land.', '2023-04-10', '2025-04-10'),
(9, 'Climate Resilience Policy', 'Encourages agricultural practices that adapt to changing climate conditions.', '2023-05-01', '2025-05-01'),
(10, 'Biodiversity Conservation Policy', 'Promotes agricultural practices that protect local biodiversity.', '2023-05-15', '2025-05-15'),
(11, 'Sustainable Livestock Management Policy', 'Guidelines for responsible and sustainable livestock farming.', '2023-06-01', '2025-06-01'),
(12, 'Farmers Market Support Policy', 'Encourages local farmers markets to promote local produce.', '2023-06-10', '2025-06-10'),

(13, 'Renewable Energy in Agriculture Policy', 'Supports the adoption of renewable energy sources in farming.', '2023-07-01', '2025-07-01'),
(14, 'Sustainable Fertilization Policy', 'Encourages the use of organic fertilizers to reduce chemical runoff.', '2023-07-15', '2025-07-15'),
(15, 'Food Waste Reduction Policy', 'Promotes practices to reduce food waste in the supply chain.', '2023-08-01', '2025-08-01'),
(16, 'Community Supported Agriculture Policy', 'Encourages direct partnerships between farmers and consumers.', '2023-08-10', '2025-08-10'),
(17, 'Urban Agriculture Policy', 'Supports the development of urban farming initiatives.', '2023-09-01', '2025-09-01'),
(18, 'Agroecology Policy', 'Promotes ecological practices in agricultural production.', '2023-09-15', '2025-09-15'),
(19, 'Carbon Sequestration Policy', 'Encourages practices that increase carbon capture in agricultural soils.', '2023-10-01', '2025-10-01'),
(20, 'Sustainable Certification Programs', 'Regulates certifications for sustainable agricultural practices.', '2023-10-10', '2025-10-10'),
(21, 'Local Food Systems Policy', 'Promotes local food production and consumption.', '2023-11-01', '2025-11-01'),
(22, 'Sustainable Fisheries Policy', 'Guidelines for sustainable practices in fisheries management.', '2023-11-15', '2025-11-15'),
(23, 'Research Funding for Sustainable Practices', 'Provides funding for research into sustainable agricultural technologies.', '2023-12-01', '2025-12-01'),
(24, 'Integrated Farming Systems Policy', 'Supports diversified farming systems to increase resilience.', '2023-12-10', '2025-12-10'),
(25, 'Sustainable Packaging Policy', 'Encourages the use of sustainable materials in agricultural packaging.', '2024-01-01', '2026-01-01'),

INSERT INTO Policies (Policy_ID, Policy_Name, Description, Start_Date, End_Date) VALUES
(26, "Food Safety Standards Policy", "Establishes safety standards for agricultural products.", "2024-01-15", "2026-01-15"),

(27, "Nutrient Management Policy", "Guidelines for managing soil nutrients sustainably.", "2024-02-01", "2026-02-01"),
(28, "Pollinator Protection Policy", "Promotes practices to protect pollinators in agricultural systems.", "2024-02-10", "2026-02-10"),
(29, "Sustainable Crop Insurance Policy", "Provides insurance options that encourage sustainable farming practices.", "2024-03-01", "2026-03-01"),
(30, "Greenhouse Gas Emissions Reduction Policy", "Targets reductions in emissions from agricultural practices.", "2024-03-15", "2026-03-15"),
(31, "Sustainable Grain Production Policy", "Encourages sustainable practices in grain farming.", "2024-04-01", "2026-04-01"),
(32, "Organic Seed Policy", "Supports the use of organic seeds in agriculture.", "2024-04-10", "2026-04-10"),
(33, "Community Garden Policy", "Encourages the establishment of community gardens in urban areas.", "2024-05-01", "2026-05-01"),
(34, "Sustainable Aquaculture Policy", "Guidelines for environmentally-friendly fish farming practices.", "2024-05-15", "2026-05-15"),
(35, "Perennial Crop Policy", "Promotes the cultivation of perennial crops for sustainability.", "2024-06-01", "2026-06-01"),
(36, "Sustainable Orchard Management Policy", "Guidelines for managing orchards sustainably.", "2024-06-10", "2026-06-10"),
(37, "Crop Insurance for Sustainable Practices", "Provides incentives for sustainable crop insurance policies.", "2024-07-01", "2026-07-01"),
(38, "Water Conservation Techniques Policy", "Encourages efficient water use in agriculture.", "2024-07-15", "2026-07-15"),
(39, "Land Use Planning Policy", "Guidelines for sustainable land use in agriculture.", "2024-08-01", "2026-08-01"),
(40, "Sustainable Orchard Policy", "Promotes organic and sustainable practices in orchard farming.", "2024-08-10", "2026-08-10"),
(41, "Food Sovereignty Policy", "Supports local control over food production and distribution.", "2024-09-01", "2026-09-01"),
(42, "Agrochemical Reduction Policy", "Encourages reduction of chemical inputs in agriculture.", "2024-09-15", "2026-09-15"),
(43, "Land Restoration Policy", "Promotes the restoration of degraded agricultural lands.", "2024-10-01", "2026-10-01"),

(44, "Conservation Tillage Policy", "Encourages reduced tillage practices to improve soil health.", "2024-10-10", "2026-10-10"),
(45, "Urban Agriculture Incentives", "Provides incentives for urban farming initiatives.", "2024-11-01", "2026-11-01"),
(46, "Food System Resilience Policy", "Supports the resilience of local food systems.", "2024-11-15", "2026-11-15"),
(47, "Sustainable Harvesting Policy", "Regulates harvesting practices to ensure sustainability.", "2024-12-01", "2026-12-01"),
(48, "National Organic Program Policy", "Guidelines for organic farming practices at the national level.", "2024-12-10", "2026-12-10"),
(49, "Community Supported Agriculture Program", "Supports programs that connect consumers directly with farmers.", "2025-01-01", "2027-01-01"),
(50, "Sustainable Grain Storage Policy", "Promotes sustainable storage methods for grains.", "2025-01-15", "2027-01-15"),
(51, "Agroecological Research Policy", "Funds research on agroecological practices.", "2025-02-01", "2027-02-01"),
(52, "Sustainable Irrigation Policy", "Guidelines for efficient irrigation practices.", "2025-02-10", "2027-02-10"),
(53, "Sustainable Harvest Policy", "Encourages responsible harvesting of crops.", "2025-03-01", "2027-03-01"),
(54, "Organic Fertilizer Policy", "Supports the use of organic fertilizers in agriculture.", "2025-03-15", "2027-03-15"),
(55, "Green Infrastructure Policy", "Promotes green infrastructure in agricultural practices.", "2025-04-01", "2027-04-01"),
(56, "Agroforestry Incentives", "Provides incentives for adopting agroforestry practices.", "2025-04-10", "2027-04-10"),
(57, "Integrated Crop-Livestock Systems Policy", "Supports integrated systems for better resource use.", "2025-05-01", "2027-05-01"),
(58, "Soil Health Policy", "Promotes practices that improve overall soil health.", "2025-05-15", "2027-05-15"),
(59, "Farmland Preservation Policy", "Protects valuable agricultural land from development.", "2025-06-01", "2027-06-01"),
(60, "Sustainable Pest Management Policy", "Encourages sustainable pest management practices.", "2025-06-10", "2027-06-10"),

(61, "Resilience in Agriculture Policy", "Supports strategies for resilience against climate change.", "2025-07-01", "2027-07-01"),
(62, "Food Security Policy", "Addresses issues of food security and access to healthy foods.", "2025-07-15", "2027-07-15"),
(63, "Seed Diversity Policy", "Encourages the preservation and use of diverse seed varieties.", "2025-08-01", "2027-08-01"),
(64, "Sustainable Transportation Policy", "Promotes sustainable transport options for agricultural products.", "2025-08-10", "2027-08-10"),
(65, "Soil Erosion Control Policy", "Guidelines for preventing soil erosion in agricultural practices.", "2025-09-01", "2027-09-01"),
(66, "Organic Crop Rotation Policy", "Promotes organic crop rotation practices for sustainable farming.", "2025-09-15", "2027-09-15"),
(67, "Sustainable Production Policy", "Supports sustainable production practices across all sectors.", "2025-10-01", "2027-10-01"),
(68, "Waste Management in Agriculture Policy", "Encourages proper waste management in agricultural settings.", "2025-10-10", "2027-10-10"),
(69, "Conservation of Natural Resources Policy", "Promotes the conservation of natural resources in agriculture.", "2025-11-01", "2027-11-01"),
(70, "Ecosystem Services Policy", "Encourages practices that enhance ecosystem services provided by agriculture.", "2025-11-15", "2027-11-15"),
(71, "Healthy Eating Policy", "Promotes healthy eating and nutrition through local agriculture.", "2025-12-01", "2027-12-01"),
(72, "Agroecological Transition Policy", "Supports the transition to agroecological practices.", "2025-12-10", "2027-12-10"),
(73, "Urban Food Policy", "Encourages sustainable food practices in urban settings.", "2026-01-01", "2028-01-01"),
(74, "Participatory Research in Agriculture Policy", "Promotes participatory research approaches in agriculture.", "2026-01-15", "2028-01-15"),
(75, "Agroecological Certification Policy", "Regulates certifications for agroecological practices.", "2026-02-01", "2028-02-01"),
(76, "Sustainable Community Development Policy", "Supports community development initiatives focused on sustainability.", "2026-02-10", "2028-02-10"),

(77, "Non-GMO Policy", "Regulates the use of non-GMO seeds and practices.", "2026-03-01", "2028-03-01"),
(78, "Indigenous Practices in Agriculture Policy", "Encourages the use of indigenous knowledge and practices in farming.", "2026-03-15", "2028-03-15"),
(79, "Integrated Resource Management Policy", "Supports integrated approaches to resource management in agriculture.", "2026-04-01", "2028-04-01"),
(80, "Green Jobs in Agriculture Policy", "Promotes job creation in the field of sustainable agriculture.", "2026-04-10", "2028-04-10");

Carbon tracking table
INSERT INTO Carbon_Tracking (Tracking_ID, Farm_ID, Total_Carbon_Emissions, Measurement_Period, Reduction_Strategies) VALUES
(1, 1200, 152.45, '2023-Q1', 'Implemented no-till farming practices'),
(2, 1201, 133.20, '2023-Q1', 'Used cover cropping to reduce emissions'),
(3, 1202, 110.75, '2023-Q1', 'Reduced fertilizer application by 20%'),
(4, 1203, 178.50, '2023-Q1', 'Installed solar-powered irrigation systems'),
(5, 1204, 145.00, '2023-Q1', 'Practiced crop rotation with legumes'),
(6, 1205, 160.30, '2023-Q2', 'Adopted precision agriculture techniques'),
(7, 1206, 139.90, '2023-Q2', 'Reduced tillage intensity'),
(8, 1207, 120.45, '2023-Q2', 'Applied organic fertilizers'),
(9, 1208, 200.00, '2023-Q2', 'Used low-emission machinery'),
(10, 1209, 180.75, '2023-Q2', 'Optimized water management'),
(11, 1210, 170.50, '2023-Q3', 'Practiced agroforestry by planting trees'),
(12, 1211, 140.25, '2023-Q3', 'Improved livestock waste management'),
(13, 1212, 115.40, '2023-Q3', 'Reduced synthetic fertilizer use by 30%'),
(14, 1213, 189.90, '2023-Q3', 'Transitioned to organic farming methods'),
(15, 1214, 160.00, '2023-Q3', 'Incorporated crop residue into soil'),
(16, 1215, 152.70, '2023-Q4', 'Switched to renewable energy sources'),
(17, 1216, 120.00, '2023-Q4', 'Utilized green manure'),
(18, 1217, 133.50, '2023-Q4', 'Practiced rotational grazing'),
(19, 1218, 195.00, '2023-Q4', 'Installed bio-digesters for waste'),
(20, 1219, 162.30, '2023-Q4', 'Reduced irrigation frequency'),

(21, 1220, 135.45, '2024-Q1', 'Enhanced soil carbon sequestration'),
(22, 1221, 178.20, '2024-Q1', 'Installed water-saving irrigation'),
(23, 1222, 110.15, '2024-Q1', 'Optimized nutrient management'),
(24, 1223, 192.40, '2024-Q1', 'Practiced minimal soil disturbance'),
(25, 1224, 175.35, '2024-Q1', 'Incorporated forest buffer zones'),
(26, 1225, 145.80, '2024-Q2', 'Reduced chemical pesticide use'),
(27, 1226, 137.20, '2024-Q2', 'Added leguminous cover crops'),
(28, 1227, 200.60, '2024-Q2', 'Utilized windbreaks to improve soil health'),
(29, 1228, 162.50, '2024-Q2', 'Improved drainage systems to reduce emissions'),
(30, 1229, 118.75, '2024-Q2', 'Converted to drip irrigation'),
(31, 1230, 192.30, '2024-Q3', 'Shifted to climate-smart farming'),
(32, 1231, 150.00, '2024-Q3', 'Installed rainwater harvesting system'),
(33, 1232, 132.45, '2024-Q3', 'Increased soil organic matter'),
(34, 1233, 167.90, '2024-Q3', 'Used renewable energy in processing'),
(35, 1234, 158.20, '2024-Q3', 'Converted to low-emission vehicles'),
(36, 1235, 110.30, '2024-Q4', 'Increased compost application'),
(37, 1236, 140.50, '2024-Q4', 'Planted native vegetation'),
(38, 1237, 190.75, '2024-Q4', 'Switched to perennial crops'),
(39, 1238, 155.40, '2024-Q4', 'Promoted residue management practices'),
(40, 1239, 180.00, '2024-Q4', 'Practiced organic mulching'),
(41, 1240, 172.15, '2025-Q1', 'Adopted carbon capture techniques'),
(42, 1241, 112.75, '2025-Q1', 'Switched to hybrid-electric equipment'),
(43, 1242, 148.40, '2025-Q1', 'Reduced diesel consumption by 15%'),
(44, 1243, 183.60, '2025-Q1', 'Used LED lighting to reduce energy use'),
(45, 1244, 157.25, '2025-Q1', 'Incorporated conservation tillage'),
(46, 1245, 162.35, '2025-Q2', 'Practiced reduced impact logging'),
(47, 1246, 135.60, '2025-Q2', 'Introduced farm-wide energy monitoring'),
(48, 1247, 142.80, '2025-Q2', 'Optimized fuel usage'),
(49, 1248, 198.55, '2025-Q2', 'Adopted manure composting'),
(50, 1249, 130.40, '2025-Q2', 'Practiced no-burn field management'),
(51, 1250, 169.20, '2025-Q3', 'Implemented multi-cropping systems'),
(52, 1251, 140.60, '2025-Q3', 'Switched to fuel-efficient machinery'),
(53, 1252, 127.45, '2025-Q3', 'Practiced integrated pest management'),
(54, 1253, 155.30, '2025-Q3', 'Increased carbon storage in soil'),

(55, 1254, 149.50, '2025-Q3', 'Utilized greenhouses for controlled growing'),
(56, 1255, 122.80, '2025-Q4', 'Shifted to regenerative grazing'),
(57, 1256, 136.90, '2025-Q4', 'Minimized use of plastic mulch'),
(58, 1257, 199.80, '2025-Q4', 'Implemented biogas energy systems'),
(59, 1258, 180.45, '2025-Q4', 'Transitioned to organic livestock feed'),
(60, 1259, 150.75, '2025-Q4', 'Reduced crop residue burning'),
(61, 1260, 155.30, '2026-Q1', 'Utilized compost teas for soil health'),
(62, 1261, 123.45, '2026-Q1', 'Optimized nutrient cycling'),
(63, 1262, 189.90, '2026-Q1', 'Practiced biological pest control'),
(64, 1263, 167.25, '2026-Q1', 'Shifted to eco-friendly pest treatments'),
(65, 1264, 135.70, '2026-Q1', 'Incorporated polyculture cropping'),
(66, 1265, 178.60, '2026-Q2', 'Installed greenhouse gas filters'),
(67, 1266, 149.20, '2026-Q2', 'Improved irrigation scheduling'),
(68, 1267, 160.40, '2026-Q2', 'Used biochar as a soil amendment'),
(69, 1268, 140.15, '2026-Q2', 'Practiced managed organic residue'),
(70, 1269, 192.00, '2026-Q2', 'Adopted rotational agroforestry'),
(71, 1270, 162.50, '2026-Q3', 'Optimized animal waste processing'),
(72, 1271, 148.80, '2026-Q3', 'Increased native biodiversity'),
(73, 1272, 121.40, '2026-Q3', 'Practiced ecological farming'),
(74, 1273, 135.55, '2026-Q3', 'Incorporated organic soil enhancers'),
(75, 1274, 179.25, '2026-Q3', 'Shifted to mixed farming'),
(76, 1275, 113.50, '2026-Q4', 'Reduced farm greenhouse gases by 20%'),
(77, 1276, 127.30, '2026-Q4', 'Adopted low-impact soil practices'),
(78, 1277, 152.80, '2026-Q4', 'Incorporated carbon-neutral energy sources'),
(79,1278,188.40 ,‘2026-Q4’, ‘Implemented eco-friendly fertilization’),
(80, 1279,155.20, ‘2026-Q4’ ‘Practiced controlled environment farming’);

Contact_detail table
INSERT INTO Contact_Details (contact_id, farmer_id, phone_number, email_address, address) VALUES
('C-1', 1, '9876543201', 'rajesh.kumar1@example.com', 'Billaspur, Rampur, Uttar Pradesh'),

('C-2', 2, '9876543202', 'aarti.sharma2@example.com', 'Billaspur, Rampur, Uttar Pradesh'),
('C-3', 3, '9876543203', 'vikram.singh3@example.com', 'Billaspur, Rampur, Uttar Pradesh'),
('C-4', 4, '9876543204', 'priya.patel4@example.com', 'Sitapur, Uttar Pradesh'),
('C-5', 5, '9876543205', 'amit.chauhan5@example.com', 'Sitapur, Uttar Pradesh'),
('C-6', 6, '9876543206', 'sunita.devi6@example.com', 'Mau, Azamgarh, Uttar Pradesh'),
('C-7', 7, '9876543207', 'rahul.mehta7@example.com', 'Mau, Azamgarh, Uttar Pradesh'),
('C-8', 8, '9876543208', 'kiran.bhatt8@example.com', 'Chhatarpur, Madhya Pradesh'),
('C-9', 9, '9876543209', 'suresh.yadav9@example.com', 'Chhatarpur, Madhya Pradesh'),
('C-10', 10, '9876543210', 'neha.singh10@example.com', 'Hapur, Uttar Pradesh'),
('C-11', 11, '9876543211', 'mohammed.ali11@example.com', 'Hapur, Uttar Pradesh'),
('C-12', 12, '9876543212', 'sita.verma12@example.com', 'Khandwa, Madhya Pradesh'),
('C-13', 13, '9876543213', 'gopal.tiwari13@example.com', 'Khandwa, Madhya Pradesh'),
('C-14', 14, '9876543214', 'deepa.nair14@example.com', 'Deoria, Uttar Pradesh'),
('C-15', 15, '9876543215', 'ramesh.gupta15@example.com', 'Deoria, Uttar Pradesh'),
('C-16', 16, '9876543216', 'kavita.rao16@example.com', 'Saharanpur, Uttar Pradesh'),
('C-17', 17, '9876543217', 'prakash.joshi17@example.com', 'Shivpuri, Madhya Pradesh'),
('C-18', 18, '9876543218', 'anjali.sharma18@example.com', 'Bulandshahr, Uttar Pradesh'),

('C-19', 19, '9876543219', 'arvind.mehta19@example.com', 'Bulandshahr, Uttar Pradesh'),
('C-20', 20, '9876543220', 'poonam.desai20@example.com', 'Morena, Madhya Pradesh'),
('C-21', 21, '9876543221', 'vijay.patil21@example.com', 'Morena, Madhya Pradesh'),
('C-22', 22, '9876543222', 'nisha.rani22@example.com', 'Faizabad, Uttar Pradesh'),
('C-23', 23, '9876543223', 'suraj.singh23@example.com', 'Faizabad, Uttar Pradesh'),
('C-24', 24, '9876543224', 'shalini.agarwal24@example.com', 'Dhar, Madhya Pradesh'),
('C-25', 25, '9876543225', 'ashok.choudhary25@example.com', 'Dhar, Madhya Pradesh'),
('C-26', 26, '9876543226', 'manoj.singh26@example.com', 'Rewa, Madhya Pradesh'),
('C-27', 27, '9876543227', 'meera.patil27@example.com', 'Rewa, Madhya Pradesh'),
('C-28', 28, '9876543228', 'akash.kumar28@example.com', 'Jabalpur, Madhya Pradesh'),
('C-29', 29, '9876543229', 'pallavi.shah29@example.com', 'Jabalpur, Madhya Pradesh'),
('C-30', 30, '9876543230', 'rohit.mehta30@example.com', 'Jaunpur, Uttar Pradesh'),
('C-31', 31, '9876543231', 'divya.kapoor31@example.com', 'Jaunpur, Uttar Pradesh'),
('C-32', 32, '9876543232', 'arjun.yadav32@example.com', 'Bhopal, Madhya Pradesh'),
('C-33', 33, '9876543233', 'nidhi.mishra33@example.com', 'Bhopal, Madhya Pradesh'),
('C-34', 34, '9876543234', 'amit.jain34@example.com', 'Jhansi, Uttar Pradesh'),
('C-35', 35, '9876543235', 'reshma.naik35@example.com', 'Jhansi, Uttar Pradesh'),

('C-36', 36, '9876543236', 'sachin.kumar36@example.com', 'Satna, Madhya Pradesh'),
('C-37', 37, '9876543237', 'geeta.singh37@example.com', 'Satna, Madhya Pradesh'),
('C-38', 38, '9876543238', 'deepak.rao38@example.com', 'Tikamgarh, Madhya Pradesh'),
('C-39', 39, '9876543239', 'priyanka.joshi39@example.com', 'Tikamgarh, Madhya Pradesh'),
('C-40', 40, '9876543240', 'kamal.kumar40@example.com', 'Mirzapur, Uttar Pradesh'),
('C-41', 41, '9876543241', 'aruna.shah41@example.com', 'Mirzapur, Uttar Pradesh'),
('C-42', 42, '9876543242', 'vivek.das42@example.com', 'Gwalior, Madhya Pradesh'),
('C-43', 43, '9876543243', 'megha.sharma43@example.com', 'Gwalior, Madhya Pradesh'),
('C-44', 44, '9876543244', 'karan.singh44@example.com', 'Sagar, Madhya Pradesh'),
('C-45', 45, '9876543245', 'nandita.rao45@example.com', 'Sagar, Madhya Pradesh'),
('C-46', 46, '9876543246', 'bhavesh.patel46@example.com', 'Etawah, Uttar Pradesh'),
('C-47', 47, '9876543247', 'neha.kumar47@example.com', 'Etawah, Uttar Pradesh'),
('C-48', 48, '9876543248', 'tarun.shah48@example.com', 'Katni, Madhya Pradesh'),
('C-49', 49, '9876543249', 'lakshmi.ram49@example.com', 'Katni, Madhya Pradesh'),
('C-50', 50, '9876543250', 'gaurav.sharma50@example.com', 'Shahdol, Madhya Pradesh');

INSERT INTO Contact_Details (Contact_ID, Farmer_ID, Phone_Number, Email_Address, Address)
VALUES

('C-51', 51, '9876543251', 'ankita.jain51@example.com', 'Shahdol, Madhya Pradesh'),
('C-52', 52, '9876543252', 'yash.gupta52@example.com', 'Vidisha, Madhya Pradesh'),
('C-53', 53, '9876543253', 'pooja.kumar53@example.com', 'Vidisha, Madhya Pradesh'),
('C-54', 54, '9876543254', 'amit.kumar54@example.com', 'Hardoi, Uttar Pradesh'),
('C-55', 55, '9876543255', 'rekha.patel55@example.com', 'Hardoi, Uttar Pradesh'),
('C-56', 56, '9876543256', 'jatin.kumar56@example.com', 'Bhind, Madhya Pradesh'),
('C-57', 57, '9876543257', 'vaishali.jain57@example.com', 'Bhind, Madhya Pradesh'),
('C-58', 58, '9876543258', 'neeraj.kumar58@example.com', 'Sehore, Madhya Pradesh'),
('C-59', 59, '9876543259', 'kavya.mehta59@example.com', 'Sehore, Madhya Pradesh'),
('C-60', 60, '9876543260', 'vishal.rana60@example.com', 'Khargone, Madhya Pradesh'),
('C-61', 61, '9876543261', 'shreya.sharma61@example.com', 'Khargone, Madhya Pradesh'),
('C-62', 62, '9876543262', 'ajay.mishra62@example.com', 'Neemuch, Madhya Pradesh'),
('C-63', 63, '9876543263', 'lalit.patel63@example.com', 'Neemuch, Madhya Pradesh'),
('C-64', 64, '9876543264', 'seema.khan64@example.com', 'Moradabad, Uttar Pradesh'),
('C-65', 65, '9876543265', 'nandini.singh65@example.com', 'Moradabad, Uttar Pradesh'),
('C-66', 66, '9876543266', 'yogesh.patel66@example.com', 'Rampur, Uttar Pradesh'),
('C-67', 67, '9876543267', 'priti.singh67@example.com', 'Rampur, Uttar Pradesh'),

('C-68', 68, '9876543268', 'ravi.sharma68@example.com', 'Unnao, Uttar Pradesh'),
('C-69', 69, '9876543269', 'rajiv.kumar69@example.com', 'Unnao, Uttar Pradesh'),
('C-70', 70, '9876543270', 'smita.das70@example.com', 'Balaghat, Madhya Pradesh'),
('C-71', 71, '9876543271', 'tarun.shah71@example.com', 'Balaghat, Madhya Pradesh'),
('C-72', 72, '9876543272', 'rahul.mishra72@example.com', 'Rajgarh, Madhya Pradesh'),
('C-73', 73, '9876543273', 'rani.sen73@example.com', 'Rajgarh, Madhya Pradesh'),
('C-74', 74, '9876543274', 'shashank.tiwari74@example.com', 'Hamirpur, Uttar Pradesh'),
('C-75', 75, '9876543275', 'priya.kumar75@example.com', 'Hamirpur, Uttar Pradesh'),
('C-76', 76, '9876543276', 'aman.khan76@example.com', 'Singrauli, Madhya Pradesh'),
('C-77', 77, '9876543277', 'rakesh.mehta77@example.com', 'Singrauli, Madhya Pradesh'),
('C-78', 78, '9876543278', 'shobha.bhat78@example.com', 'Tikamgarh, Madhya Pradesh'),
('C-79', 79, '9876543279', 'ajay.kumar79@example.com', 'Tikamgarh, Madhya Pradesh'),
('C-80', 80, '9876543280', 'parul.jain80@example.com', 'Sonbhadra, Uttar Pradesh'),
('C-81', 81, '9876543281', 'lalit.patel81@example.com', 'Sonbhadra, Uttar Pradesh'),
('C-82', 82, '9876543282', 'anita.mehta82@example.com', 'Ratlam, Madhya Pradesh'),
('C-83', 83, '9876543283', 'krishna.yadav83@example.com', 'Ratlam, Madhya Pradesh'),
('C-84', 84, '9876543284', 'sunil.kumar84@example.com', 'Chhindwara, Madhya Pradesh'),

('C-85', 85, '9876543285', 'vikas.rao85@example.com', 'Chhindwara, Madhya Pradesh'),
('C-86', 86, '9876543286', 'rakesh.singh86@example.com', 'Datia, Madhya Pradesh'),
('C-87', 87, '9876543287', 'deepak.patel87@example.com', 'Datia, Madhya Pradesh'),
('C-88', 88, '9876543288', 'meenal.shah88@example.com', 'Raebareli, Uttar Pradesh'),
('C-89', 89, '9876543289', 'sumit.rana89@example.com', 'Raebareli, Uttar Pradesh'),
('C-90', 90, '9876543290', 'vinod.kumar90@example.com', 'Barwani, Madhya Pradesh'),
('C-91', 91, '9876543291', 'priyanka.naik91@example.com', 'Barwani, Madhya Pradesh'),
('C-92', 92, '9876543292', 'arvind.kumar92@example.com', 'Etah, Uttar Pradesh'),
('C-93', 93, '9876543293', 'ashwini.singh93@example.com', 'Etah, Uttar Pradesh'),
('C-94', 94, '9876543294', 'naveen.patel94@example.com', 'Hardoi, Uttar Pradesh'),
('C-95', 95, '9876543295', 'alok.sharma95@example.com', 'Hardoi, Uttar Pradesh'),
('C-96', 96, '9876543296', 'sanjay.patel96@example.com', 'Firozabad, Uttar Pradesh'),
('C-97', 97, '9876543297', 'kiran.sharma97@example.com', 'Firozabad, Uttar Pradesh'),
('C-98', 98, '9876543298', 'tarun.das98@example.com', 'Shajapur, Madhya Pradesh'),
('C-99', 99, '9876543299', 'ankur.patel99@example.com', 'Shajapur, Madhya Pradesh'),
('C-100', 100, '9876543300', 'vinay.kumar100@example.com', 'Banda, Uttar Pradesh');

Farm_activities table
INSERT INTO Farm_Activities (activity_id, farm_id, activity_type)

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VALUES
(1, 1200, 'Plowing'),
(2, 1200, 'Sowing'),
(3, 1201, 'Irrigation'),
(4, 1201, 'Fertilizer Application'),
(5, 1202, 'Weeding'),
(6, 1202, 'Harvesting'),
(7, 1203, 'Soil Testing'),
(8, 1203, 'Pest Control'),
(9, 1204, 'Irrigation'),
(10, 1204, 'Crop Rotation'),
(11, 1205, 'Fertilizer Application'),
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(13, 1206, 'Plowing'),
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(15, 1207, 'Harvesting'),
(16, 1207, 'Pest Control'),
(17, 1208, 'Irrigation'),
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(21, 1210, 'Weeding'),
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(26, 1212, 'Fertilizer Application'),
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(35, 1217, 'Harvesting'),
(36, 1217, 'Plowing'),
(37, 1218, 'Soil Testing'),
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(39, 1219, 'Pest Control'),
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(42, 1220, 'Fertilizer Application'),
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Farm_crops table
INSERT INTO Farm_Crops (farm_crop_id, farm_id, crop_id) VALUES
(1, 1200, 300),

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(95, 1230, 329),
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(98, 1205, 330),
(99, 1239, 330),
(100, 1286, 330);

Researcher table
INSERT INTO Researchers (researcher_id, researcher_name, field_of_study, affiliation, contact_info)
VALUES

('R001', 'Dr. Aditi Sharma', 'Agricultural Science', 'ICAR',
'aditi.sharma@icar.org'),
('R002', 'Dr. Rajesh Patel', 'Horticulture', 'GAU', 'rajesh.patel@gau.edu.in'),
('R003', 'Dr. Kavita Mehta', 'Soil Science', 'IARI', 'kavita.mehta@iari.res.in'),
('R004', 'Dr. Amit Joshi', 'Crop Protection', 'NAAS', 'amit.joshi@naas.org'),
('R005', 'Dr. Priya Singh', 'Plant Physiology', 'PAU', 'priya.singh@pau.edu'),
('R006', 'Dr. Sanjay Verma', 'Entomology', 'Punjab Agricultural University',
'sanjay.verma@pau.edu'),
('R007', 'Dr. Neha Gupta', 'Agricultural Economics', 'ICAR',
'neha.gupta@icar.org'),
('R008', 'Dr. Vinay Kumar', 'Agricultural Engineering', 'GBPUAT',
'vinay.kumar@gbpuat.ac.in'),
('R009', 'Dr. Shweta Nair', 'Crop Genetics', 'NARS', 'shweta.nair@nars.org'),
('R010', 'Dr. Karan Bansal', 'Plant Pathology', 'IARI',
'karan.bansal@iari.res.in'),
('R011', 'Dr. Riya Thakur', 'Sustainable Agriculture', 'NDUAT',
'riya.thakur@nduat.edu.in'),
('R012', 'Dr. Arvind Rao', 'Agroforestry', 'DCRUST',
'arvind.rao@dcrust.edu.in'),
('R013', 'Dr. Poonam Joshi', 'Weed Science', 'TNAU',
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('R014', 'Dr. Varun Sharma', 'Soil Health', 'JNU', 'varun.sharma@jnu.ac.in'),
('R015', 'Dr. Sheetal Agarwal', 'Agronomy', 'PAU',
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('R016', 'Dr. Mohit Kapoor', 'Food Science', 'G.B. Pant University',
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('R018', 'Dr. Neeraj Saini', 'Plant Breeding', 'NDUAT',
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('R019', 'Dr. Rani Khanna', 'Fisheries', 'CIFE', 'rani.khanna@cife.edu.in'),
('R020', 'Dr. Aditya Raghav', 'Microbiology', 'NDRI',
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('R021', 'Dr. Shubham Gupta', 'Postharvest Technology', 'ICAR',
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('R022', 'Dr. Geeta Iyer', 'Plant Nutrition', 'DABRU',
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('R024', 'Dr. Deepa Jain', 'Organic Farming', 'UAS',
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('R025', 'Dr. Neha Bhardwaj', 'Crop Physiology', 'IARI',
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('R027', 'Dr. Priyanka Sethi', 'Agricultural Extension', 'PAU',
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('R028', 'Dr. Ashok Malhotra', 'Animal Husbandry', 'NDRI',
'ashok.malhotra@ndri.res.in'),
('R029', 'Dr. Tarun Sharma', 'Food Technology', 'IIT Kharagpur',
'tarun.sharma@iitkgp.ac.in'),
('R030', 'Dr. Deepak Bhatia', 'Climate Change', 'WMO',
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('R031', 'Dr. Anisha Dutta', 'Hydrology', 'IISc', 'anisha.dutta@iisc.ac.in'),
('R032', 'Dr. Vikas Choudhary', 'Remote Sensing', 'ISRO',
'vikas.choudhary@isro.gov.in'),
('R033', 'Dr. Sneha Rai', 'Sustainable Development', 'NID',
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('R034', 'Dr. Gaurav Malik', 'Agricultural Statistics', 'NABARD',
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('R035', 'Dr. Aishwarya Rathi', 'Environmental Science', 'NALSAR',
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('R036', 'Dr. Mukesh Sharma', 'Farm Management', 'IIFM',
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('R037', 'Dr. Piyush Agarwal', 'Horticultural Technology', 'UHS',
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('R038', 'Dr. Swati Gupta', 'Food Security', 'MSSRF',
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('R039', 'Dr. Rahul Yadav', 'Agri-business', 'GKVK',
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('R040', 'Dr. Tanuja Joshi', 'Plant Ecology', 'IIT Bombay',
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('R041', 'Dr. Anirudh Sharma', 'Bioinformatics', 'IISER',
'anirudh.sharma@iiser.edu.in'),
('R042', 'Dr. Suman Prasad', 'Soil Conservation', 'GBPUAT',
'suman.prasad@gbpuat.ac.in'),
('R043', 'Dr. Jatin Malhotra', 'Pesticide Research', 'CIRG',
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('R044', 'Dr. Poonam Suri', 'Dairy Science', 'NDRI',
'poonam.suri@ndri.res.in'),
('R045', 'Dr. Aayush Tyagi', 'Rural Development', 'IRMA',
'aayush.tyagi@irma.ac.in'),
('R046', 'Dr. Kanika Sharma', 'Climate Resilience', 'NIDM',
'kanika.sharma@nidm.gov.in'),
('R047', 'Dr. Raghav Sethi', 'Crop Modelling', 'ICAR',
'raghav.sethi@icar.org'),
('R048', 'Dr. Nisha Bhardwaj', 'Agricultural Biotechnology', 'TNAU',
'nisha.bhardwaj@tnau.ac.in'),
('R049', 'Dr. Vineet Agarwal', 'Fisheries Science', 'CIFE',
'vineet.agarwal@cife.edu.in'),
('R050', 'Dr. Parul Chaudhary', 'Integrated Farming', 'PAU',
'parul.chaudhary@pau.edu');

INSERT INTO Researchers (Researcher_ID, Name, Field_of_Study,
Institution, Email)
VALUES
('R051', 'Dr. Suryakant Bansal', 'Plant Biotechnology', 'IARI',
'suryakant.bansal@iari.res.in'),
('R052', 'Dr. Tanvi Kapoor', 'Urban Agriculture', 'JNU',
'tanvi.kapoor@jnu.ac.in'),
('R053', 'Dr. Rajiv Sharma', 'Nutritional Science', 'AIIMS',
'rajiv.sharma@aiims.edu.in'),
('R054', 'Dr. Rina Kumari', 'Natural Resource Management', 'NDUAT',
'rina.kumari@nduat.edu.in'),
('R055', 'Dr. Ashwini Nair', 'Genomics', 'ICAR', 'ashwini.nair@icar.org'),

('R056', 'Dr. Ritesh Yadav', 'Agroecology', 'IISc', 'ritesh.yadav@iisc.ac.in'),
('R057', 'Dr. Meera Sharma', 'Agricultural Meteorology', 'IMD',
'meera.sharma@imd.gov.in'),
('R058', 'Dr. Sidhu Choudhary', 'Veterinary Science', 'IVRI',
'sidhu.choudhary@ivri.res.in'),
('R059', 'Dr. Nitin Sharma', 'Food Science', 'IIT Delhi',
'nitin.sharma@iitd.ac.in'),
('R060', 'Dr. Riya Kapoor', 'Plant Breeding', 'GBPUAT',
'riya.kapoor@gbpuat.ac.in'),
('R061', 'Dr. Tarun Khanna', 'Sustainable Agriculture', 'IARI',
'tarun.khanna@iari.res.in'),
('R062', 'Dr. Snehal Patel', 'Aquaculture', 'CIFE', 'snehal.patel@cife.edu.in'),
('R063', 'Dr. Amol Jadhav', 'Plant Pathology', 'TNAU',
'amol.jadhav@tnau.ac.in'),
('R064', 'Dr. Ruchi Sethi', 'Crop Science', 'UAS', 'ruchi.sethi@uas.edu.in'),
('R065', 'Dr. Mohan Agarwal', 'Horticulture', 'PAU',
'mohan.agarwal@pau.edu'),
('R066', 'Dr. Kanak Thakur', 'Soil Conservation', 'ICAR',
'kanak.thakur@icar.org'),
('R067', 'Dr. Vidya Joshi', 'Agroforestry', 'GBPUAT',
'vidya.joshi@gbpuat.ac.in'),
('R068', 'Dr. Adarsh Kumar', 'Organic Farming', 'IISc',
'adarsh.kumar@iisc.ac.in'),
('R069', 'Dr. Ananya Sharma', 'Water Resource Management', 'NIDM',
'ananya.sharma@nidm.gov.in'),
('R070', 'Dr. Nisha Jain', 'Food Processing', 'IIT Kharagpur',
'nisha.jain@iitkgp.ac.in'),
('R071', 'Dr. Vikas Bansal', 'Environmental Studies', 'JNU',
'vikas.bansal@jnu.ac.in'),
('R072', 'Dr. Gaurav Patel', 'Animal Nutrition', 'NDRI',
'gaurav.patel@ndri.res.in'),
('R073', 'Dr. Payal Choudhary', 'Crop Protection', 'NDUAT',
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('R074', 'Dr. Shashank Gupta', 'Sustainable Development', 'NABARD',
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('R075', 'Dr. Arjun Mehta', 'Plant Physiology', 'IARI',
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('R085', 'Dr. Amit Khanna', 'Soil Microbiology', 'NDUAT',
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('R087', 'Dr. Prashant Rathi', 'Natural Resource Management', 'GBPUAT',
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('R093', 'Dr. Neelam Agarwal', 'Sustainable Agriculture', 'IARI',
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('R100', 'Dr. Tanya Yadav', 'Crop Science', 'UAS',
'tanya.yadav@uas.edu.in');

INSERT INTO Research_data (Researchdata_ID, Research_Title, Researcher_id, Data_collected_date, conclusion) VALUES
(1, 'Agricultural Science in Modern Farming', 'R001', '2024-01-01', 'Research on the application of agricultural science in modern farming techniques.'),
(2, 'Horticulture and Crop Growth', 'R002', '2024-02-01', 'Study on the effect of horticulture practices on crop growth in temperate climates.'),
(3, 'Soil Science in Sustainable Farming', 'R003', '2024-03-01', 'Exploring soil health and its role in sustainable farming practices.'),
(4, 'Crop Protection in Modern Agriculture', 'R004', '2024-04-01', 'Investigating new methods of crop protection in agriculture.'),
(5, 'Plant Physiology and Growth Enhancement', 'R005', '2024-05-01', 'Study of the role of plant physiology in enhancing crop growth.'),
(6, 'Entomology and Pest Control', 'R006', '2024-06-01', 'Research on pest control and its impact on crop yields.'),
(7, 'Agricultural Economics in Policy Making', 'R007', '2024-07-01', 'Analysis of agricultural economics and its role in policy formation.'),
(8, 'Agricultural Engineering for Sustainable Development', 'R008', '2024-08-01', 'Study on how agricultural engineering can contribute to sustainable agriculture.'),

(9, 'Crop Genetics and Biotechnology', 'R009', '2024-09-01', 'Research into the genetic modifications in crops to enhance yield.'),
(10, 'Plant Pathology and Disease Resistance', 'R010', '2024-10-01', 'Exploring disease resistance in crops and the role of plant pathology.'),
(11, 'Sustainable Agricultural Practices for Future', 'R011', '2024-11-01', 'Investigating sustainable agricultural practices for future generations.'),
(12, 'Agroforestry for Climate Mitigation', 'R012', '2024-12-01', 'Study of agroforestry as a climate mitigation strategy.'),
(13, 'Weed Science for Crop Management', 'R013', '2025-01-01', 'Research on weed management strategies in crop production.'),
(14, 'Soil Health and Fertility Management', 'R014', '2025-02-01', 'Exploring soil health and fertility management techniques.'),
(15, 'Agronomy and Soil Management', 'R015', '2025-03-01', 'Study on the impact of agronomy and soil management practices on crop productivity.'),
(16, 'Food Science and Agricultural Production', 'R016', '2025-04-01', 'Research on food science and its connection with agricultural production processes.'),
(17, 'Water Management for Agriculture', 'R017', '2025-05-01', 'Research on efficient water management techniques for agriculture.'),
(18, 'Plant Breeding for Enhanced Crop Yield', 'R018', '2025-06-01', 'Study of plant breeding techniques for increasing crop yield.'),
(19, 'Fisheries Science and Sustainable Practices', 'R019', '2025-07-01', 'Investigating sustainable practices in fisheries science.'),
(20, 'Microbiology and Crop Production', 'R020', '2025-08-01', 'Study of the role of microbiology in enhancing crop production.'),
(21, 'Postharvest Technology for Food Preservation', 'R021', '2025-09-01', 'Research into postharvest technology and its role in food preservation.'),
(22, 'Plant Nutrition and Fertilization Techniques', 'R022', '2025-10-01', 'Study on plant nutrition and the use of fertilizers to improve crop yields.'),
(23, 'Pest Management in Agricultural Systems', 'R023', '2025-11-01', 'Research on integrated pest management systems in agriculture.'),
(24, 'Organic Farming Practices and Benefits', 'R024', '2025-12-01', 'Study on the benefits of organic farming for sustainable agriculture.'),

(25, 'Crop Physiology and Environmental Stress', 'R025', '2026-01-01', 'Research on the physiological responses of crops to environmental stress factors.'),
(26, 'Soil Fertility and Crop Yield', 'R026', '2026-02-01', 'Investigating the relationship between soil fertility and crop yield.'),
(27, 'Agricultural Extension and Education', 'R027', '2026-03-01', 'Study on the role of agricultural extension services in educating farmers.'),
(28, 'Animal Husbandry and Farm Productivity', 'R028', '2026-04-01', 'Research on animal husbandry techniques and their impact on farm productivity.'),
(29, 'Food Technology in Agricultural Products', 'R029', '2026-05-01', 'Exploring the role of food technology in processing agricultural products.'),
(30, 'Climate Change and Agriculture', 'R030', '2026-06-01', 'Research on the impacts of climate change on agricultural systems.')

(31, "Hydrology and Irrigation Systems", "R031", "2026-07-01", "Study on the role of hydrology in irrigation and water management for agriculture."),
(32, "Remote Sensing for Agricultural Monitoring", "R032", "2026-08-01", "Research on the use of remote sensing technologies for agricultural monitoring."),
(33, "Sustainable Development in Agriculture", "R033", "2026-09-01", "Study of sustainable development strategies in agriculture."),
(34, "Agricultural Statistics for Policy Planning", "R034", "2026-10-01", "Research on the use of agricultural statistics in policy planning and decision-making."),
(35, "Environmental Science in Agriculture", "R035", "2026-11-01", "Exploring environmental science in the context of agriculture."),
(36, "Farm Management and Economic Analysis", "R036", "2026-12-01", "Study on farm management strategies and their economic implications."),
(37, "Horticultural Technology for Crop Production", "R037", "2027-01-01", "Research on the role of horticultural technology in improving crop production."),
(38, "Food Security and Agricultural Policy", "R038", "2027-02-01", "Investigating the relationship between food security and agricultural policy."),

(39, "Agri-business and Market Development", "R039", "2027-03-01", "Study on agri-business models and market development strategies."),
(40, "Plant Ecology in Agroecosystems", "R040", "2027-04-01", "Research on plant ecology and its role in agroecosystem management."),
(41, "Bioinformatics in Agricultural Research", "R041", "2027-05-01", "Study of bioinformatics applications in agricultural research."),
(42, "Soil Conservation Techniques", "R042", "2027-06-01", "Research on soil conservation methods for sustainable farming."),
(43, "Pesticide Research and Safety", "R043", "2027-07-01", "Study on pesticide safety and new research in pest control."),
(44, "Dairy Science and Milk Production", "R044", "2027-08-01", "Research on dairy science and its contribution to milk production."),
(45, "Rural Development and Agricultural Economy", "R045", "2027-09-01", "Study on the relationship between rural development and the agricultural economy."),
(46, "Climate Resilience in Agriculture", "R046", "2027-10-01", "Research on building climate resilience in agriculture."),
(47, "Crop Modelling for Yield Prediction", "R047", "2027-11-01", "Study on crop modelling techniques for predicting crop yields."),
(48, "Agricultural Biotechnology and Genetic Engineering", "R048", "2027-12-01", "Exploring the role of biotechnology and genetic engineering in agriculture."),
(49, "Fisheries Science for Sustainable Fisheries", "R049", "2028-01-01", "Study on sustainable practices in fisheries science and management."),
(50, "Integrated Farming Systems for Sustainability", "R050", "2028-02-01", "Research on integrated farming systems and their sustainability.")
(51, "Plant Biotechnology and Crop Improvement", "R051", "2028-03-01", "Study of plant biotechnology techniques for crop improvement."),
(52, "Urban Agriculture and Sustainability", "R052", "2028-04-01", "Research on urban agriculture and its potential for sustainable development."),
(53, "Nutritional Science in Food Security", "R053", "2028-05-01", "Study on the role of nutritional science in enhancing food security."),
(54, "Natural Resource Management in Agriculture", "R054", "2028-06-01", "Research on natural resource management in agricultural systems."),

(55, "Genomics in Crop Development", "R055", "2028-07-01", "Study of genomics in enhancing crop development and resistance."),
(56, "Sustainable Food Production Systems", "R056", "2028-08-01", "Research on sustainable food production systems for future generations."),
(57, "Poultry Science and Egg Production", "R057", "2028-09-01", "Study on poultry science and efficient egg production techniques."),
(58, "Greenhouse Gas Emissions in Agriculture", "R058", "2028-10-01", "Research on reducing greenhouse gas emissions in agricultural practices."),
(59, "Forest Management for Agroforestry", "R059", "2028-11-01", "Study on forest management techniques for agroforestry systems."),
(60, "Agrochemical Use and Environmental Impact", "R060", "2028-12-01", "Research on the impact of agrochemical use on the environment."),
(61, "Soil Microorganisms and Crop Growth", "R061", "2029-01-01", "Study on the role of soil microorganisms in promoting crop growth."),
(62, "Agro-ecology and Biodiversity", "R062", "2029-02-01", "Research on agro-ecology and its impact on agricultural biodiversity."),
(63, "Farming Techniques for Small-scale Farmers", "R063", "2029-03-01", "Study of efficient farming techniques for small-scale farmers."),
(64, "Biological Control of Agricultural Pests", "R064", "2029-04-01", "Research on biological control methods for managing agricultural pests."),
(65, "Water Use Efficiency in Agriculture", "R065", "2029-05-01", "Study on improving water use efficiency in agriculture."),
(66, "Crop Diversification for Sustainable Agriculture", "R066", "2029-06-01", "Research on crop diversification strategies for sustainable farming."),
(67, "Farming Systems and Rural Livelihoods", "R067", "2029-07-01", "Study on the impact of farming systems on rural livelihoods."),
(68, "Soil Erosion and Conservation Strategies", "R068", "2029-08-01", "Research on soil erosion prevention and conservation strategies."),
(69, "Agri-food Systems and Nutrition Security", "R069", "2029-09-01", "Study on the relationship between agri-food systems and nutrition security."),

(70, "Farmer Education and Technological Adoption", "R070", "2029-10-01", "Research on farmer education programs and the adoption of new technologies."),
(71, "Postharvest Losses and Waste Reduction", "R071", "2029-11-01", "Study on reducing postharvest losses and food waste in agriculture."),
(72, "Genetic Resources for Crop Improvement", "R072", "2029-12-01", "Research on utilizing genetic resources for improving crops."),
(73, "Food Waste Management in Agricultural Systems", "R073", "2030-01-01", "Study on managing food waste within agricultural systems."),
(74, "Farming Innovations for Climate Adaptation", "R074", "2030-02-01", "Research on innovative farming practices to adapt to climate change."),
(75, "Soil Restoration Techniques", "R075", "2030-03-01", "Study on techniques for restoring soil health in degraded land."),
(76, "Farm Technology for Precision Agriculture", "R076", "2030-04-01", "Research on precision agriculture technologies for improving farm productivity."),
(77, "Agro-industry and Rural Economy", "R077", "2030-05-01", "Study on the role of agro-industry in strengthening the rural economy."),
(78, "Animal Feed and Nutrition Research", "R078", "2030-06-01", "Research on animal feed formulations and their impact on animal nutrition."),
(79, "Sustainable Aquaculture Practices", "R079", "2030-07-01", "Study on sustainable practices in aquaculture for environmental protection."),
(80, "Invasive Species and Agricultural Systems", "R080", "2030-08-01", "Research on the impact of invasive species on agricultural systems."),
(81, "Farm-to-Table Supply Chain Management", "R081", "2030-09-01", "Study on improving farm-to-table supply chain efficiency."),
(82, "Agro-tourism and Rural Development", "R082", "2030-10-01", "Research on the role of agro-tourism in promoting rural development."),
(83, "Food Safety Standards and Agricultural Production", "R083", "2030-11-01", "Study on food safety standards in agricultural production."),
(84, "Biopesticides and Organic Farming", "R084", "2030-12-01", "Research on the effectiveness of biopesticides in organic farming systems."),

(85, "Climate Smart Agriculture", "R085", "2031-01-01", "Study on implementing climate-smart agricultural practices."),
(86, "Genetic Diversity and Crop Sustainability", "R086", "2031-02-01", "Research on genetic diversity in crops and its role in sustainability."),
(87, "Agro-chemical Alternatives for Pest Control", "R087", "2031-03-01", "Study on agro-chemical alternatives for controlling pests."),
(88, "Integrated Pest Management for Sustainable Agriculture", "R088", "2031-04-01", "Research on integrated pest management for sustainable agricultural practices."),
(89, "Soil Fertilization and Crop Productivity", "R089", "2031-05-01", "Study on soil fertilization practices to improve crop productivity."),
(90, "Farming Innovations for Food Security", "R090", "2031-06-01", "Research on innovative farming practices to enhance food security."),
(91, "Land Use Patterns and Agricultural Sustainability", "R091", "2031-07-01", "Study on the relationship between land use patterns and agricultural sustainability."),
(92, "Agri-food Systems and Climate Resilience", "R092", "2031-08-01", "Research on the resilience of agri-food systems to climate change."),
(93, "Crop Diseases and Control Methods", "R093", "2031-09-01", "Study on various crop diseases and the most effective control methods."),
(94, "Aquaponics and Sustainable Food Production", "R094", "2031-10-01", "Research on aquaponics systems for sustainable food production."),
(95, "Rural Livelihoods and Climate Change Adaptation", "R095", "2031-11-01", "Study on how rural livelihoods can adapt to climate change."),
(96, "Farm Water Management for Food Security", "R096", "2031-12-01", "Research on managing farm water resources to ensure food security."),
(97, "Soil Erosion and Agricultural Productivity", "R097", "2032-01-01", "Study on soil erosion and its impact on agricultural productivity."),
(98, "Pest Resistance and Crop Protection", "R098", "2032-02-01", "Research on pest resistance mechanisms and their role in crop protection."),
(99, "Precision Agriculture and Technology Integration", "R099", "2032-03-01", "Study on integrating precision agriculture technologies for farm management."),

(100, "Sustainable Food Systems and Rural Development", "R100", "2032-04-01", "Research on building sustainable food systems to promote rural development.");

Resource_usage table
INSERT INTO Resource_usage (Activity_ID, Resource_ID, Resource_Name) VALUES
(1, 1, 'Tractor'),
(2, 3, 'Irrigation Pipes'),
(3, 7, 'Soil Sample Kit'),
(4, 9, 'Labor'),
(5, 11, 'Fertilizer'),
(6, 2, 'Seeds'),
(7, 2, 'Seeder Machine'),
(8, 4, 'Fertilizer'),
(9, 4, 'Spreader'),
(10, 6, 'Harvester'),
(11, 6, 'Transport Truck'),
(12, 14, 'Weed Cutter'),
(13, 14, 'Labor'),
(14, 5, 'Weed Cutter'),
(15, 5, 'Manual Labor'),
(16, 5, 'Protective Gear'),
(17, 10, 'Compost'),
(18, 10, 'Rotavator'),
(19, 10, 'Tractor'),
(20, 13, 'Plow'),
(21, 13, 'Tractor'),
(22, 13, 'Fuel'),
(23, 8, 'Pesticide'),
(24, 8, 'Sprayer Machine'),
(25, 8, 'Protective Gear'),
(26, 8, 'Labor'),
(27, 12, 'Seeds'),
(28, 12, 'Seeder Machine'),

(29, 12, 'Fertilizer'),
(30, 12, 'Water Supply'),
(31, 15, 'Harvester'),
(32, 15, 'Transport Truck'),
(33, 15, 'Labor Support'),
(34, 15, 'Packaging Material'),
(35, 17, 'Water Pump'),
(36, 17, 'Sprinklers'),
(37, 18, 'Soil Sampler'),
(38, 18, 'Test Kit'),
(39, 20, 'Harvester'),
(40, 20, 'Transport Truck'),
(41, 21, 'Weeder'),
(42, 21, 'Labor'),
(43, 23, 'Seeds'),
(44, 23, 'Seeder Machine'),
(45, 24, 'Pesticide'),
(46, 25, 'Plow'),
(47, 26, 'Fertilizer'),
(48, 26, 'Spreader'),
(49, 28, 'Labor'),
(50, 28, 'Truck'),
(51, 29, 'Compost'),
(52, 29, 'Rotavator'),
(53, 29, 'Tractor'),
(54, 32, 'Water Pump'),
(55, 32, 'Sprinklers'),
(56, 32, 'Labor'),
(57, 33, 'Fertilizer'),
(58, 34, 'Weeder'),
(59, 35, 'Harvester'),
(60, 35, 'Truck'),
(61, 37, 'Tester Kit'),
(62, 37, 'Transport'),
(63, 39, 'Sprayer'),

(64, 39, 'Labor'),
(65, 41, 'Rotavator'),
(66, 41, 'Compost'),
(67, 42, 'Fertilizer'),
(68, 42, 'Spreader'),
(69, 44, 'Labor'),
(70, 45, 'Plow'),
(71, 46, 'Irrigation Pump'),
(72, 46, 'Pipes'),
(73, 48, 'Soil Sampler'),
(74, 48, 'Test Kit'),
(75, 49, 'Weeder'),
(76, 50, 'Sprayer'),
(77, 51, 'Water'),
(78, 51, 'Fertilizer'),
(79, 51, 'Labor'),
(80, 52, 'Tractor'),
(81, 52, 'Seeds'),
(82, 52, 'Labor'),
(83, 53, 'Seeder'),
(84, 54, 'Transport'),
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(86, 56, 'Labor'),
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(88, 58, 'Seeder'),
(89, 59, 'Transport'),
(90, 60, 'Rotavator'),
(91, 61, 'Labor'),
(92, 62, 'Compost'),
(93, 63, 'Plow'),
(94, 64, 'Labor'),
(95, 65, 'Water'),
(96, 66, 'Pesticide'),
(97, 67, 'Sprayer'),
(98, 68, 'Transport'),

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(99, 69, 'Seeder Machine'),
(100, 70, 'Compost');

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humidity, wind_speed, observation_date) VALUES
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(3, 1202, 28.70, 8.60, 65.30, 12.10, '2024-10-03'),
(4, 1203, 27.50, 7.40, 80.00, 14.50, '2024-10-04'),
(5, 1204, 26.80, 15.20, 72.80, 13.60, '2024-10-05'),
(6, 1205, 30.10, 10.50, 77.90, 12.30, '2024-10-06'),
(7, 1206, 25.30, 11.80, 68.20, 16.70, '2024-10-07'),
(8, 1207, 29.70, 14.20, 69.50, 10.90, '2024-10-08'),
(9, 1208, 31.50, 9.90, 75.30, 11.20, '2024-10-09'),
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(35, 1234, 30.10, 12.80, 74.00, 10.50, '2024-11-04'),
(36, 1235, 27.00, 13.10, 76.70, 14.20, '2024-11-05'),
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(39, 1238, 30.20, 11.50, 77.40, 14.90, '2024-11-08'),
(40, 1239, 27.90, 13.20, 70.30, 12.30, '2024-11-09'),
(41, 1240, 26.20, 15.00, 72.20, 13.80, '2024-11-10'),
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(49, 1248, 31.60, 14.30, 74.40, 14.40, '2024-11-18'),
(50, 1249, 29.40, 10.80, 69.50, 11.90, '2024-11-19'),
(51, 1250, 27.90, 13.40, 70.90, 10.30, '2024-11-20'),
(52, 1251, 30.90, 15.50, 76.60, 12.60, '2024-11-21'),
(53, 1252, 28.40, 8.70, 68.00, 15.20, '2024-11-22'),
(54, 1253, 30.00, 9.10, 75.00, 12.20, '2024-11-23'),
(55, 1254, 26.90, 13.00, 73.80, 11.10, '2024-11-24'),
(56, 1255, 29.80, 14.60, 70.70, 13.30, '2024-11-25'),
(57, 1256, 28.70, 10.20, 69.00, 14.00, '2024-11-26'),

INSERT INTO Weather_Data (id, station_id, temperature, humidity, pressure, wind_speed, date_recorded) VALUES
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(69, 1268, 31.70, 9.30, 71.60, 13.00, '2024-12-08'),
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(71, 1270, 29.40, 8.70, 68.30, 12.50, '2024-12-10'),
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(74, 1273, 30.20, 9.50, 70.40, 14.90, '2024-12-13'),
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(76, 1275, 29.90, 12.80, 72.90, 10.40, '2024-12-15'),
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(78, 1277, 31.40, 11.90, 71.50, 13.20, '2024-12-17'),
(79, 1278, 29.00, 10.80, 74.50, 15.40, '2024-12-18'),
(80, 1279, 28.90, 12.10, 72.00, 14.70, '2024-12-19');

INSERT INTO Sustainability_Measures (measure_id, farm_id, sustainability_type, implementation_date, effectiveness) VALUES
(1, 1200, 'Soil Erosion Control', '2024-01-15', 'Reduced soil erosion by 30%'),
(2, 1201, 'Water Conservation', '2024-02-10', 'Decreased water usage by 20%'),
(3, 1202, 'Organic Fertilization', '2024-03-12', 'Increased crop yield by 15%'),
(4, 1203, 'Integrated Pest Management', '2024-04-18', 'Reduced pesticide use by 40%'),
(5, 1204, 'Crop Rotation', '2024-05-20', 'Improved soil health'),
(6, 1205, 'Renewable Energy Use', '2024-06-15', 'Saved 200 kWh per month'),

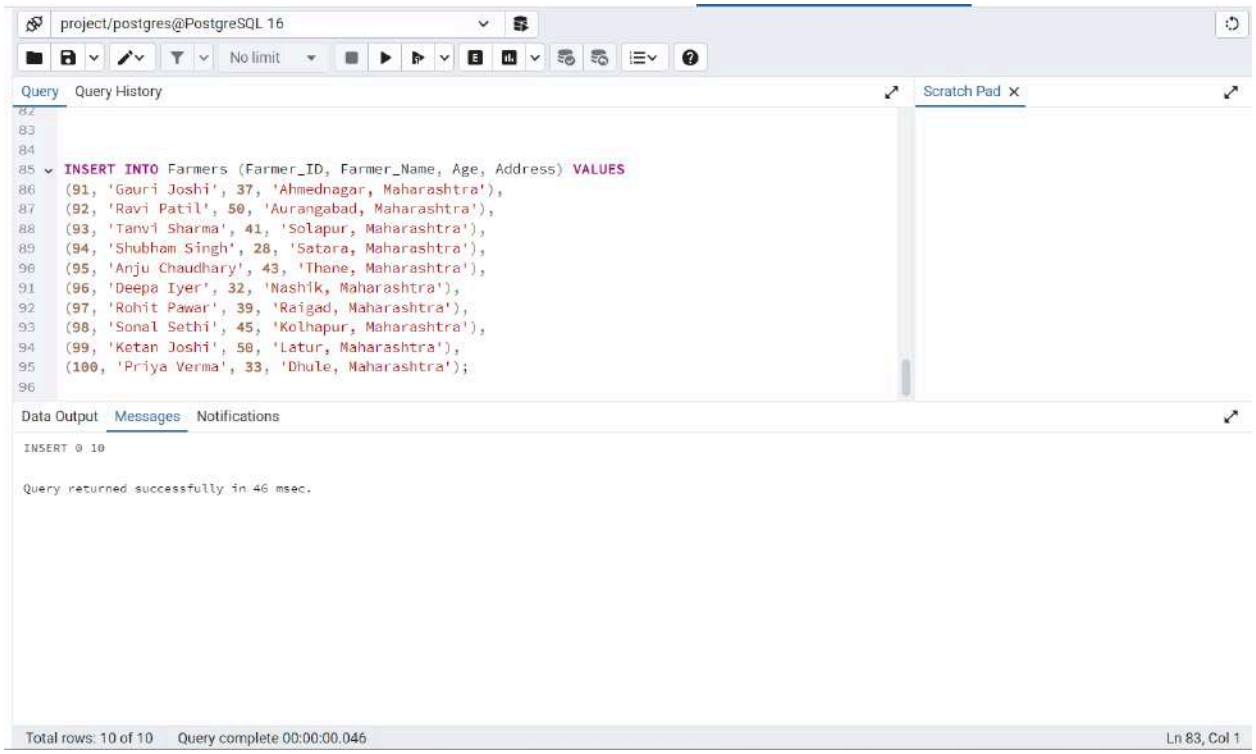
(7, 1206, 'Biodiversity Conservation', '2024-07-10', 'Enhanced local biodiversity'),
(8, 1207, 'Composting', '2024-08-05', 'Reduced waste by 25%'),
(9, 1208, 'Water Harvesting', '2024-09-02', 'Increased water availability'),
(10, 1209, 'No-Till Farming', '2024-10-01', 'Enhanced soil structure and health'),
(11, 1210, 'Cover Cropping', '2024-01-20', 'Improved nutrient cycling'),
(12, 1211, 'Precision Agriculture', '2024-02-25', 'Increased efficiency by 30%'),
(13, 1212, 'Organic Mulching', '2024-03-30', 'Reduced soil moisture loss'),
(14, 1213, 'Pollinator Habitat', '2024-04-10', 'Attracted 50% more pollinators'),
(15, 1214, 'Rainwater Harvesting', '2024-05-15', 'Collected additional 500 liters'),
(16, 1215, 'Solar Energy Adoption', '2024-06-20', 'Reduced energy costs by 25%'),
(17, 1216, 'Agroforestry', '2024-07-25', 'Enhanced ecosystem diversity'),
(18, 1217, 'Perennial Cropping', '2024-08-15', 'Reduced annual planting costs'),
(19, 1218, 'Integrated Weed Management', '2024-09-10', 'Reduced herbicide use by 20%'),
(20, 1219, 'Nutrient Management', '2024-10-20', 'Improved crop growth'),
(21, 1220, 'Reduced Tillage', '2024-11-01', 'Improved soil carbon content'),
(22, 1221, 'Precision Irrigation', '2024-01-10', 'Water savings of 15%'),
(23, 1222, 'Biological Pest Control', '2024-02-05', 'Lowered pesticide costs by 30%'),
(24, 1223, 'Zero-Burning Practice', '2024-03-18', 'Eliminated crop residue burning'),
(25, 1224, 'Fishery Enhancement', '2024-04-15', 'Increased fish stock by 20%'),
(26, 1225, 'Greenhouse Management', '2024-05-25', 'Improved yield in controlled conditions'),
(27, 1226, 'Organic Soil Amendments', '2024-06-10', 'Reduced chemical use by 50%'),

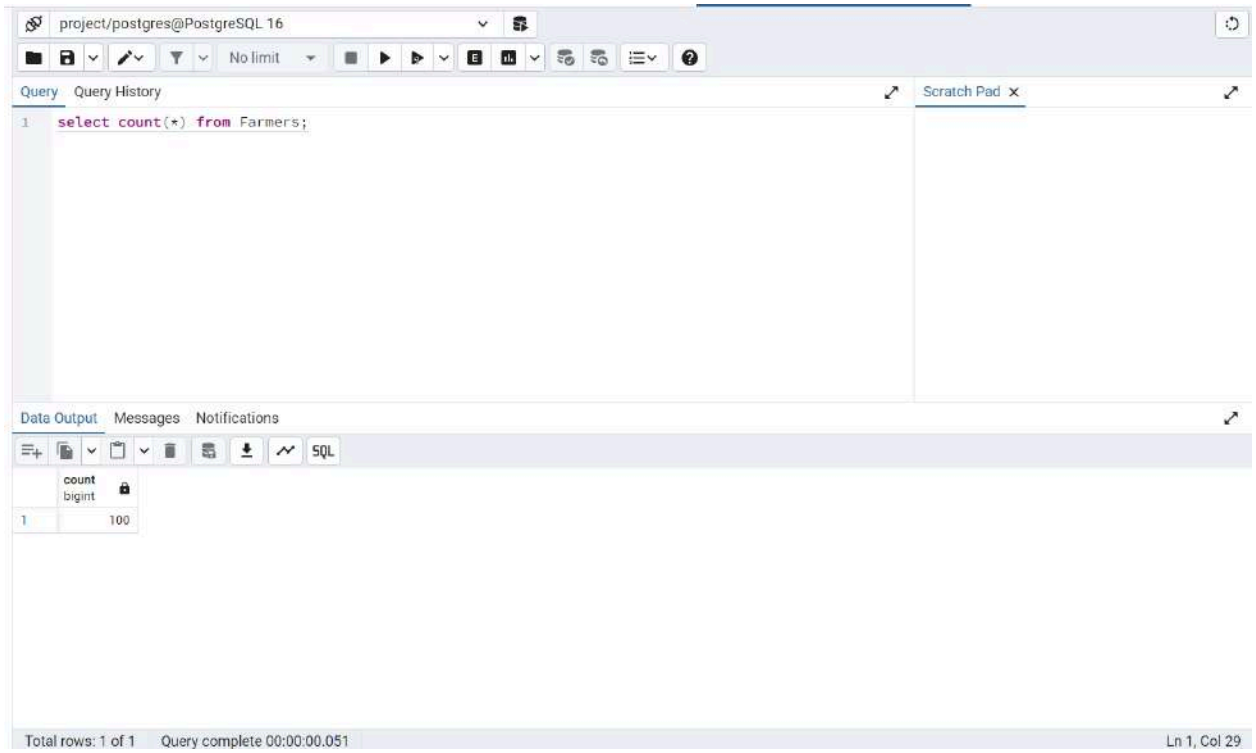
(28, 1227, 'Silvopasture', '2024-07-01', 'Enhanced animal welfare and soil health'),
(29, 1228, 'Soil Fertility Testing', '2024-08-10', 'Optimized fertilizer application'),
(30, 1229, 'Riparian Buffers', '2024-09-20', 'Protected waterways from runoff'),
(31, 1230, 'Vertical Farming', '2024-10-05', 'Increased production per unit area'),
(32, 1231, 'Controlled Release Fertilizer', '2024-11-15', 'Improved nutrient availability'),
(33, 1232, 'Saline Soil Management', '2024-01-25', 'Reduced soil salinity levels'),
(34, 1233, 'Agroecological Practices', '2024-02-20', 'Enhanced natural ecosystem functions'),
(35, 1234, 'Organic Pest Management', '2024-03-25', 'Decreased pest infestation by 25%'),
(36, 1235, 'Soil Moisture Conservation', '2024-04-05', 'Reduced water loss by 10%'),
(37, 1236, 'Eco-Friendly Packaging', '2024-05-18', 'Reduced plastic waste by 60%'),
(38, 1237, 'Rotational Grazing', '2024-06-25', 'Improved pasture health'),
(39, 1238, 'Conservation Buffers', '2024-07-15', 'Reduced erosion near fields'),
(40, 1239, 'Grassland Restoration', '2024-08-25', 'Increased biodiversity by 30%'),
(41, 1240, 'Carbon Sequestration Practices', '2024-09-05', 'Captured 50 tons of CO2'),
(42, 1241, 'Integrated Livestock', '2024-10-15', 'Enhanced farm productivity'),
(43, 1242, 'Renewable Fuel Usage', '2024-11-20', 'Lowered fossil fuel use by 40%'),
(44, 1243, 'Green Manure', '2024-01-18', 'Improved nitrogen content in soil'),
(45, 1244, 'Wind Breaks', '2024-02-15', 'Reduced wind erosion by 50%'),

(46, 1245, 'Rainfed Farming', '2024-03-12', 'Decreased reliance on irrigation'),
(47, 1246, 'Biochar Application', '2024-04-17', 'Improved soil water retention'),
(48, 1247, 'Sustainable Pest Management', '2024-05-08', 'Reduced chemical pesticide use'),
(49, 1248, 'Eco-Friendly Fertilizer', '2024-06-19', 'Enhanced soil quality'),
(50, 1249, 'Pollution Prevention', '2024-07-09', 'Reduced runoff contamination'),
(51, 1250, 'Wildlife Habitat Conservation', '2024-08-12', 'Improved biodiversity by 15%');
INSERT INTO Sustainability_Measures (measure_id, farm_id, sustainability_type, implementation_date, effectiveness)
VALUES
(52, 1251, 'Crop-Livestock Integration', '2024-09-15', 'Improved nutrient cycling on farm'),
(53, 1252, 'Reduced Chemical Inputs', '2024-10-22', 'Lowered input costs by 20%'),
(54, 1253, 'Wind Energy Adoption', '2024-11-08', 'Reduced reliance on grid electricity'),
(55, 1254, 'Water Recycling', '2024-01-22', 'Saved 300 liters of water per day'),
(56, 1255, 'Manure Management', '2024-02-10', 'Enhanced soil organic matter'),
(57, 1256, 'Low-Impact Harvesting', '2024-03-14', 'Minimized soil disturbance'),
(58, 1257, 'Soil Carbon Monitoring', '2024-04-25', 'Increased soil carbon storage'),
(59, 1258, 'Invasive Species Management', '2024-05-07', 'Reduced invasive species by 60%'),
(60, 1259, 'Wildflower Strips', '2024-06-11', 'Boosted pollinator population'),
(61, 1260, 'Nutrient Recycling', '2024-07-22', 'Improved soil fertility'),
(62, 1261, 'Drought-Resistant Crops', '2024-08-09', 'Increased resilience to dry seasons'),
(63, 1262, 'Rotational Cropping', '2024-09-01', 'Enhanced soil nutrients'),

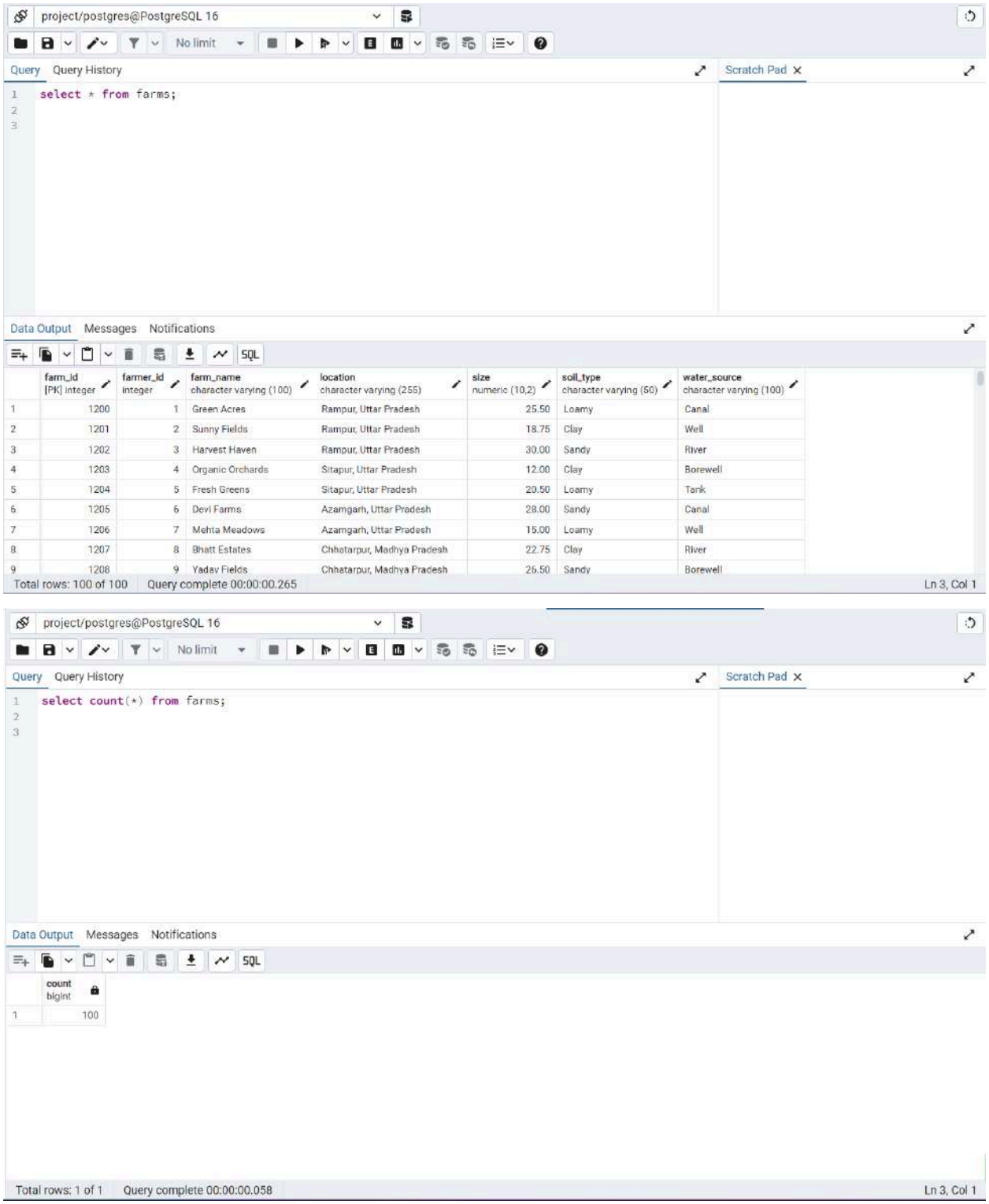
(64, 1263, 'Biodegradable Mulch', '2024-10-12', 'Reduced plastic waste'),
(65, 1264, 'Integrated Soil Fertility', '2024-11-14', 'Improved crop growth rates'),
(66, 1265, 'Natural Pest Predators', '2024-01-30', 'Lowered pest-related crop loss'),
(67, 1266, 'Agroforestry with Crops', '2024-02-17', 'Enhanced shade and soil moisture'),
(68, 1267, 'Compost Application', '2024-03-05', 'Increased organic matter by 15%'),
(69, 1268, 'Efficient Irrigation Systems', '2024-04-09', 'Reduced water usage by 25%'),
(70, 1269, 'Organic Seed Use', '2024-05-13', 'Reduced GMO dependence'),
(71, 1270, 'Reduced Fertilizer Use', '2024-06-24', 'Decreased chemical runoff'),
(72, 1271, 'Ecosystem-Based Management', '2024-07-30', 'Boosted natural ecosystem services'),
(73, 1272, 'Water Filtration Buffers', '2024-08-15', 'Improved water quality'),
(74, 1273, 'Farm Carbon Offsetting', '2024-09-19', 'Offset 100 tons CO2 per year'),
(75, 1274, 'Sustainable Irrigation', '2024-10-20', 'Reduced water loss'),
(76, 1275, 'Energy-Efficient Machinery', '2024-11-21', 'Decreased energy costs'),
(77, 1276, 'Biodynamic Farming', '2024-01-12', 'Enhanced soil vitality'),
(78, 1277, 'Drip Irrigation', '2024-02-28', 'Saved 500 liters of water daily'),
(79, 1278, 'Water Retention Practices', '2024-03-16', 'Improved drought resistance'),
(80, 1279, 'Green Cover Crops', '2024-04-22', 'Reduced erosion during offseason'),
(81, 1280, 'Crop-Livestock Rotations', '2024-05-26', 'Increased soil organic content'),
(82, 1281, 'Conservation Grazing', '2024-06-29', 'Improved pasture biodiversity'),
(83, 1282, 'No-Pesticide Farming', '2024-07-23', 'Improved crop resilience'),
(84, 1283, 'Eco-Ag Practices', '2024-08-19', 'Reduced ecosystem impact'),
(85, 1284, 'Integrated Soil Care', '2024-09-25', 'Enhanced soil texture'),

(86, 1285, 'Recycling Farm Waste', '2024-10-02', 'Reduced waste production'),
(87, 1286, 'Energy-Conserving Equipment', '2024-11-18', 'Lowered energy use by 10%'),
(88, 1287, 'Sustainable Fuel', '2024-01-15', 'Reduced CO2 emissions'),
(89, 1288, 'Eco-Friendly Pest Solutions', '2024-02-14', 'Reduced pesticide residue'),
(90, 1289, 'Agro-Biodiversity Conservation', '2024-03-19', 'Enhanced ecosystem health'),
(91, 1290, 'Wetland Preservation', '2024-04-30', 'Protected natural water sources'),
(92, 1291, 'Low-Emission Machinery', '2024-05-10', 'Lowered carbon footprint'),
(93, 1292, 'Alternative Fertilizers', '2024-06-16', 'Reduced chemical dependence'),
(94, 1293, 'Carbon Footprint Reduction', '2024-07-04', 'Reduced emissions by 20 tons'),
(95, 1294, 'Precision Fertilizer Application', '2024-08-13', 'Lowered fertilizer waste'),
(96, 1295, 'Soil Health Monitoring', '2024-09-26', 'Improved soil pH balance'),
(97, 1296, 'GMO-Free Farming', '2024-10-11', 'Increased organic market value'),
(98, 1297, 'Renewable Electricity', '2024-11-25', 'Powered farm operations sustainably'),
(99, 1298, 'Sustainable Crop Production', '2024-01-28', 'Boosted sustainability metrics'),
(100, 1299, 'Farm Waste Reduction', '2024-02-18', 'Lowered farm waste by 15%');
Farmers table:

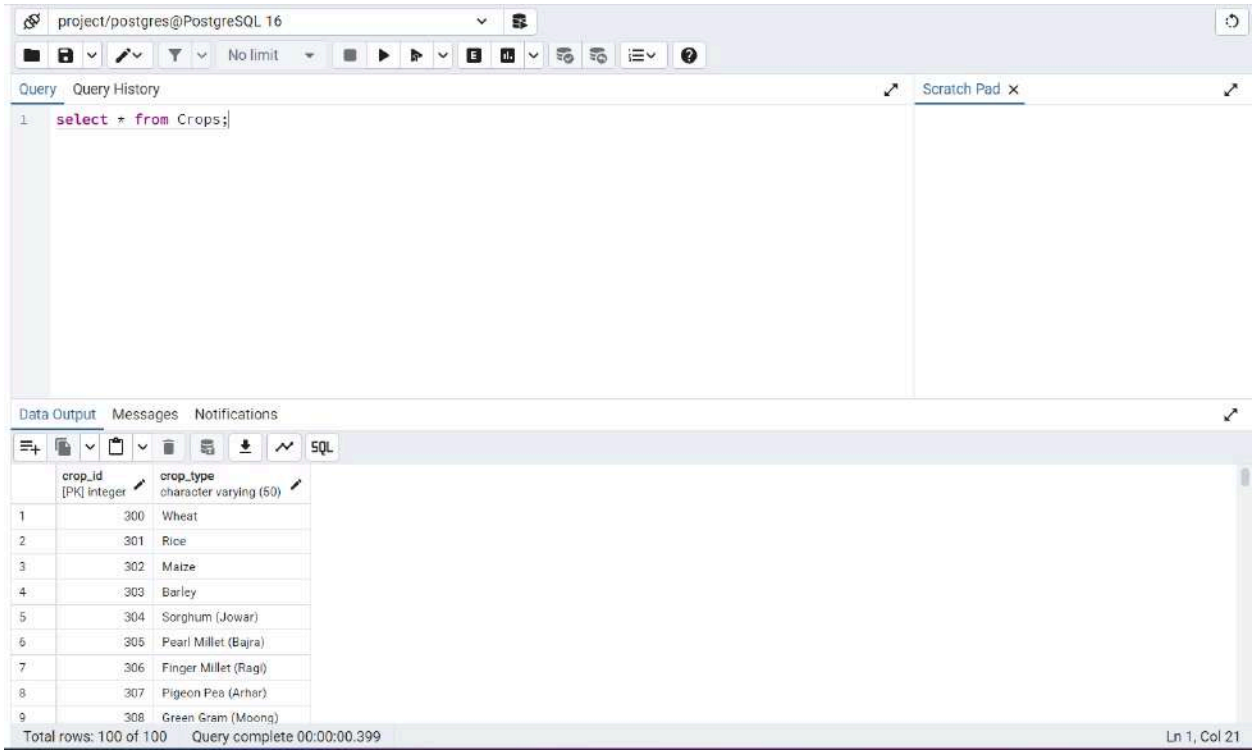


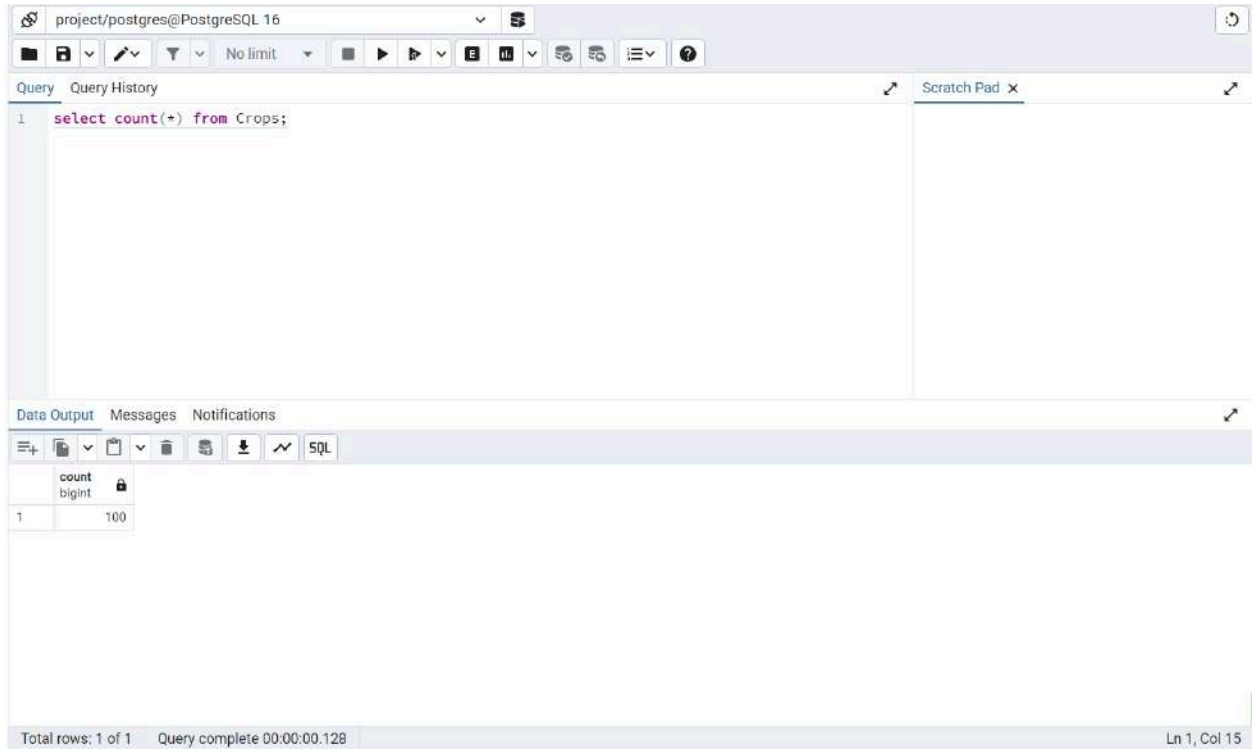


2.Farms table:

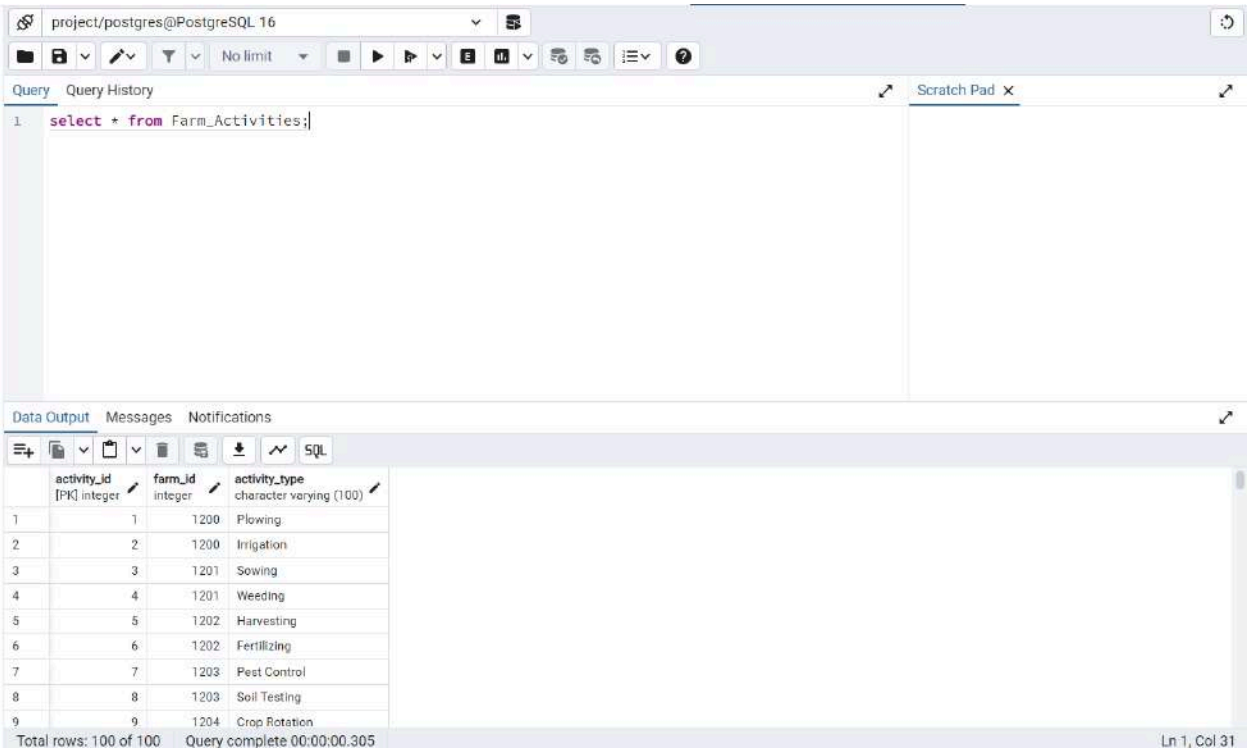


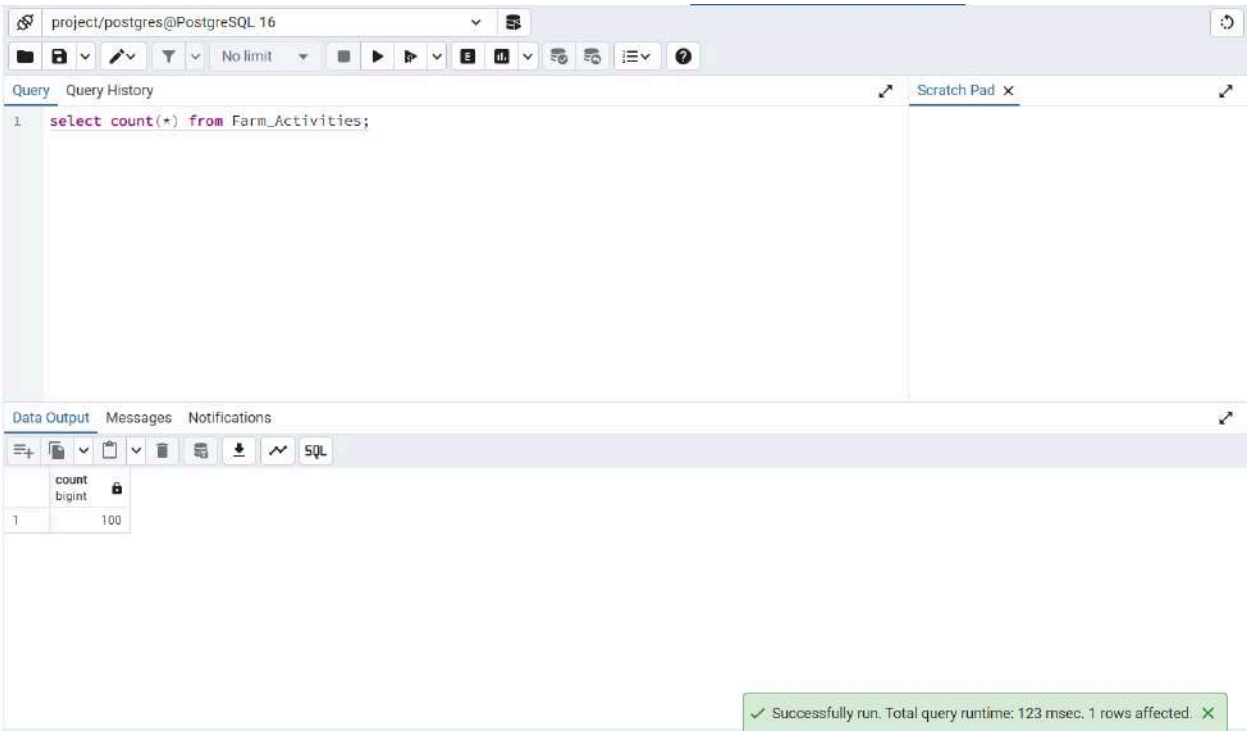
3. Crops table:



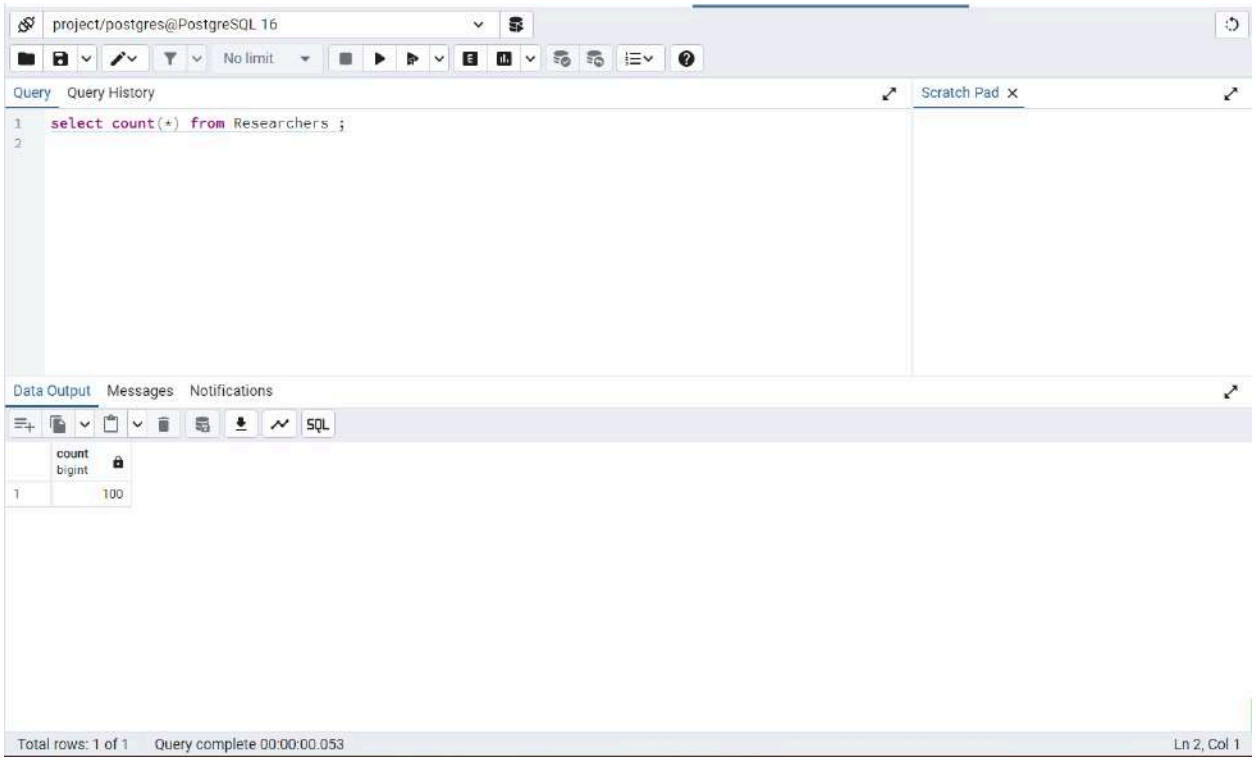


4. Farm_Activities

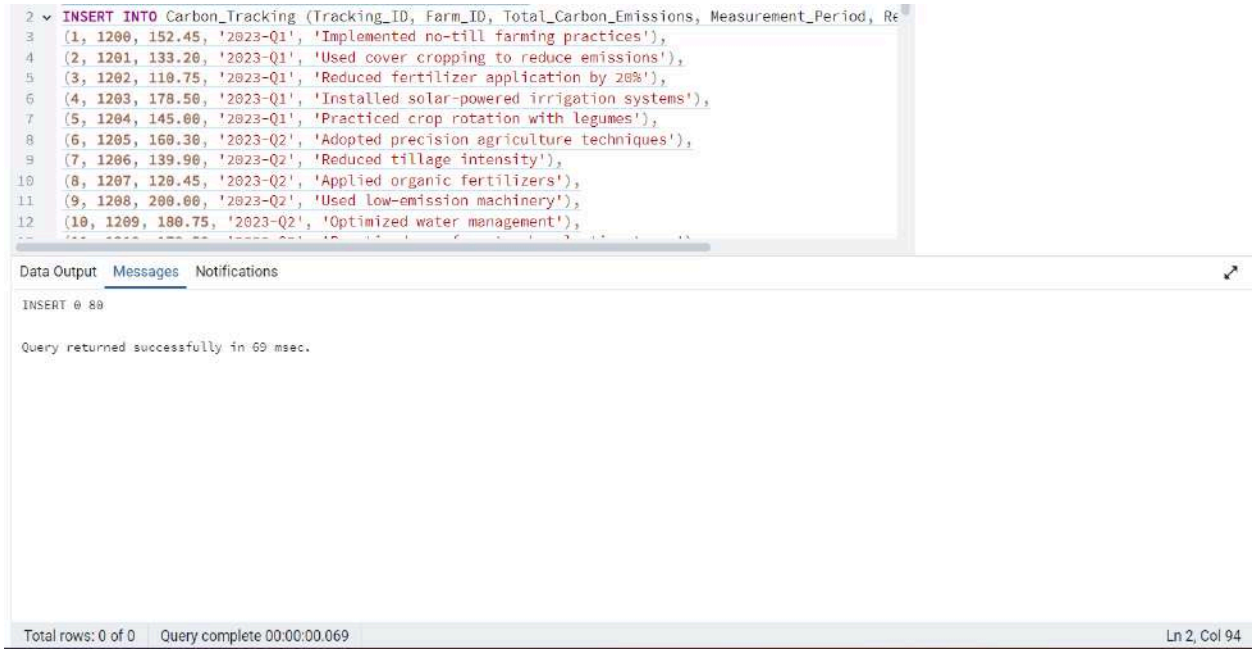


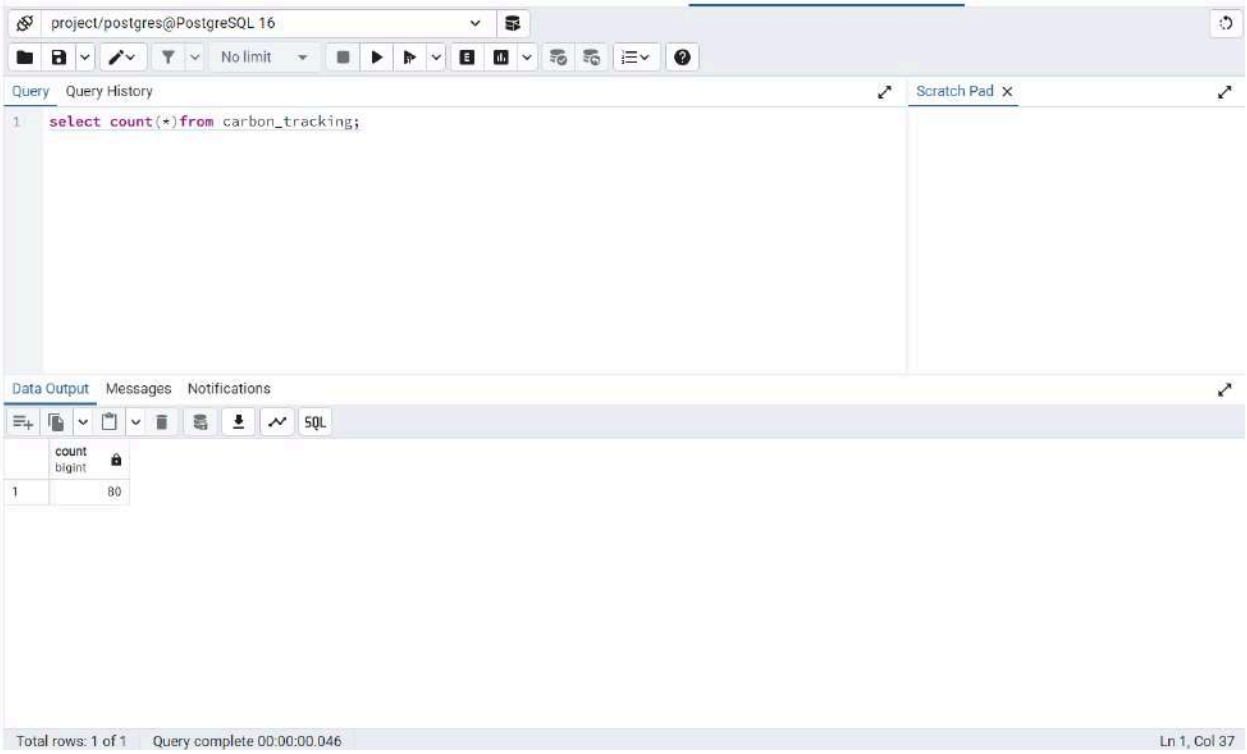


5.Researchers table :

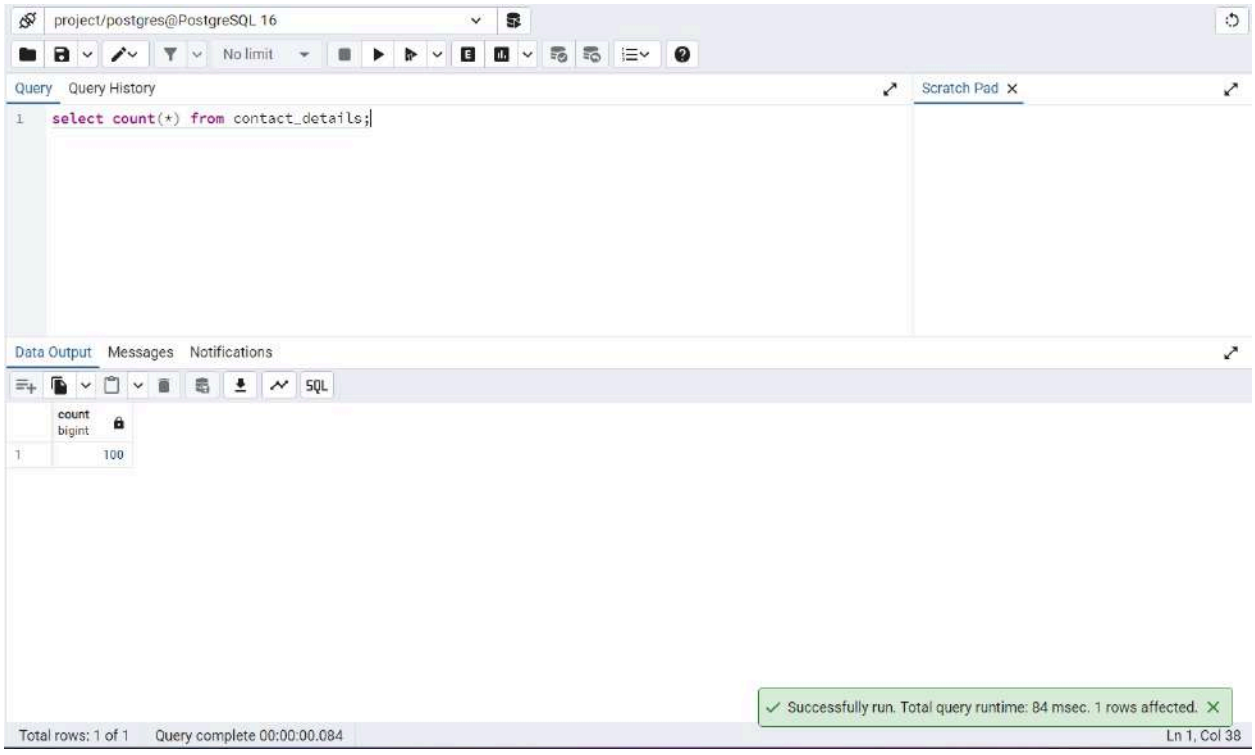


6.Carbon_tracking table

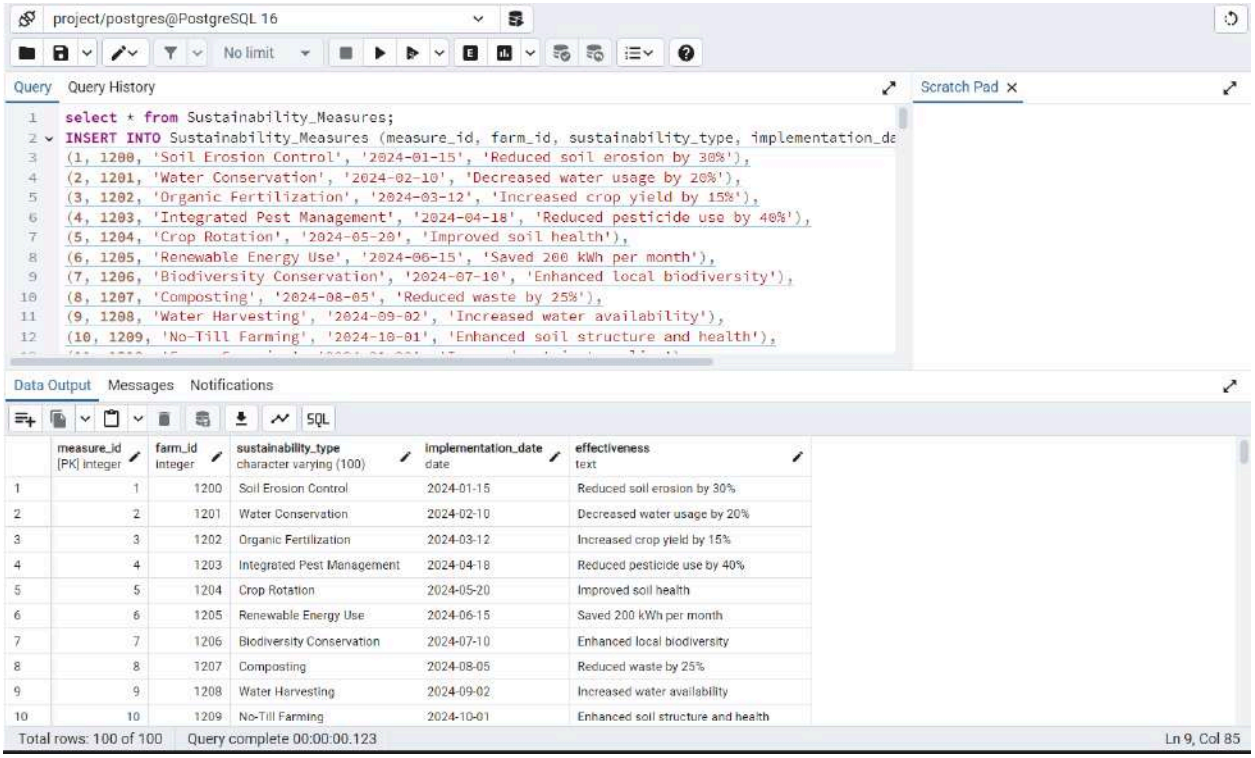


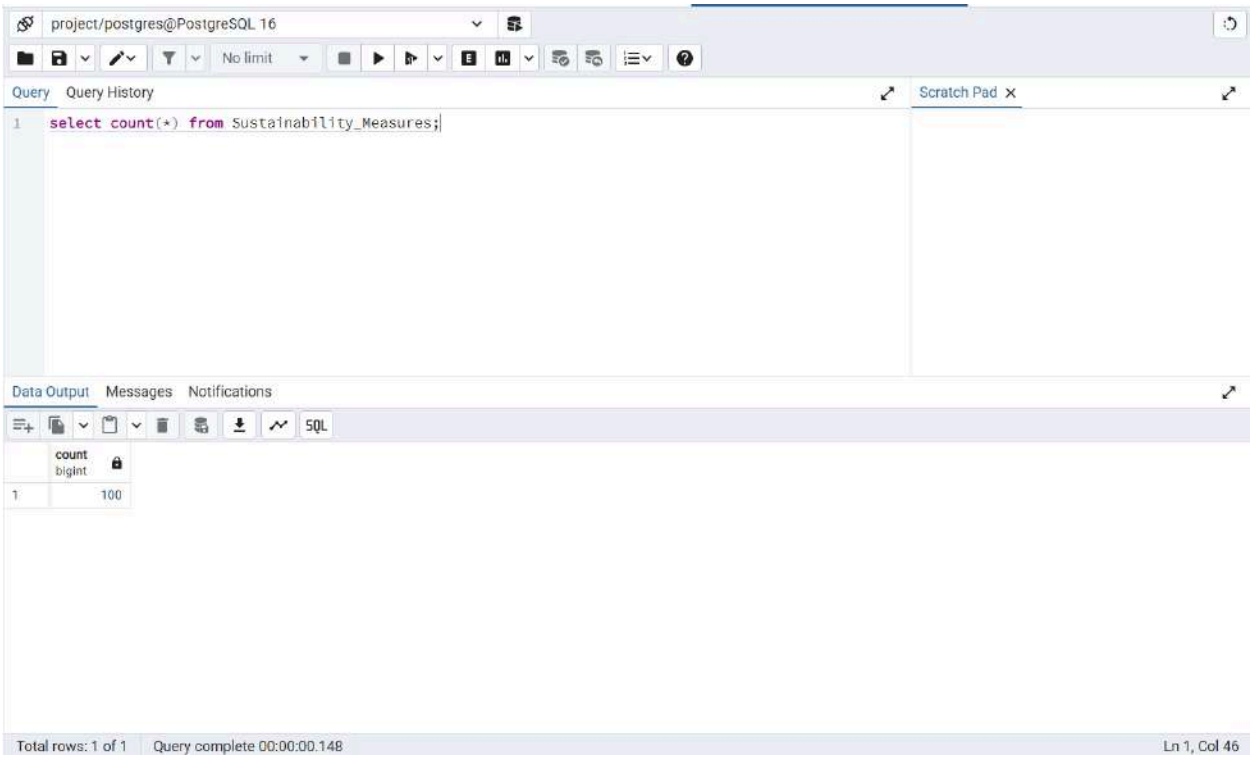


7.Contact_details(farmers)

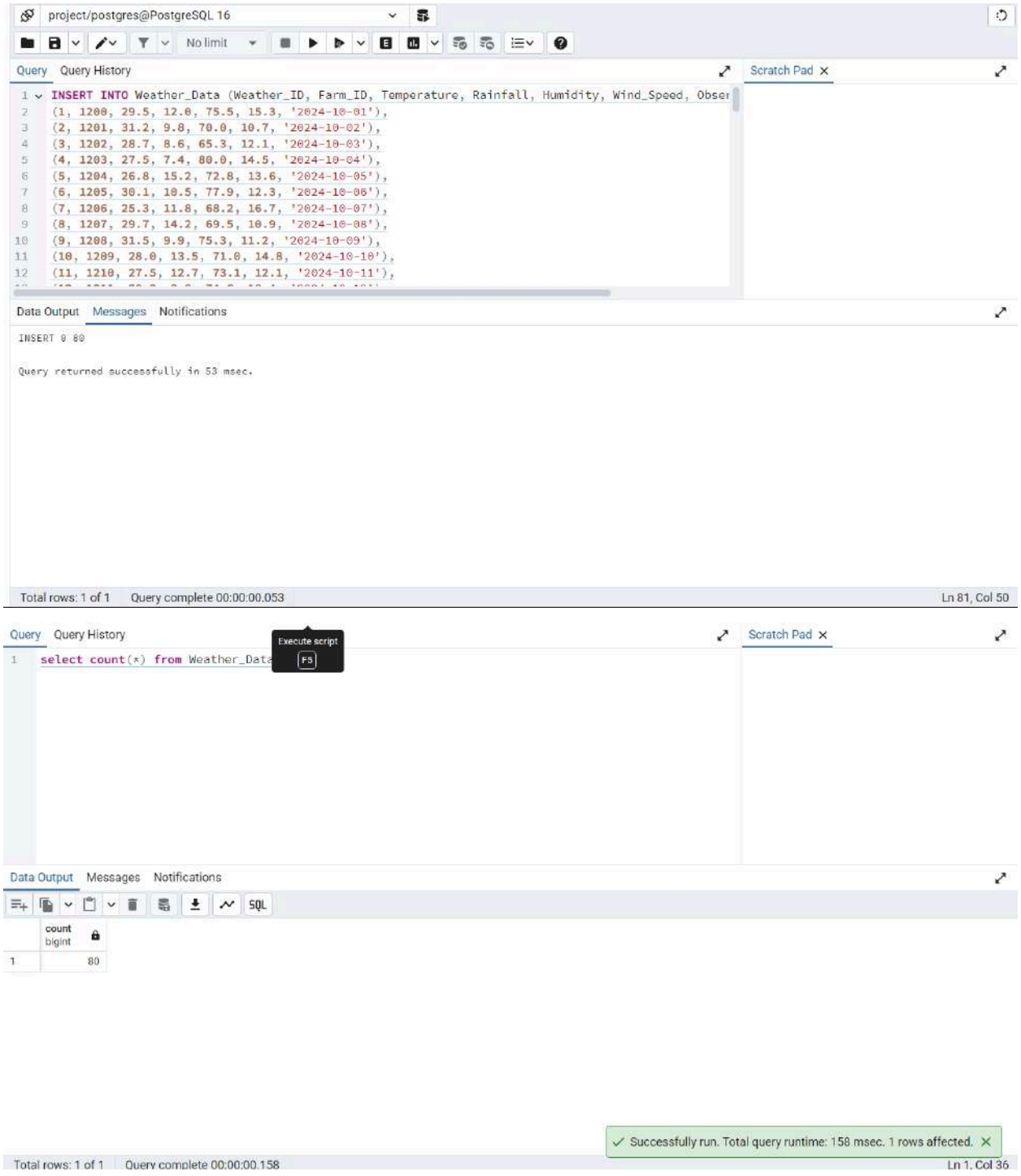


8.Sustainability_Measures

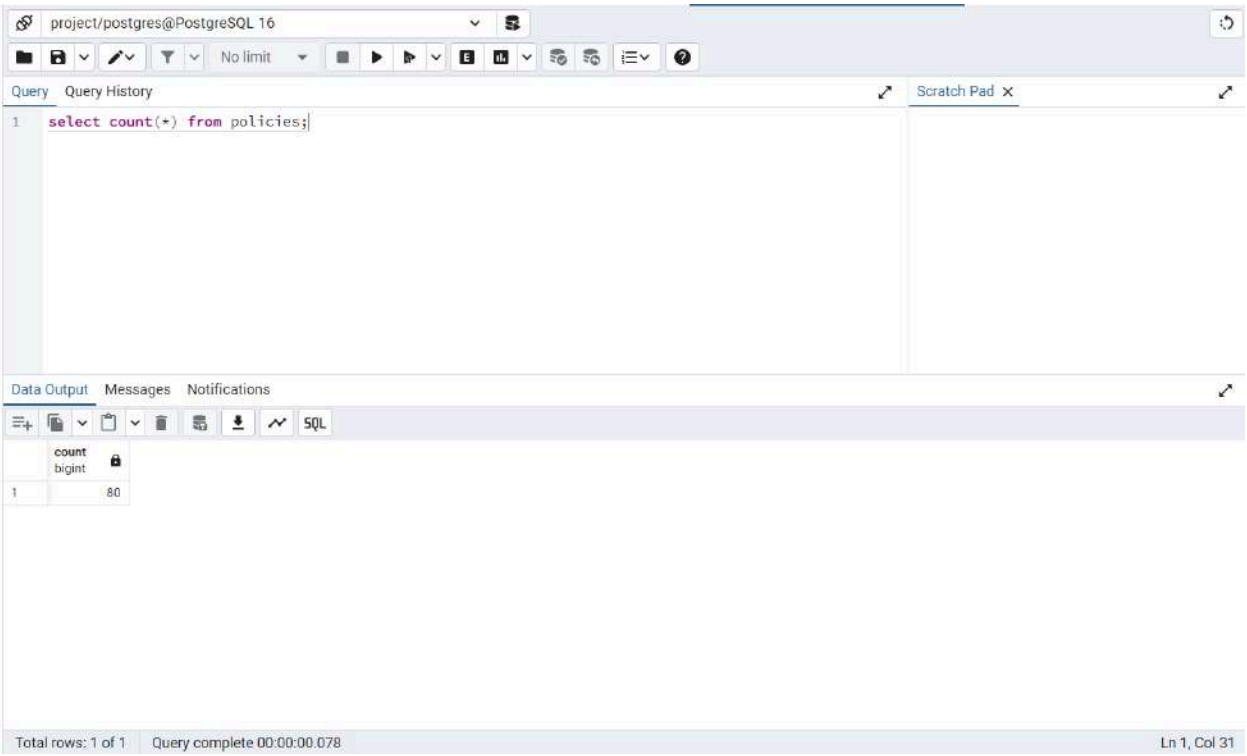




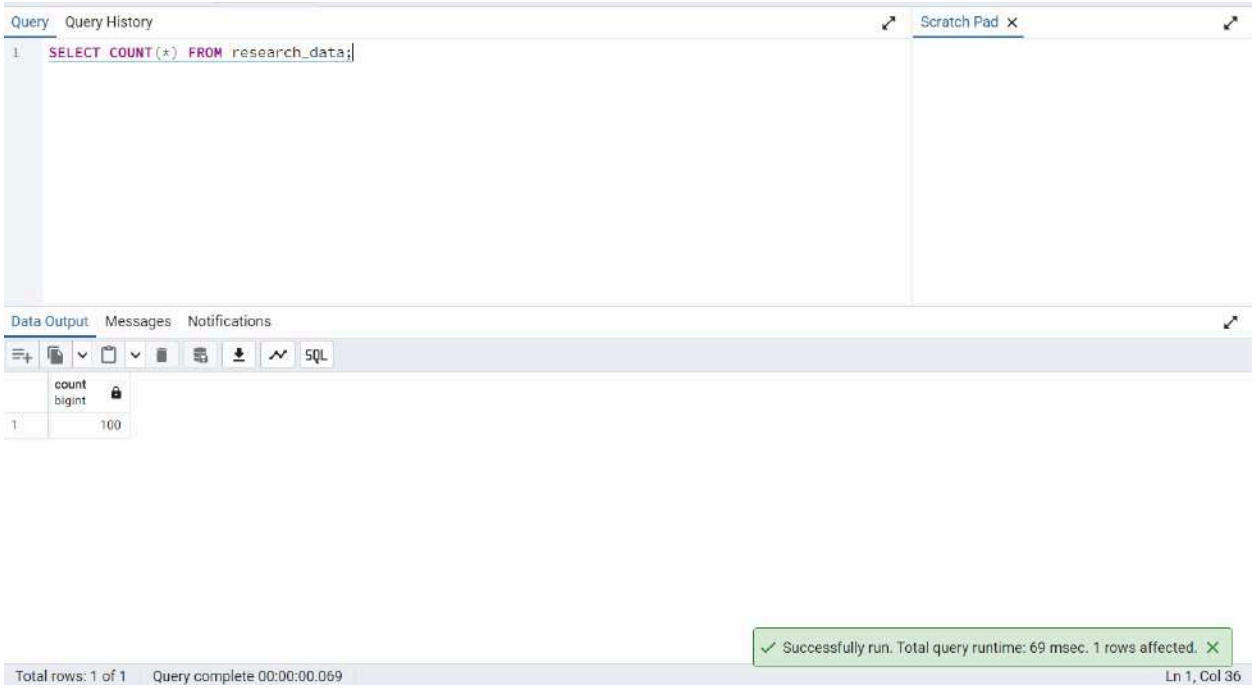
8.Weather_Data



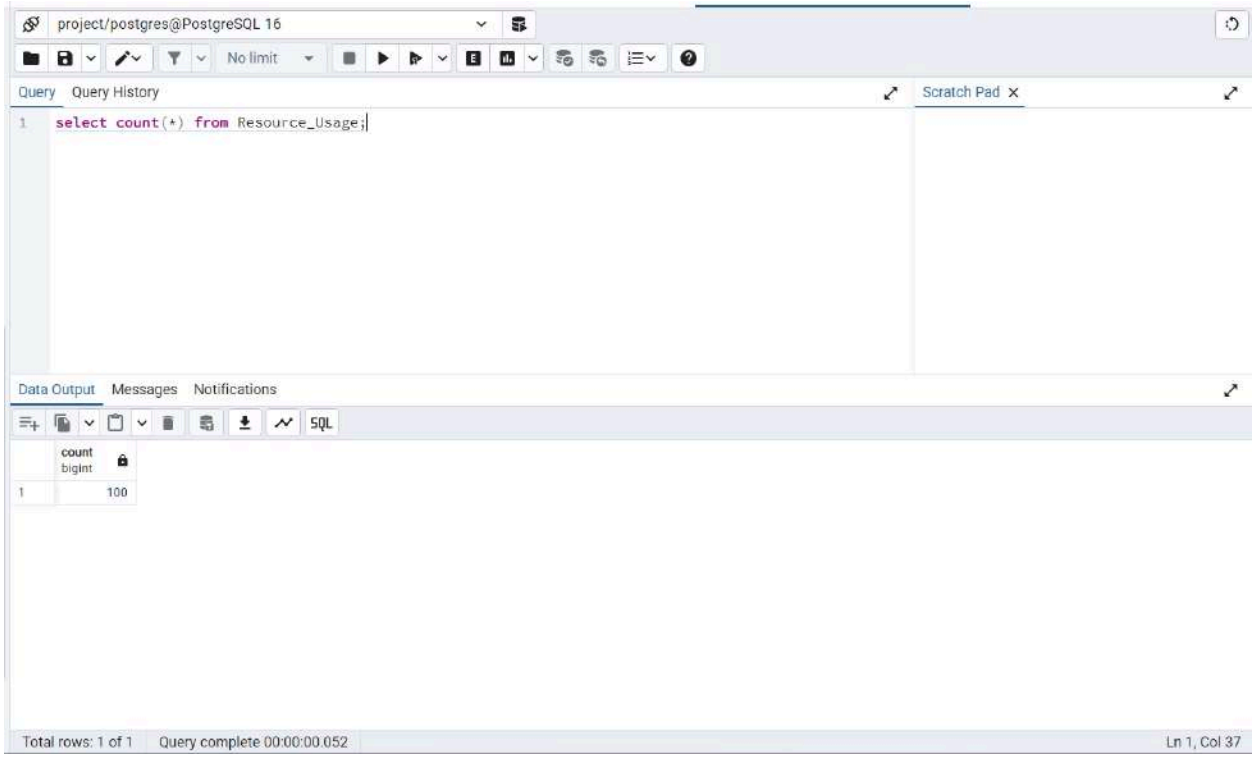
9.Policies table



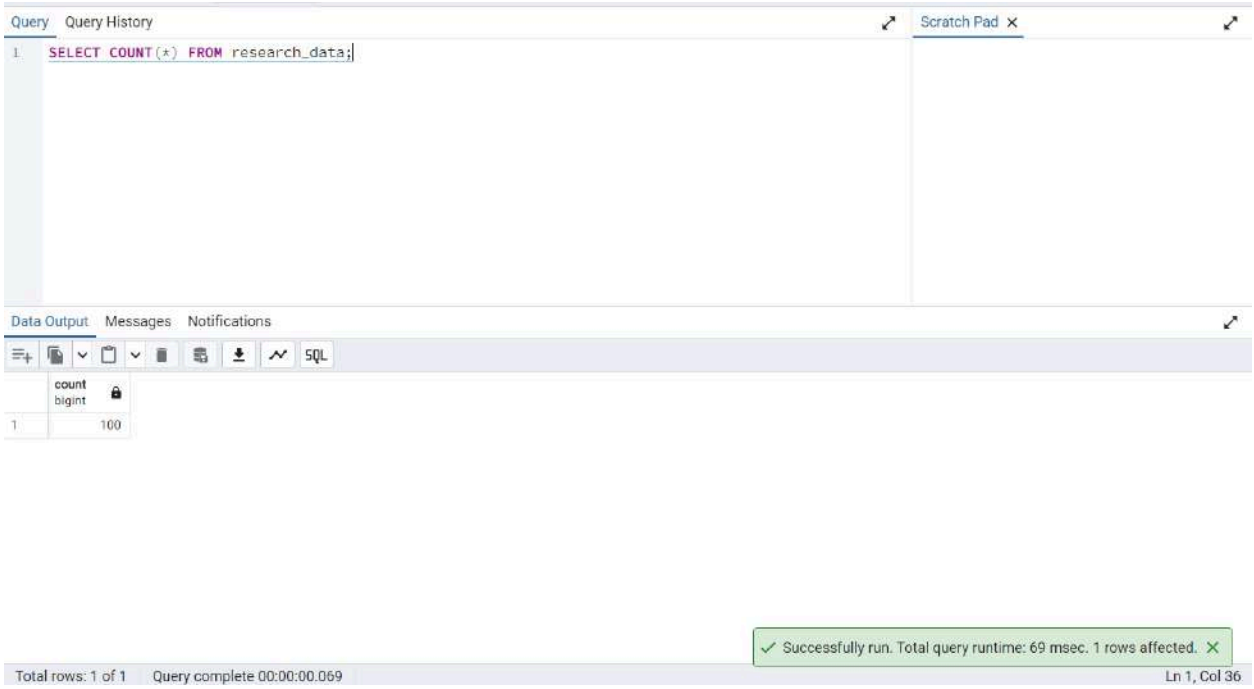
10.Resource usage table :



11.Researchers table :



11.Research_Data



12.Farm_crop table:

```
select * from Farm_Crops;
INSERT INTO Farm_Crops (Farm_Crop_ID, Farm_ID, Crop_ID) VALUES
(1, 1200, 300),
(2, 1234, 300),
(3, 1278, 300),
(4, 1288, 300),
(5, 1223, 300),
(6, 1214, 312),
(7, 1234, 312),
(8, 1200, 312),
(9, 1213, 312),
(10, 1284, 312),
(11, 1212, 312),
```

	farm_crop_id [PK] integer	farm_id integer	crop_id integer
1	1	1200	300
2	2	1234	300
3	3	1278	300
4	4	1288	300
5	5	1223	300
6	6	1214	312
7	7	1234	312
8	8	1200	312
9	9	1213	312
10	10	1284	312

```
select count(*) from Farm_Crops;
```

	count bigint
1	100

Total rows: 1 of 1 Query complete 00:00:00.098 Ln 2, Col 1

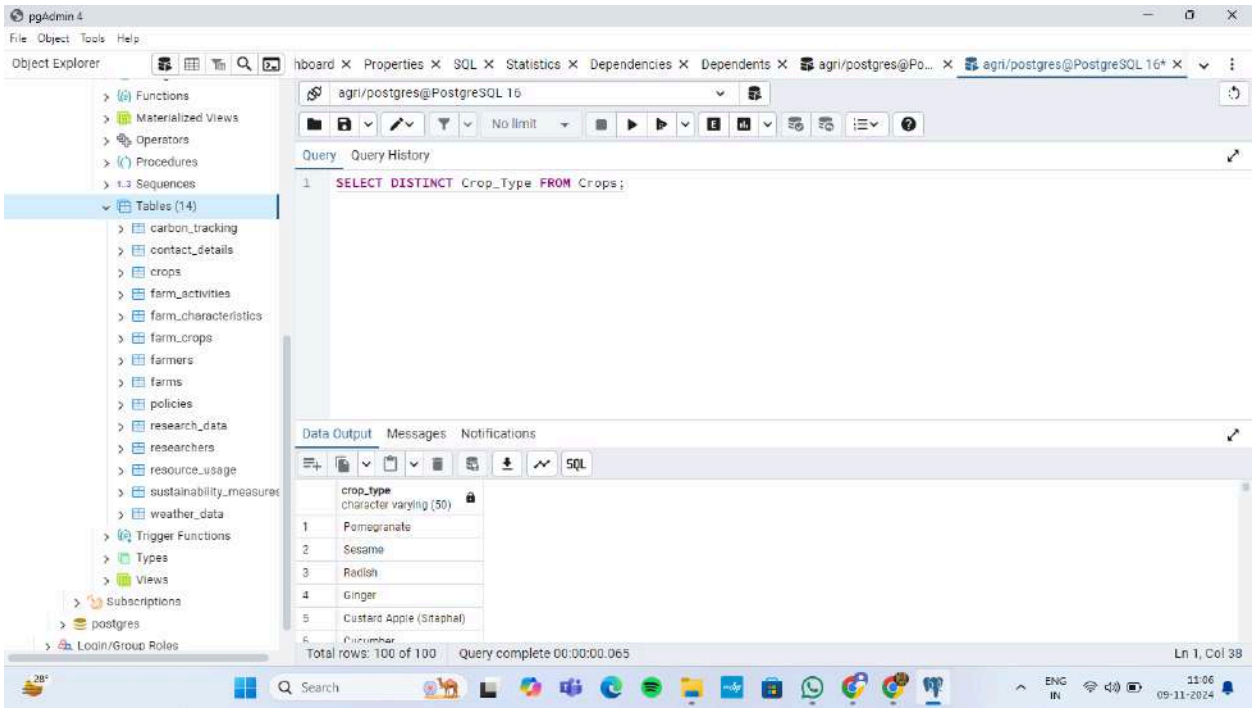
4.3 SQL Queries

List of Simple and Complex Queries

SIMPLE 20 QUERIES

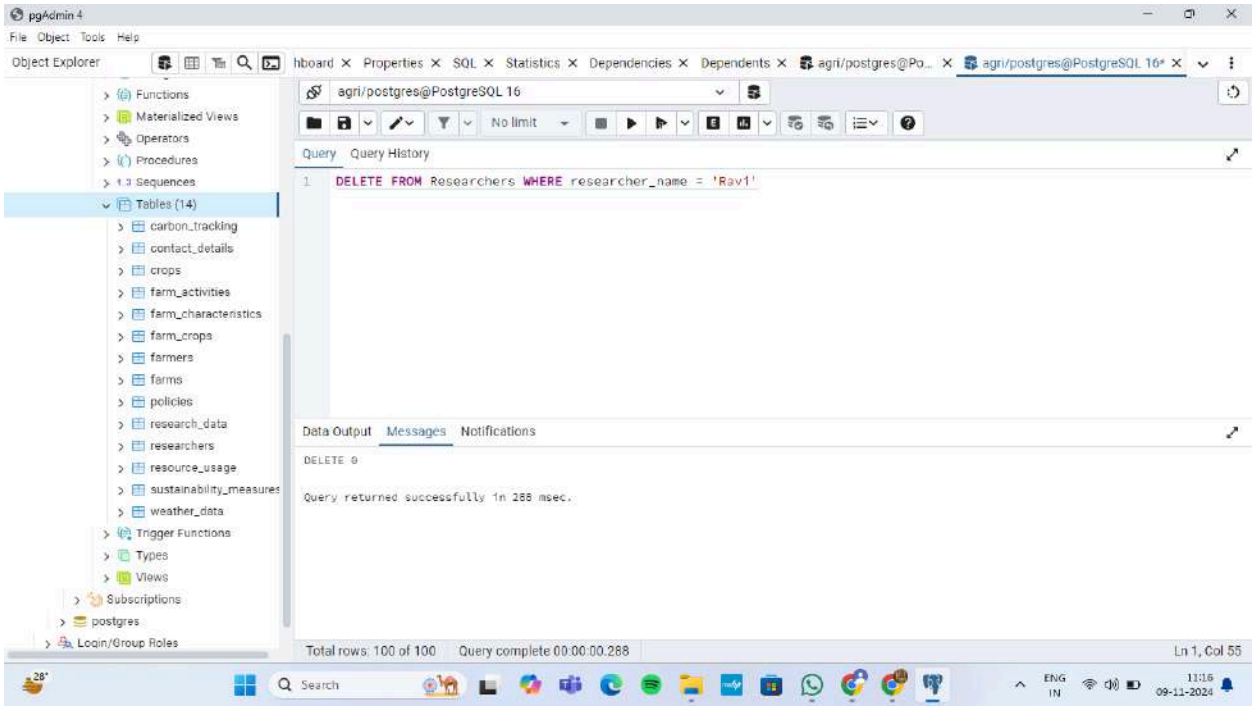
1) Problem: Retrieve unique crop types.

Query: `SELECT DISTINCT Crop_Type FROM Crops;`



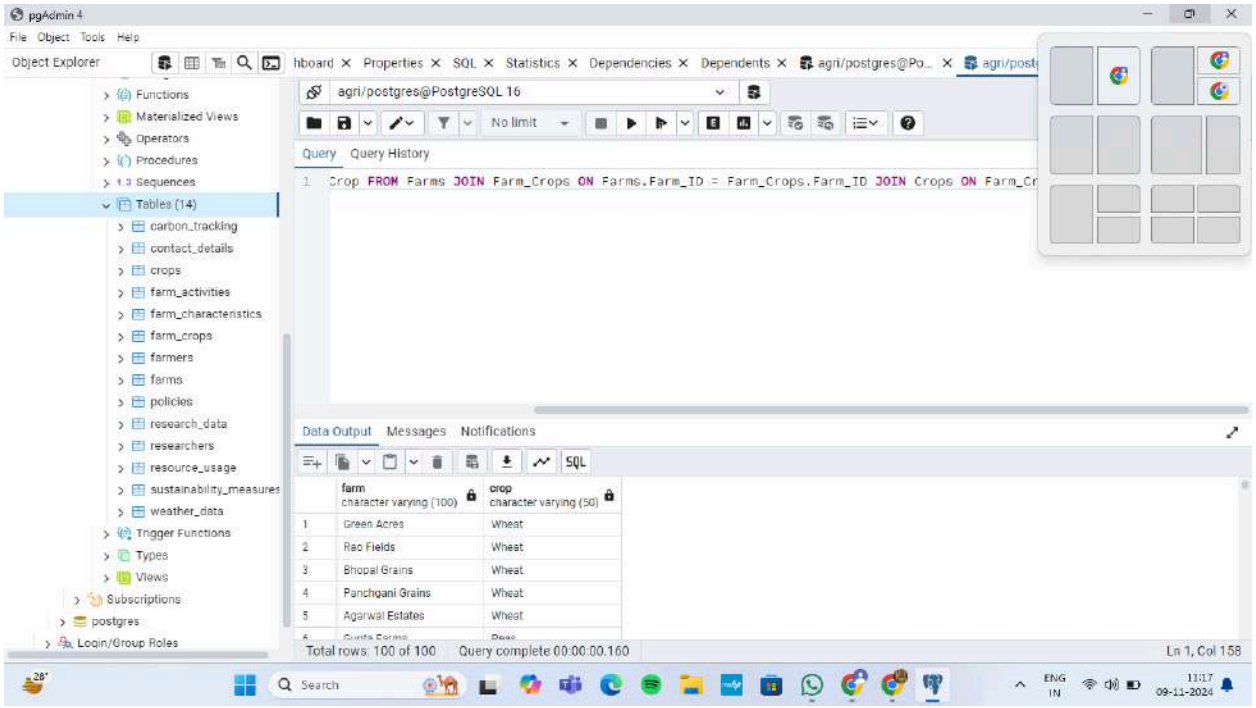
2) Problem: Delete data of any researcher with the name "Ravi".

Query: `DELETE FROM Researchers WHERE researcher_name = 'Ravi';`



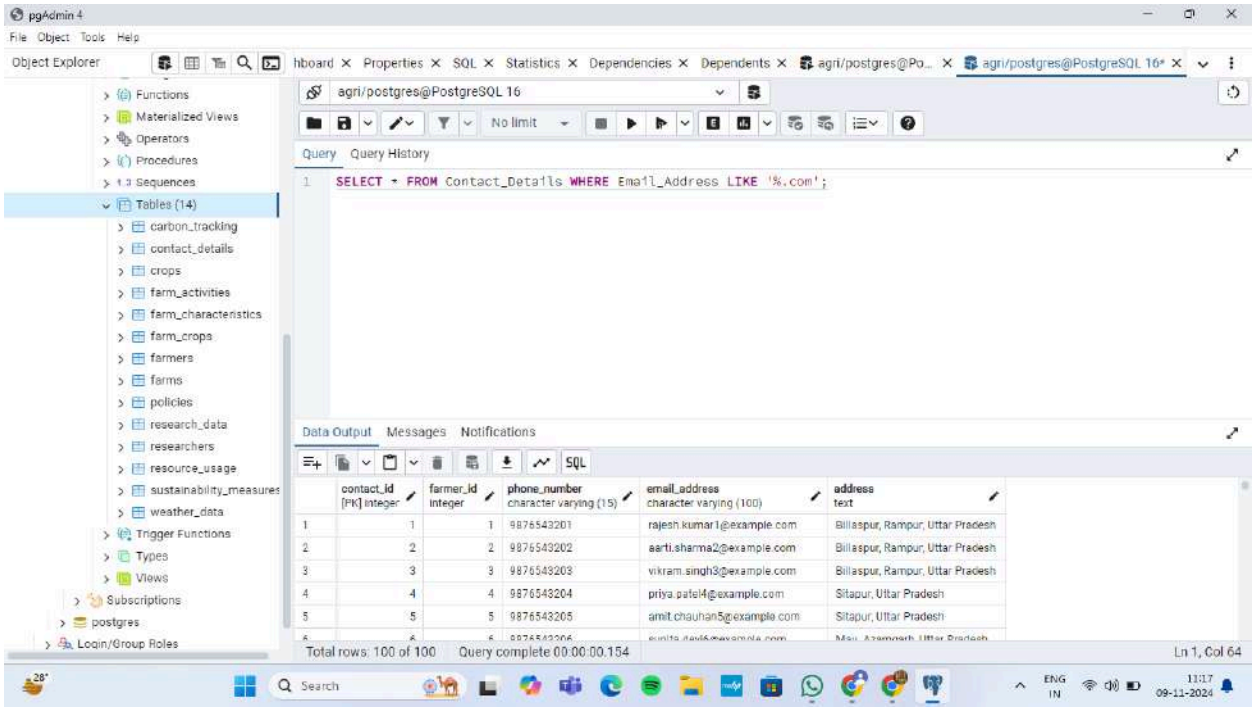
3) Problem: Show farm names and crop types for all farms with an alias for column names.

Query: `SELECT Farm_Name AS Farm, Crop_Type AS Crop FROM Farms JOIN Farm_Crops ON Farms.Farm_ID = Farm_Crops.Farm_ID JOIN Crops ON Farm_Crops.Crop_ID = Crops.Crop_ID;`



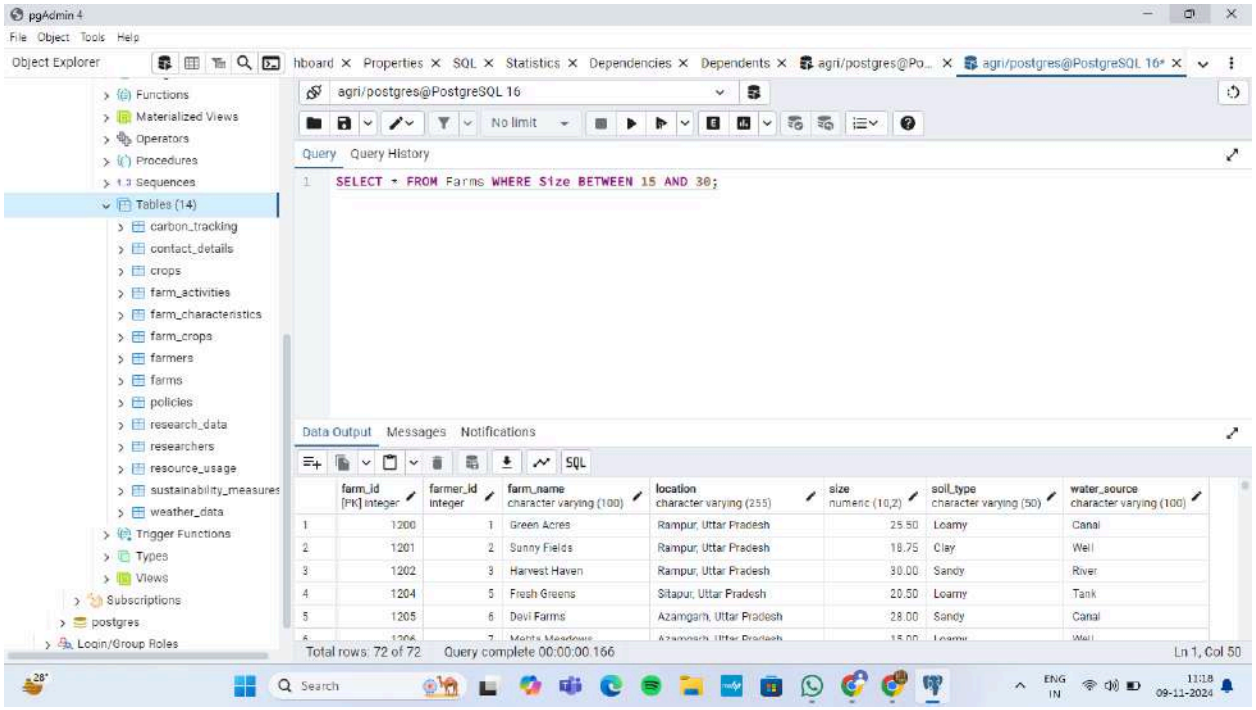
4) Problem: Retrieve contact details that have an email address ending with ".com".

Query: `SELECT * FROM Contact_Details WHERE Email_Address LIKE '%.com';`



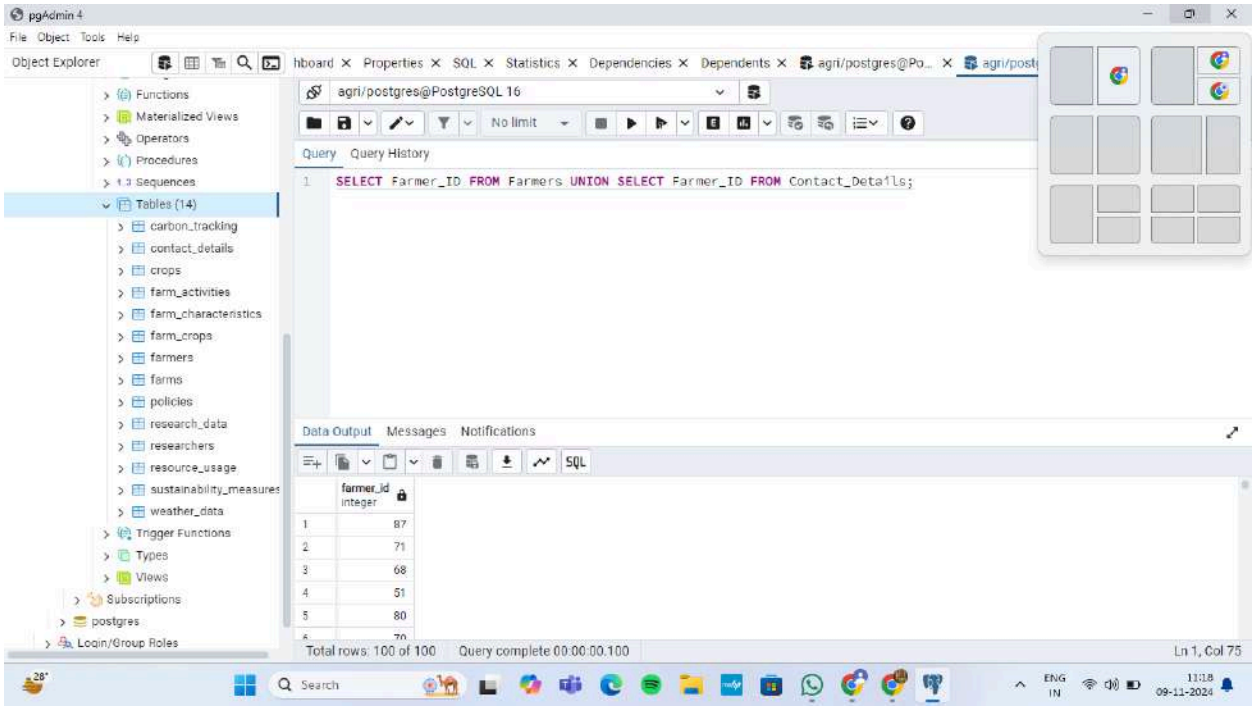
5) Problem: List farms that are between 15 and 30 acres in size.

Query: `SELECT * FROM Farms WHERE Size BETWEEN 15 AND 30;`



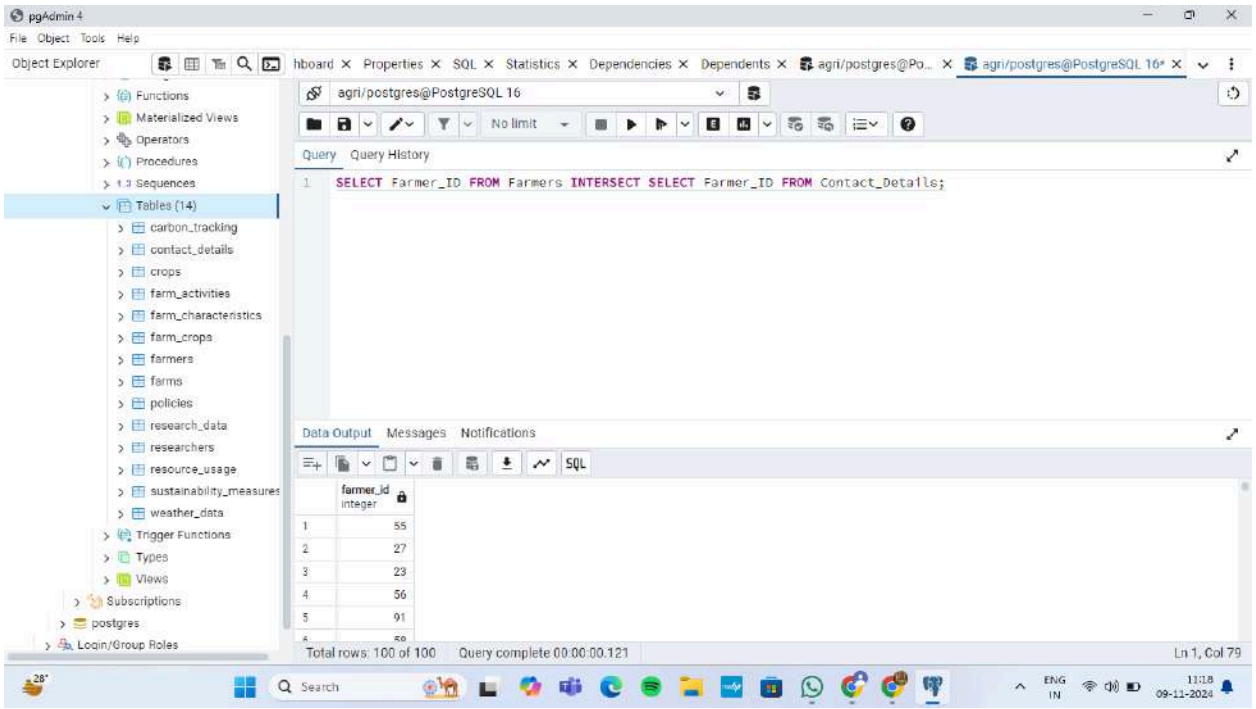
6) Problem: Combine Farmer_IDs from Farmers and Contact_Details tables.

Query: `SELECT Farmer_ID FROM Farmers UNION SELECT Farmer_ID FROM Contact_Details;`



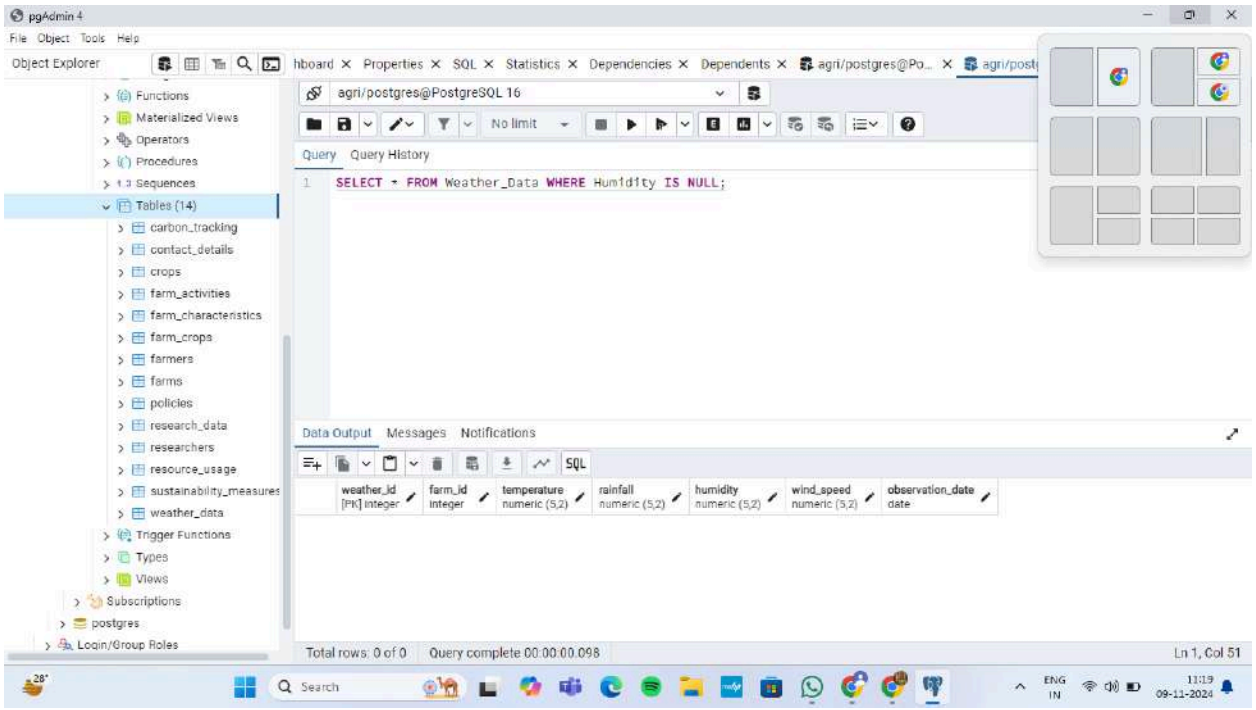
7) Problem: Get the intersection of Farmer_IDs between Farmers and Contact_Details tables.

Query: `SELECT Farmer_ID FROM Farmers INTERSECT SELECT Farmer_ID FROM Contact_Details;`



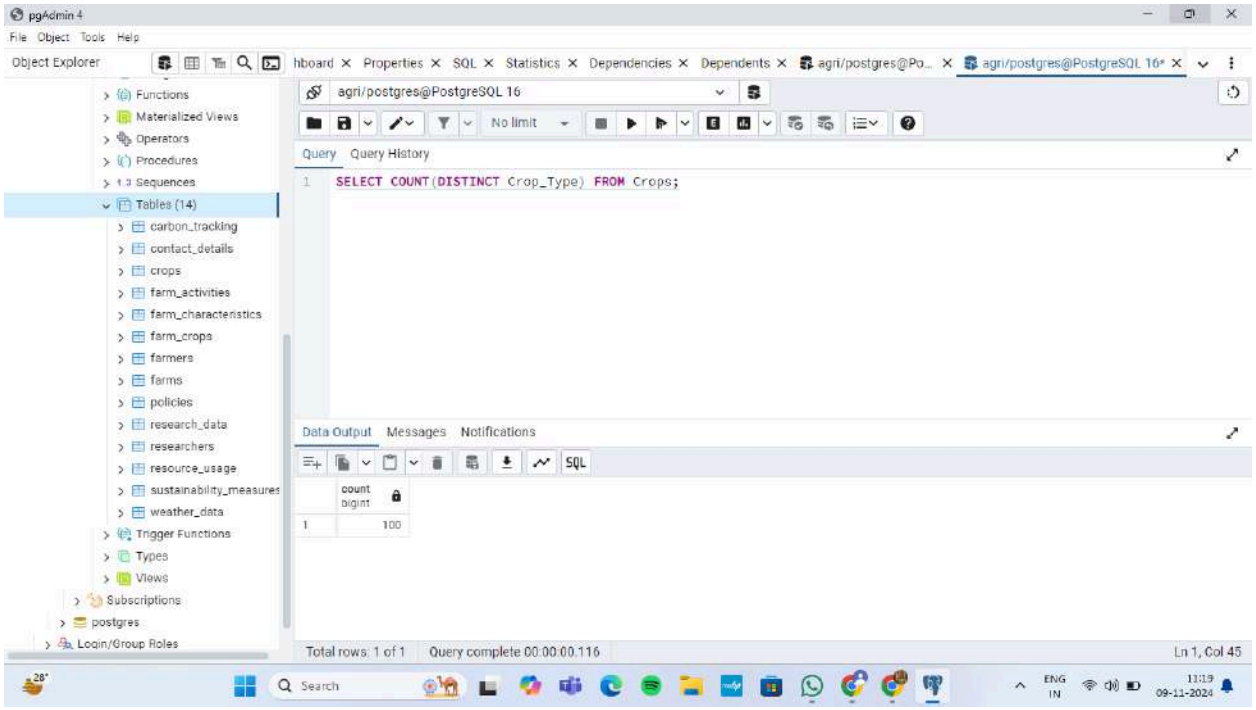
8) Problem: Retrieve weather data with NULL values in Humidity.

Query: `SELECT * FROM Weather_Data WHERE Humidity IS NULL;`



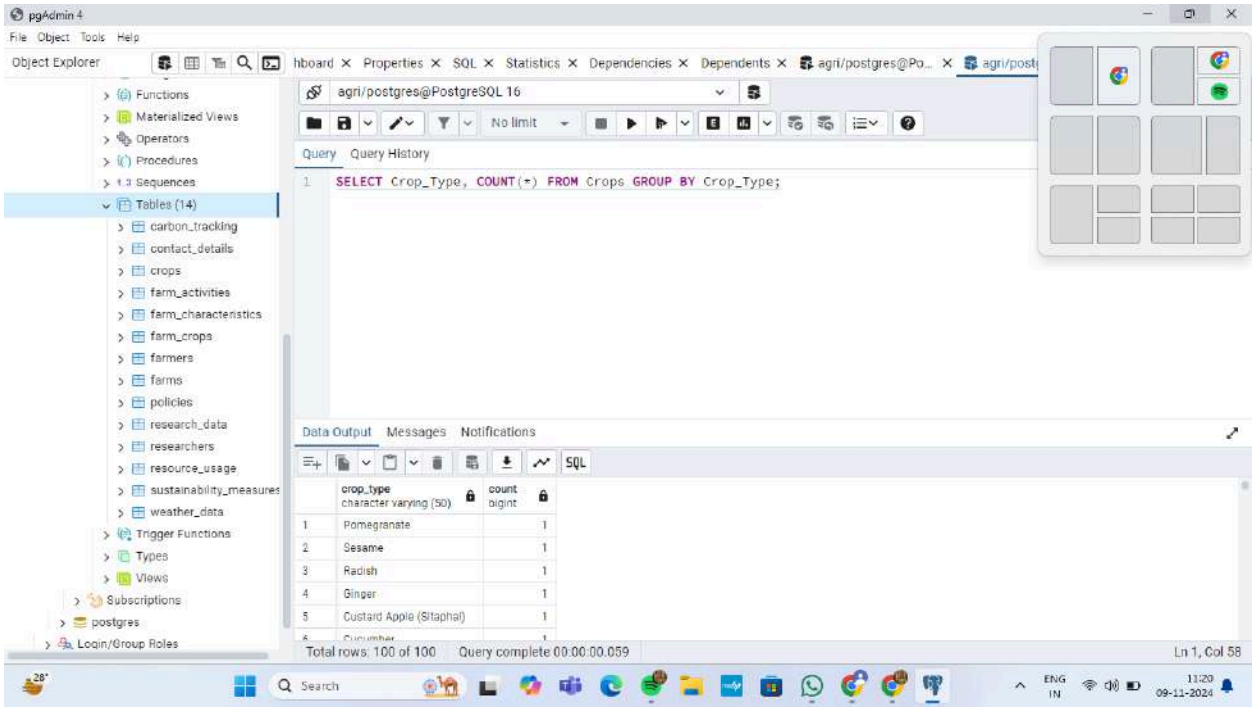
9) Problem: Count the number of unique crop types.

Query: `SELECT COUNT(DISTINCT Crop_Type) FROM Crops;`



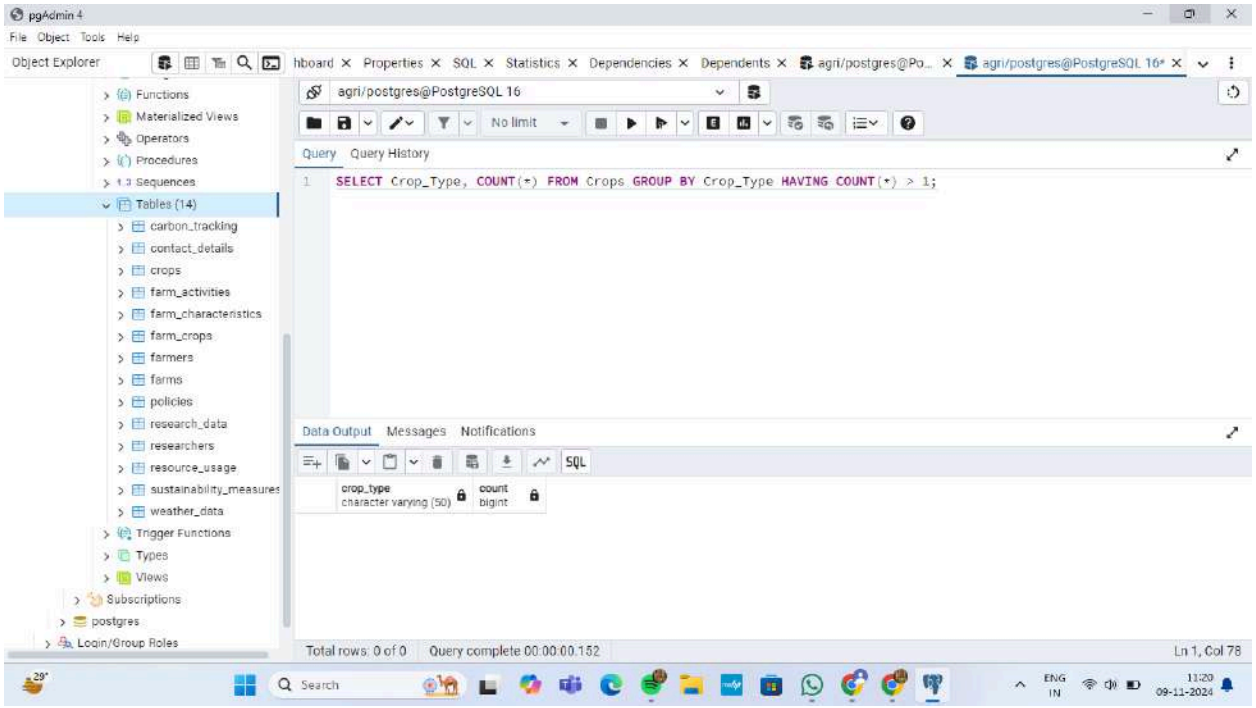
10) Problem: Group crops by type and count each group.

Query: `SELECT Crop_Type, COUNT(*) FROM Crops GROUP BY Crop_Type;`

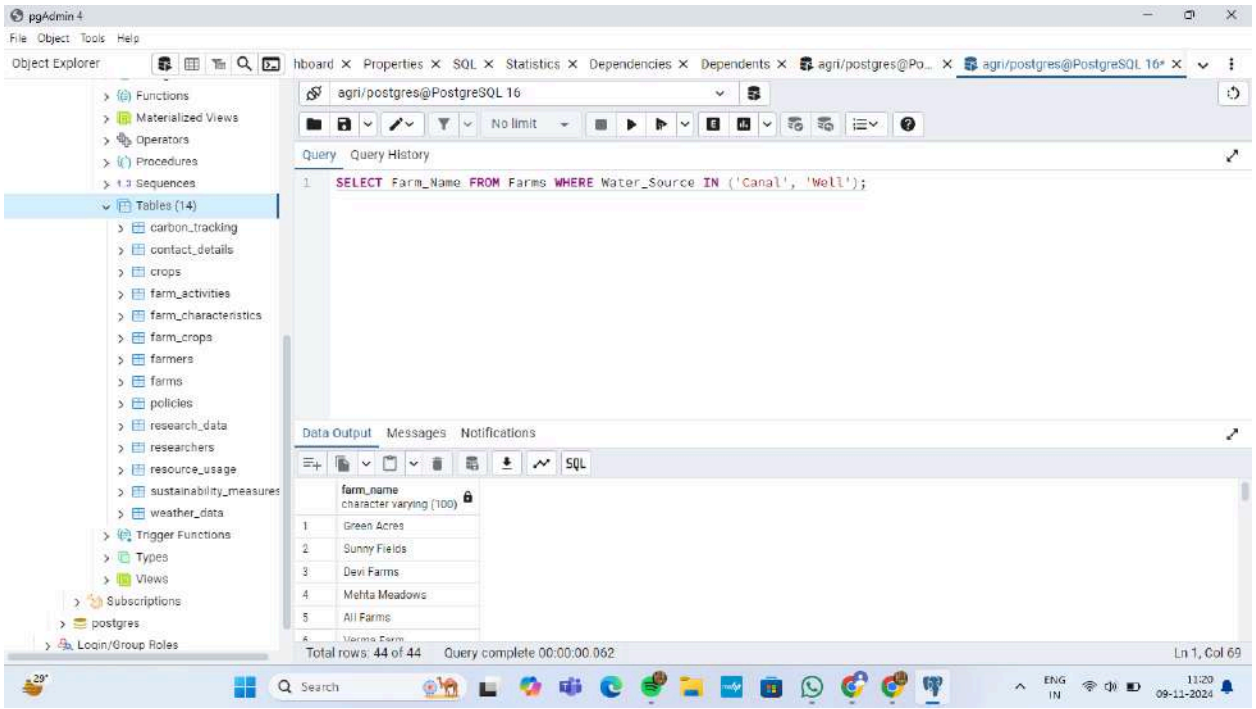


11) Problem: Find crop types that have more than one entry.

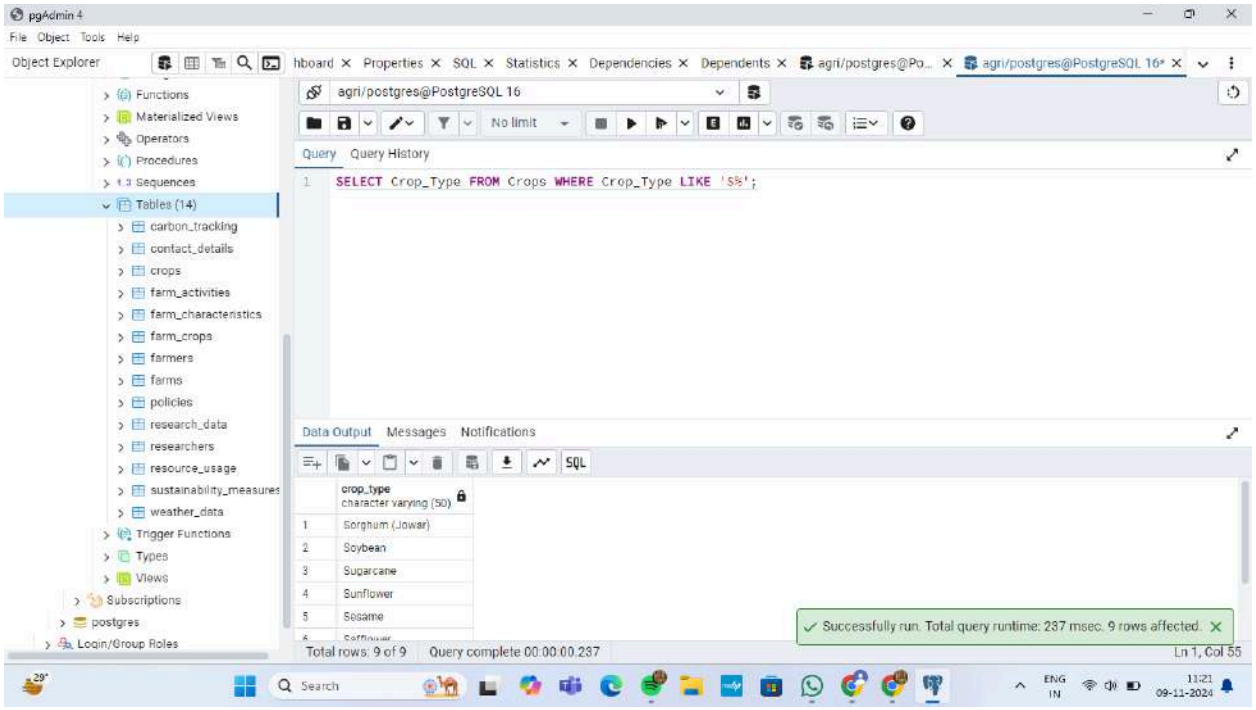
Query: `SELECT Crop_Type, COUNT(*) FROM Crops GROUP BY Crop_Type HAVING COUNT(*) > 1;`



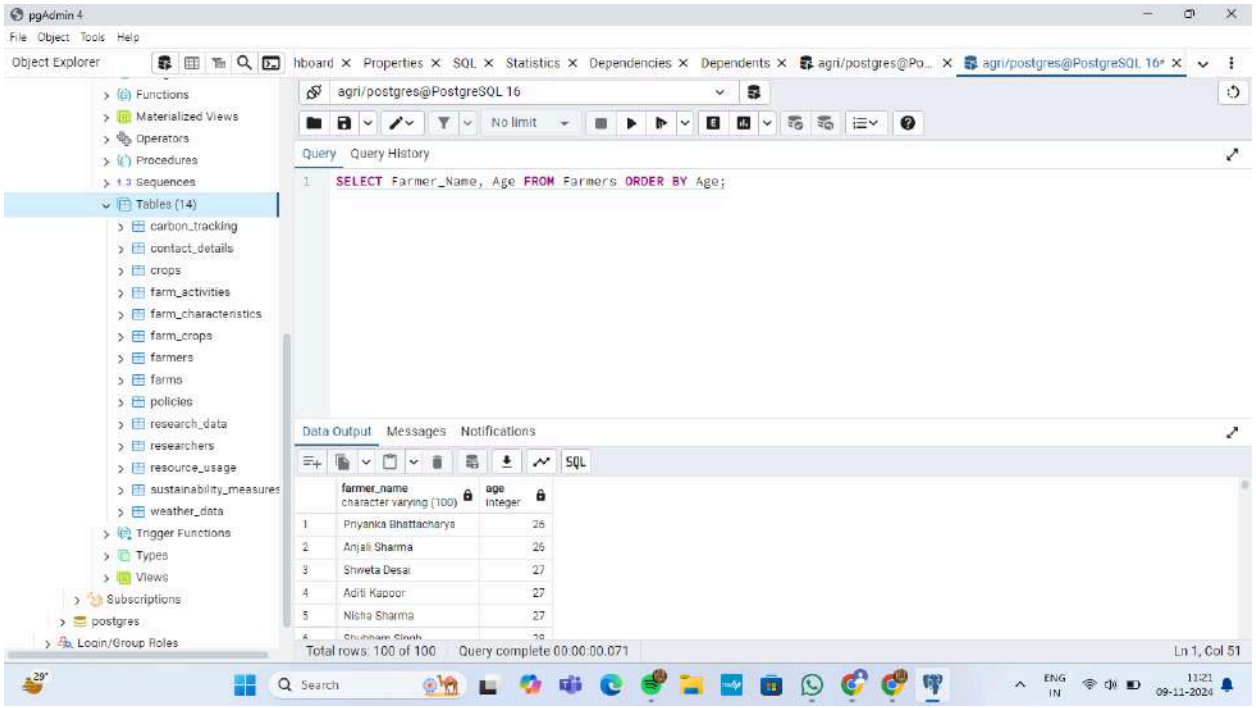
12) Problem: List farms that use either "Canal" or "Well" as a water source.
Query: `SELECT Farm_Name FROM Farms WHERE Water_Source IN ('Canal', 'Well');`



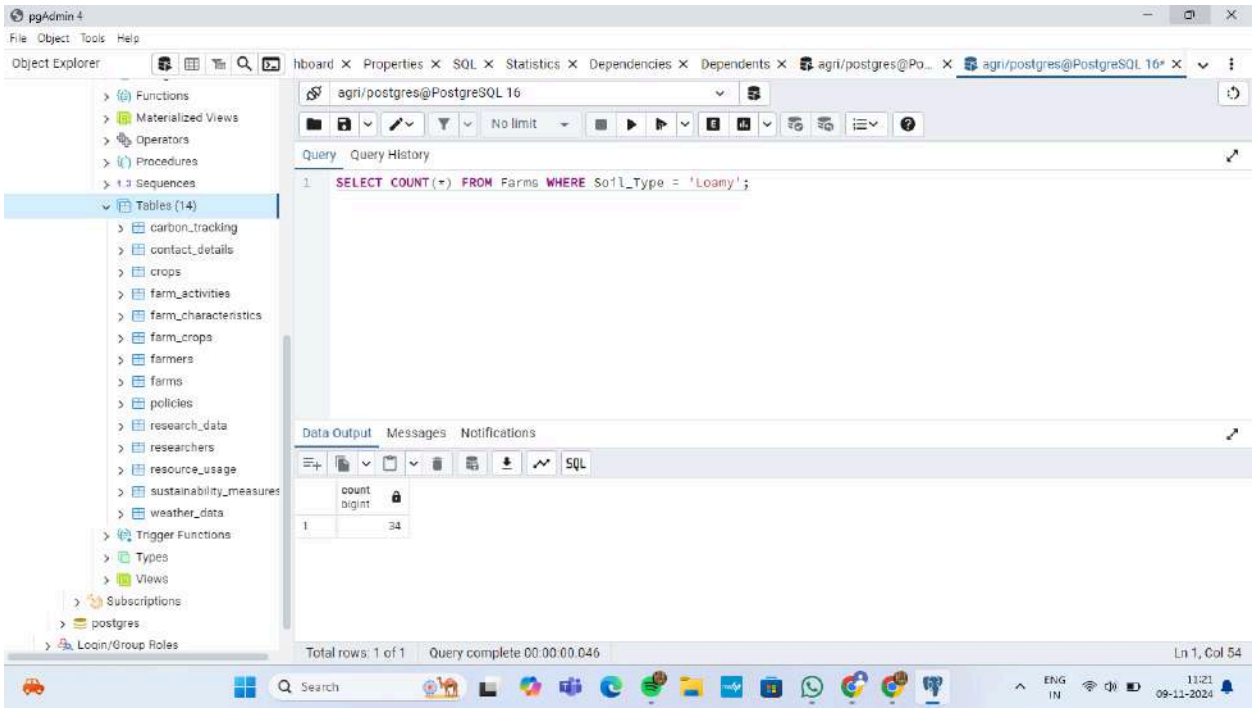
13) Problem: Retrieve crops with a name starting with "S".
Query: `SELECT Crop_Type FROM Crops WHERE Crop_Type LIKE 'S%';`



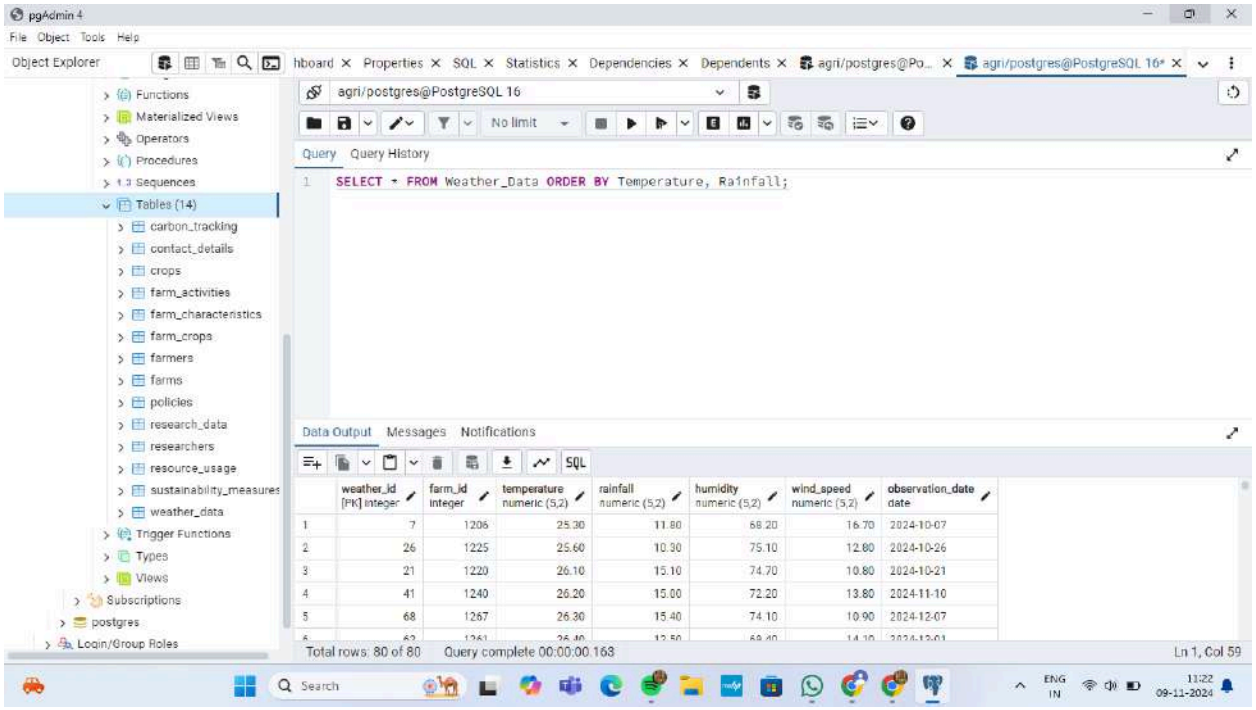
14) Problem: List farmer names and their ages, ordering by age in ascending order.
Query: `SELECT Farmer_Name, Age FROM Farmers ORDER BY Age;`



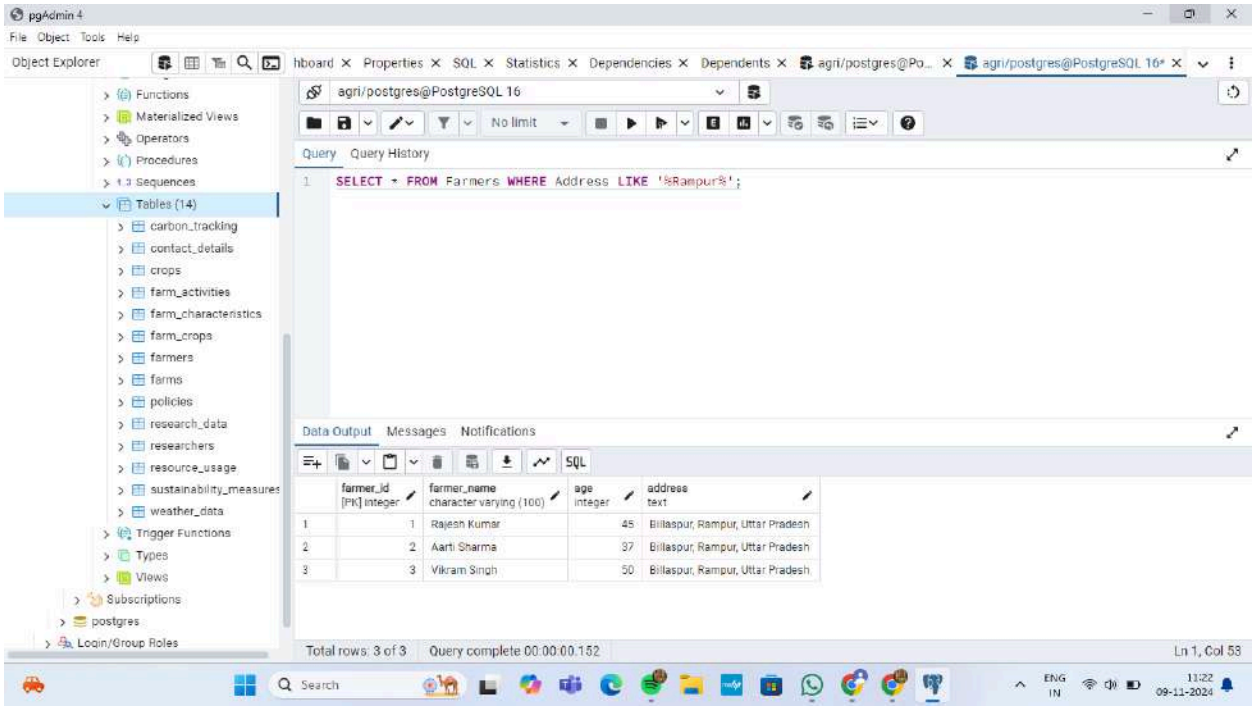
15) Problem: Count farms that use "Loamy" soil.
Query: `SELECT COUNT(*) FROM Farms WHERE Soil_Type = 'Loamy';`



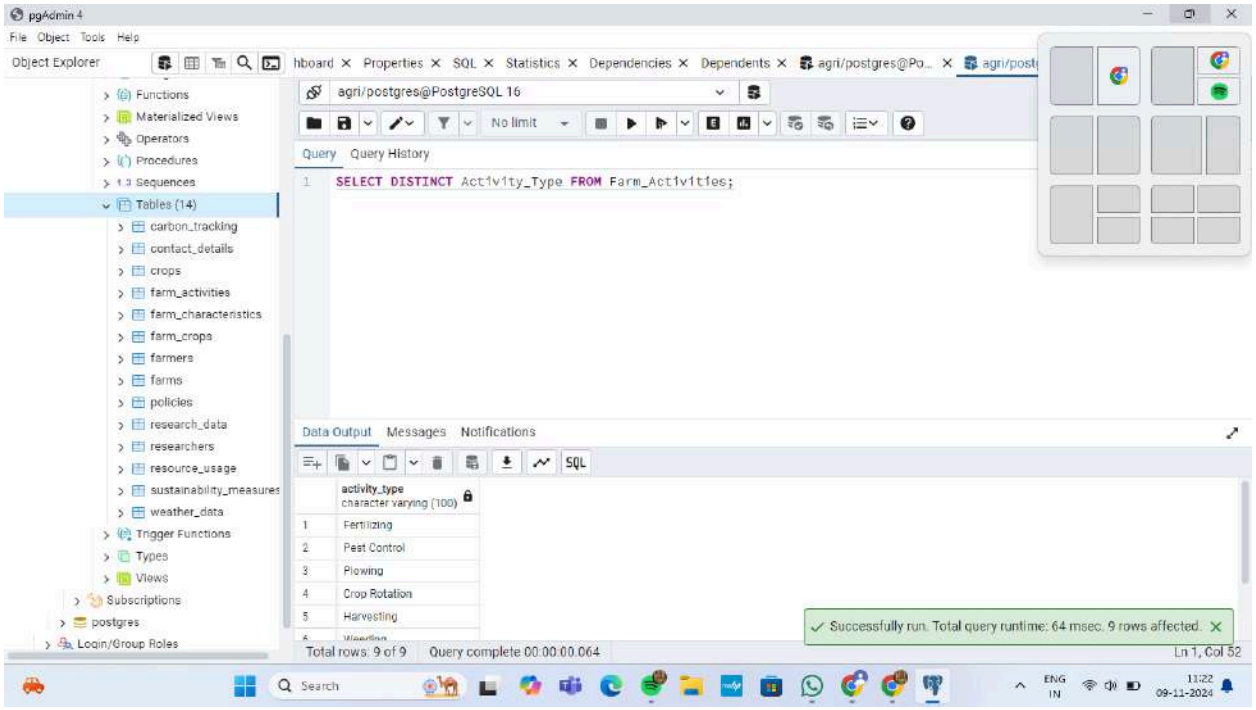
16) Problem: Display weather data sorted by both temperature and rainfall.
Query: `SELECT * FROM Weather_Data ORDER BY Temperature, Rainfall;`



17) Problem: Show all farmers whose address includes "Rampur".
Query: `SELECT * FROM Farmers WHERE Address LIKE '%Rampur%';`

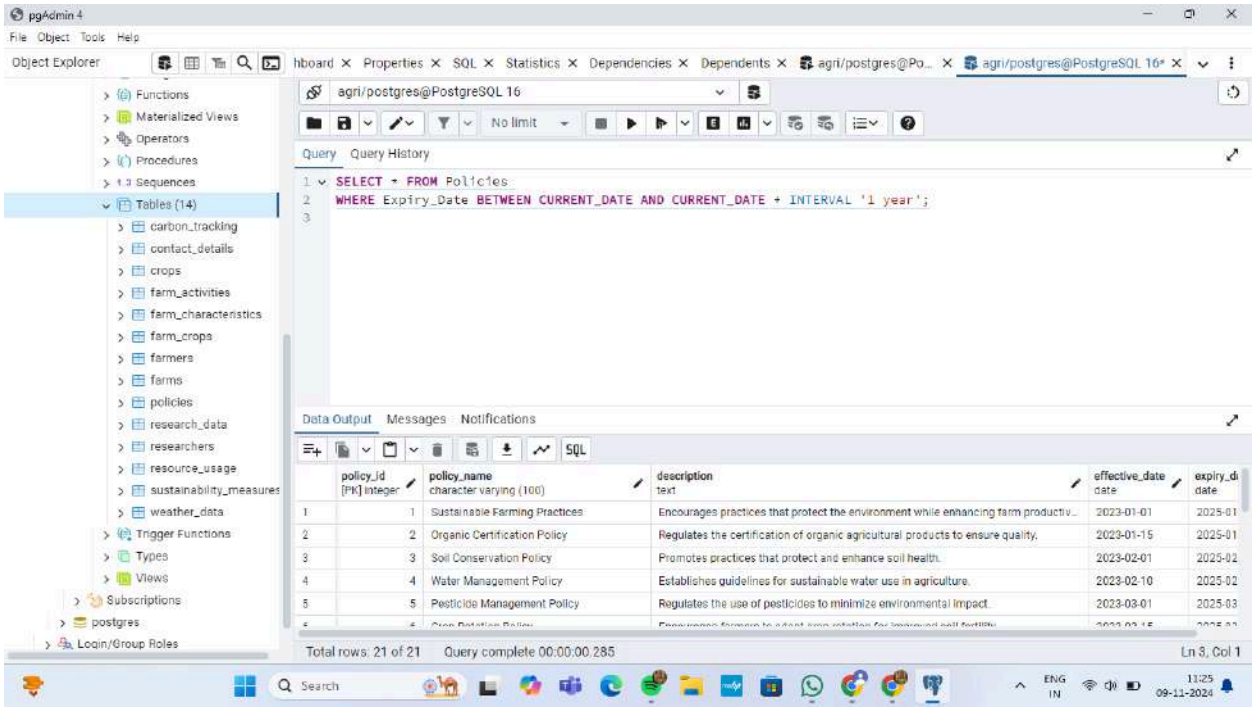


18) Problem: Retrieve distinct activity types in Farm_Activities.
Query: `SELECT DISTINCT Activity_Type FROM Farm_Activities;`

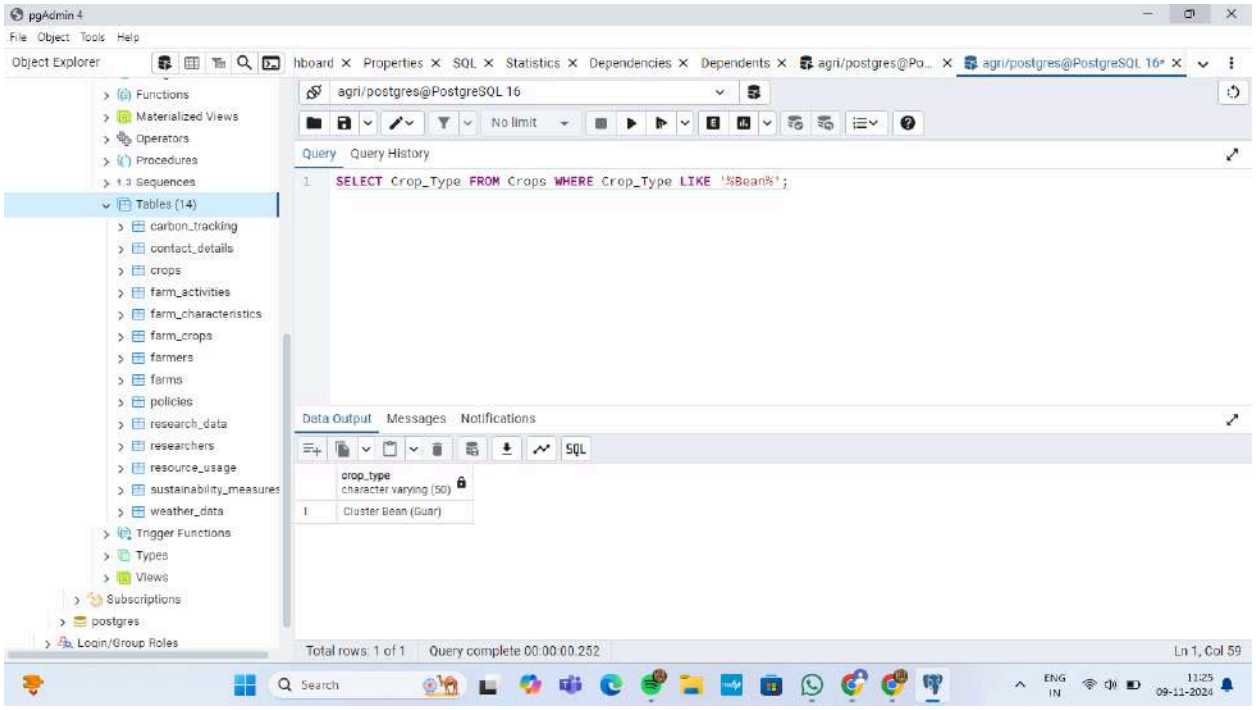


19) Problem: Find all policies expiring within the next year.

Query: `SELECT * FROM Policies
WHERE Expiry_Date BETWEEN CURRENT_DATE AND
CURRENT_DATE + INTERVAL '1 year';`



20) Problem: List all crop types containing "Bean" in their name.
Query: `SELECT Crop_Type FROM Crops WHERE Crop_Type LIKE '%Bean%';`

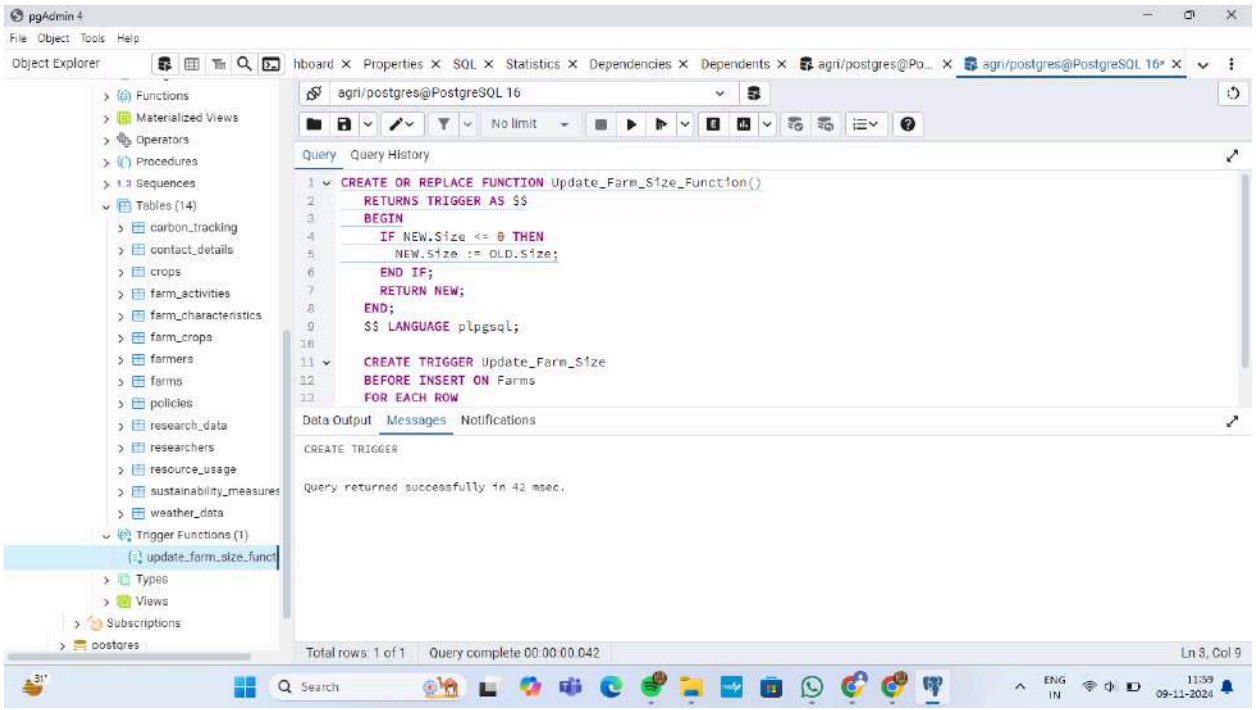


COMPLEX QUERIES:

1) Problem: Create a trigger to automatically update `Farm_Size` in the `Farms` table if a new size is inserted.

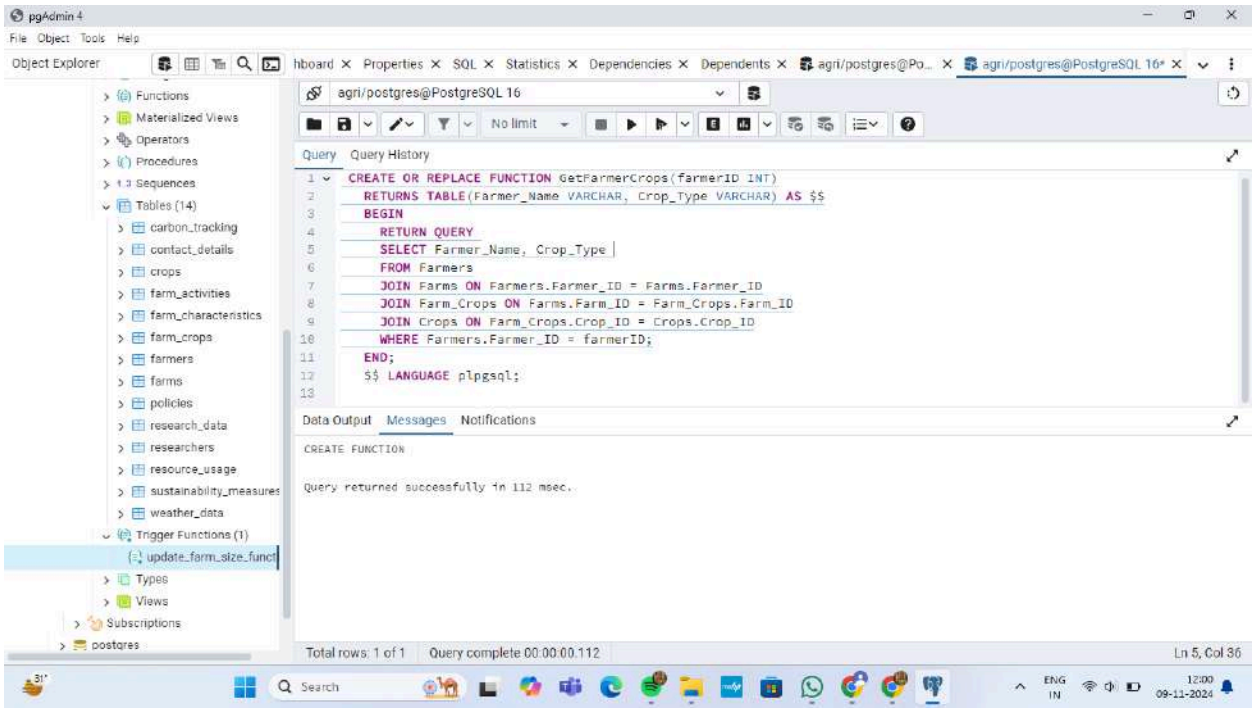
```
CREATE OR REPLACE FUNCTION Update_Farm_Size_Function()
RETURNS TRIGGER AS $$
BEGIN
  -- Ensure that Size is positive
  IF NEW.Size <= 0 THEN
    NEW.Size := OLD.Size;
  END IF;
  RETURN NEW;
END;
CREATE TRIGGER Update_Farm_Size
BEFORE INSERT ON Farms
FOR EACH ROW
```

EXECUTE FUNCTION Update_Farm_Size_Function();



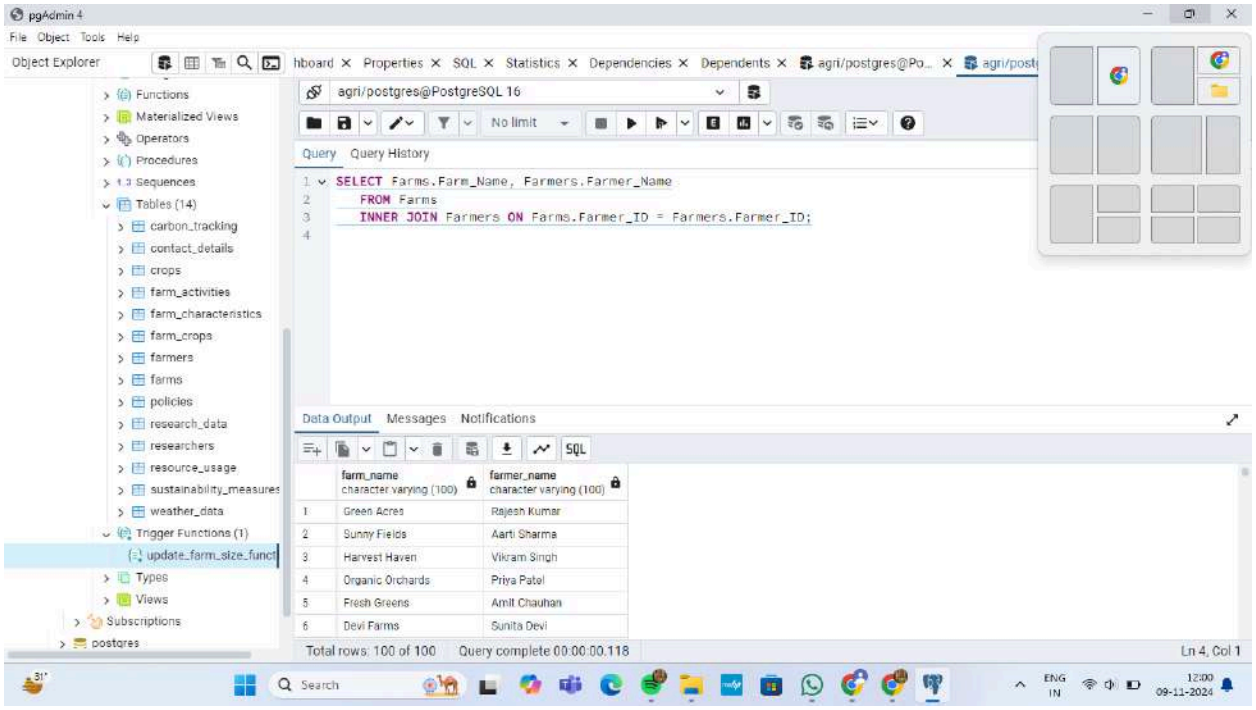
2) Problem: Create a procedure to retrieve `Farmer_Name` and associated `Crops` grown by a given `Farmer_ID`.

```
CREATE OR REPLACE FUNCTION GetFarmerCrops(farmerID INT)
RETURNS TABLE(Farmer_Name VARCHAR, Crop_Type VARCHAR) AS $$
BEGIN
  RETURN QUERY
  SELECT Farmer_Name, Crop_Type
  FROM Farmers
  JOIN Farms ON Farmers.Farmer_ID = Farms.Farmer_ID
  JOIN Farm_Crops ON Farms.Farm_ID = Farm_Crops.Farm_ID
  JOIN Crops ON Farm_Crops.Crop_ID = Crops.Crop_ID
  WHERE Farmers.Farmer_ID = farmerID;
END;
```



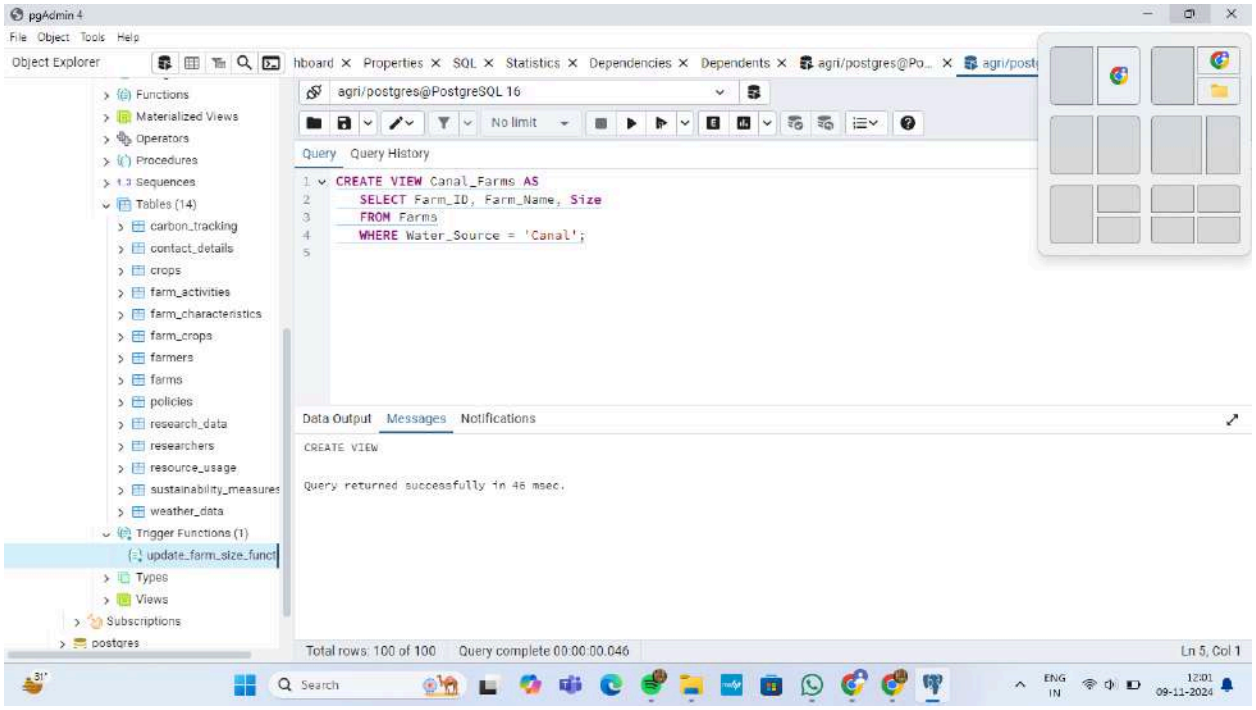
3) Problem: Use an INNER JOIN to list `Farm_Name` and `Farmer_Name` for all farms.

```
SELECT Farms.Farm_Name, Farmers.Farmer_Name
FROM Farms
INNER JOIN Farmers ON Farms.Farmer_ID = Farmers.Farmer_ID;
```



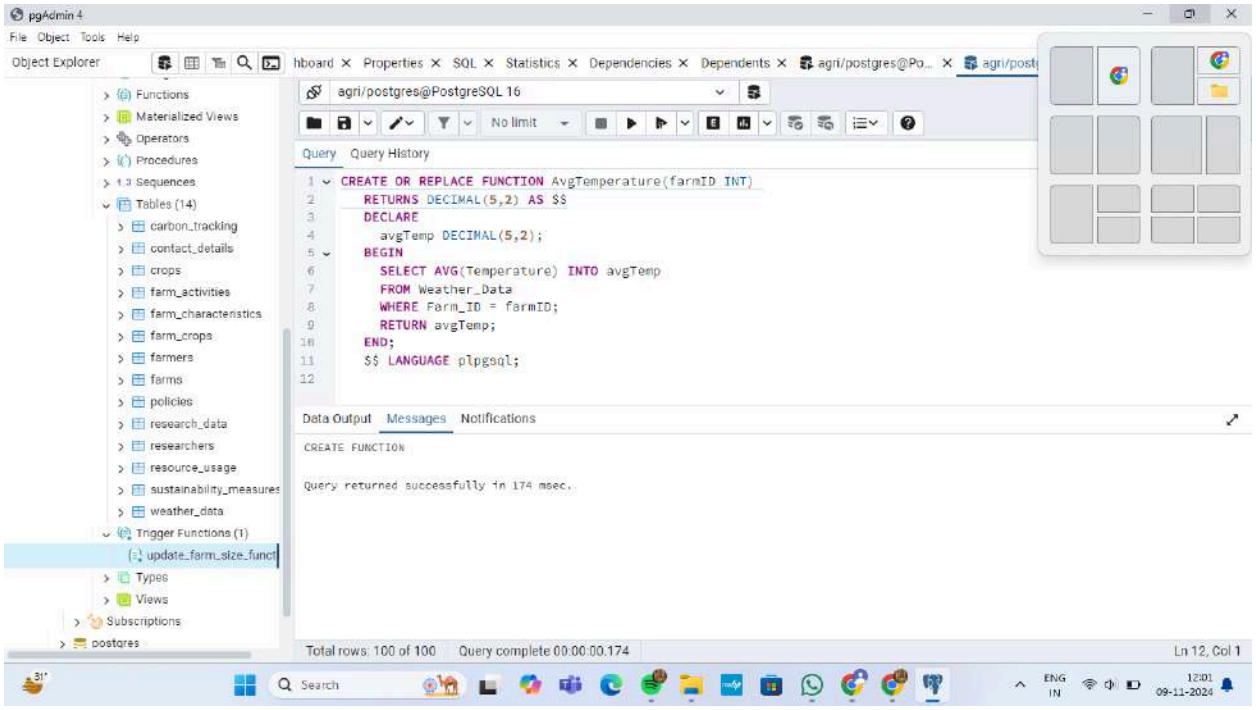
4) Problem: Create a view of all farms that use "Canal" as a water source.

```
CREATE VIEW Canal_Farms AS
SELECT Farm_ID, Farm_Name, Size
FROM Farms
WHERE Water_Source = 'Canal';
```



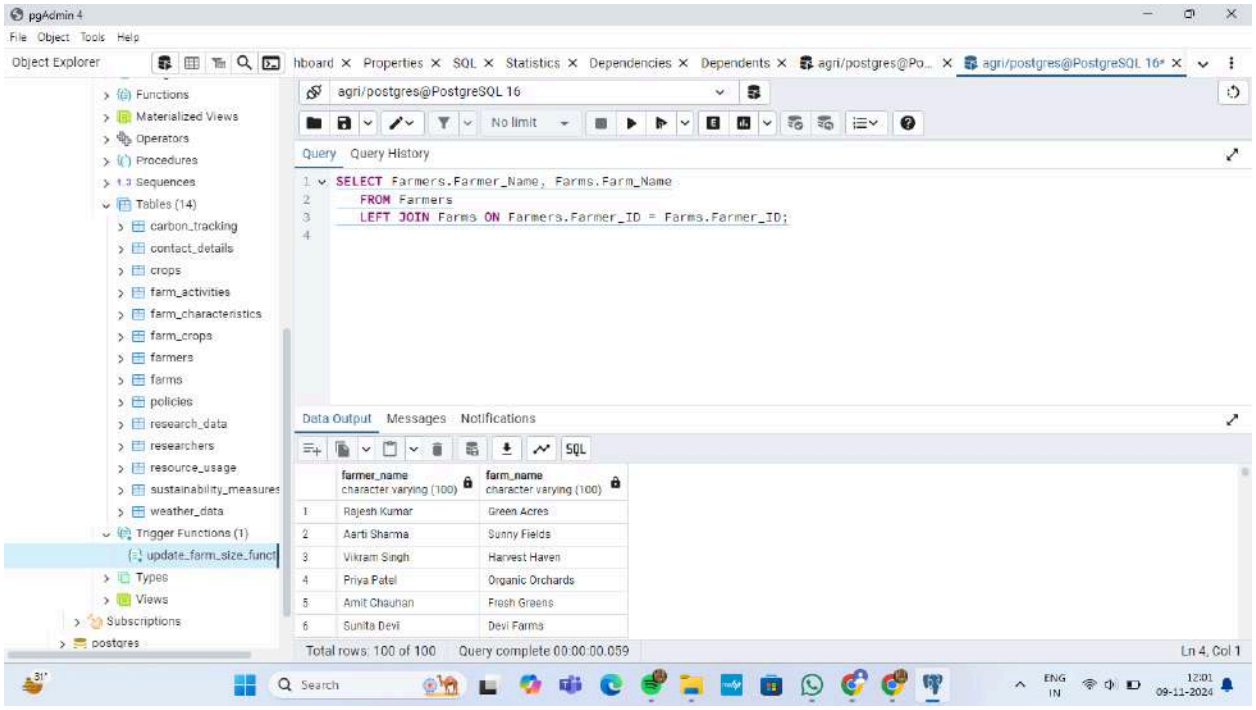
5) Problem: Write a function to calculate the average `Temperature` for a specific `Farm_ID`.

```
CREATE OR REPLACE FUNCTION AvgTemperature(farmID INT)
RETURNS DECIMAL(5,2) AS $$
DECLARE
  avgTemp DECIMAL(5,2);
BEGIN
  SELECT AVG(Temperature) INTO avgTemp
  FROM Weather_Data
  WHERE Farm_ID = farmID;
  RETURN avgTemp;
END;
```



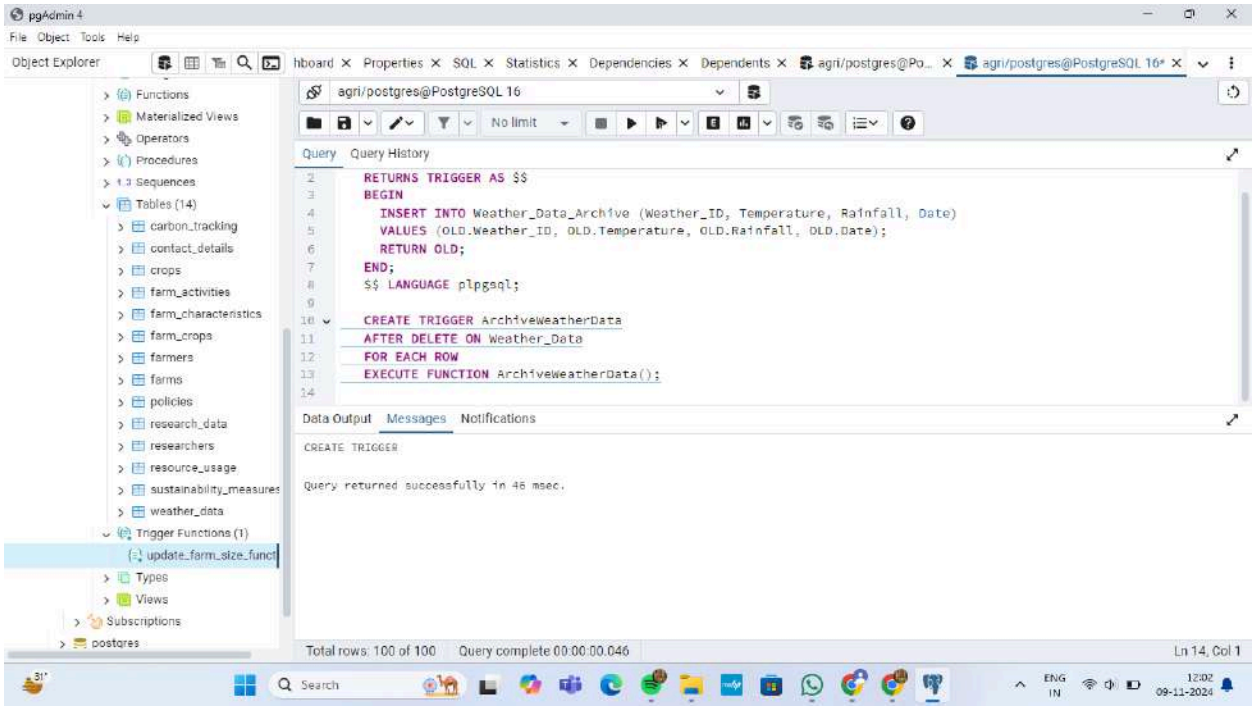
6) Problem: Use LEFT JOIN to list all Farmers and any associated `Farm_Name`.

```
SELECT Farmers.Farmer_Name, Farms.Farm_Name
FROM Farmers
LEFT JOIN Farms ON Farmers.Farmer_ID = Farms.Farmer_ID;
```



7) Problem: Create a trigger to log deleted records from `Weather_Data` in an archive table.

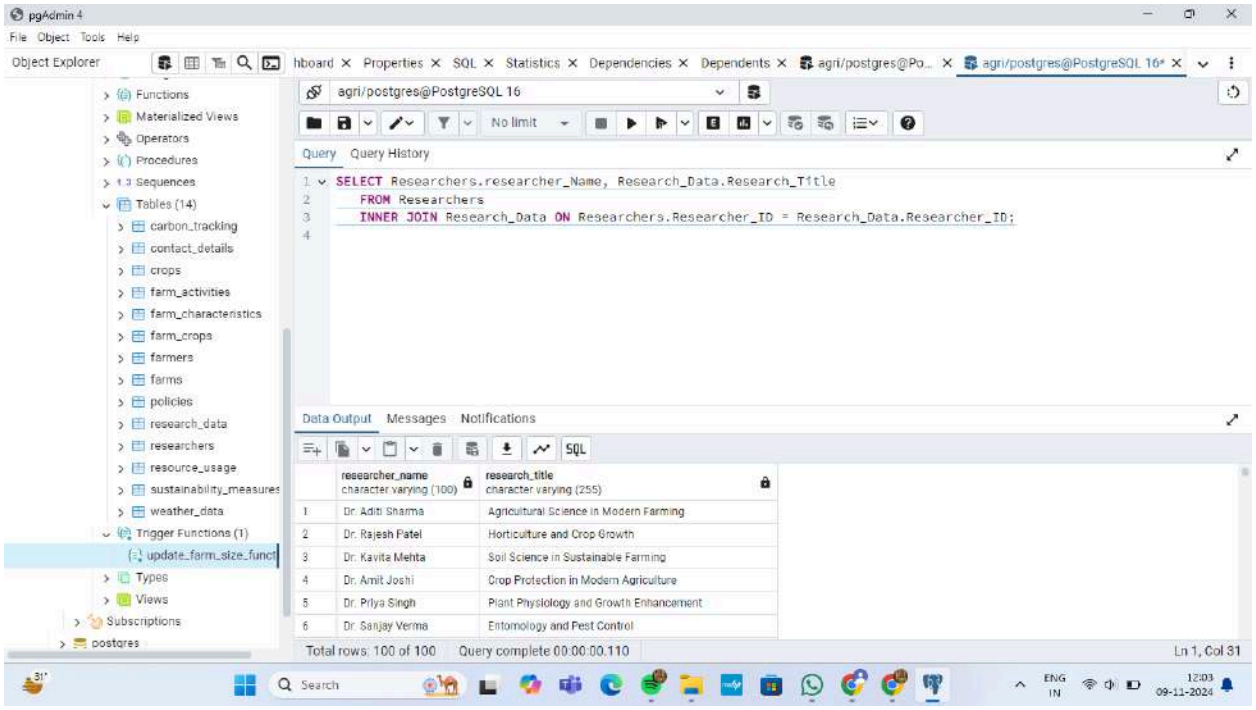
```
CREATE OR REPLACE FUNCTION ArchiveWeatherData()
RETURNS TRIGGER AS $$
BEGIN
  INSERT INTO Weather_Data_Archive (Weather_ID, Temperature, Rainfall, Date)
  VALUES (OLD.Weather_ID, OLD.Temperature, OLD.Rainfall, OLD.Date);
  RETURN OLD;
END;
```




```
CREATE TRIGGER ArchiveWeatherData
AFTER DELETE ON Weather_Data
FOR EACH ROW
EXECUTE FUNCTION ArchiveWeatherData();
```

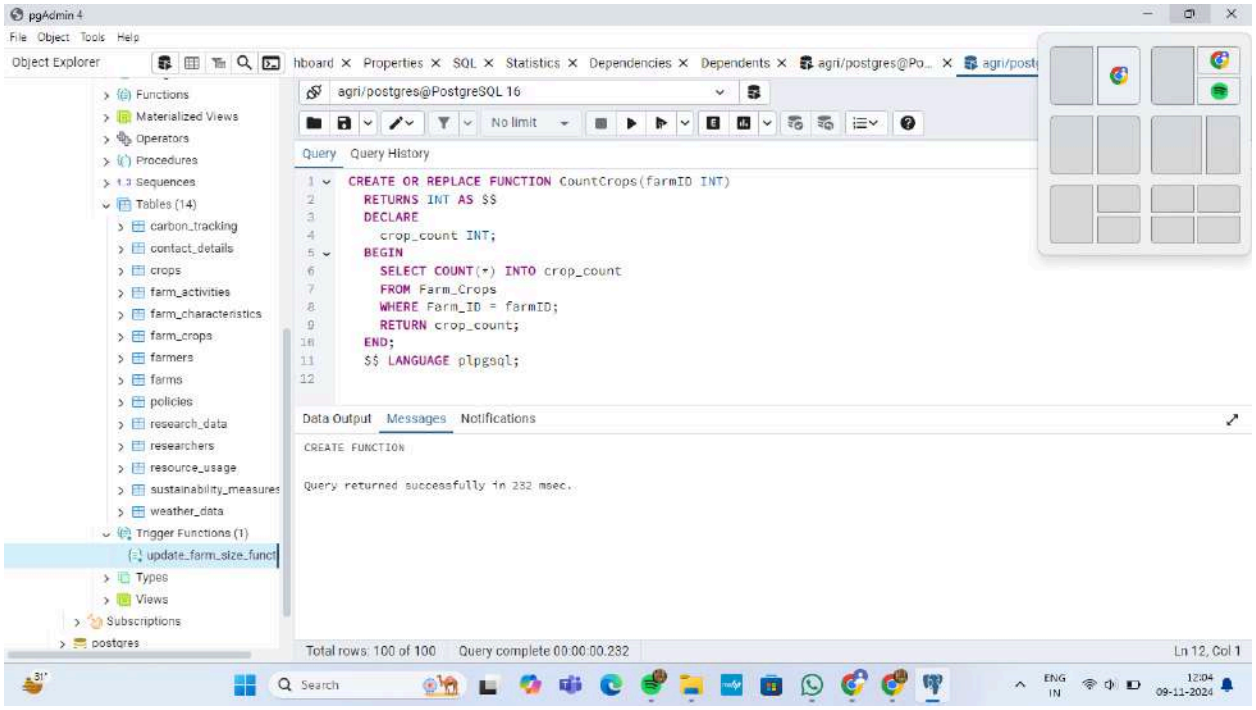
8) Problem: Display `Researcher` names and their `Research_Title` using INNER JOIN.

```
SELECT Researchers.researcher_Name, Research_Data.Research_Title
FROM Researchers
INNER JOIN Research_Data ON Researchers.Researcher_ID =
Research_Data.Researcher_ID;
```



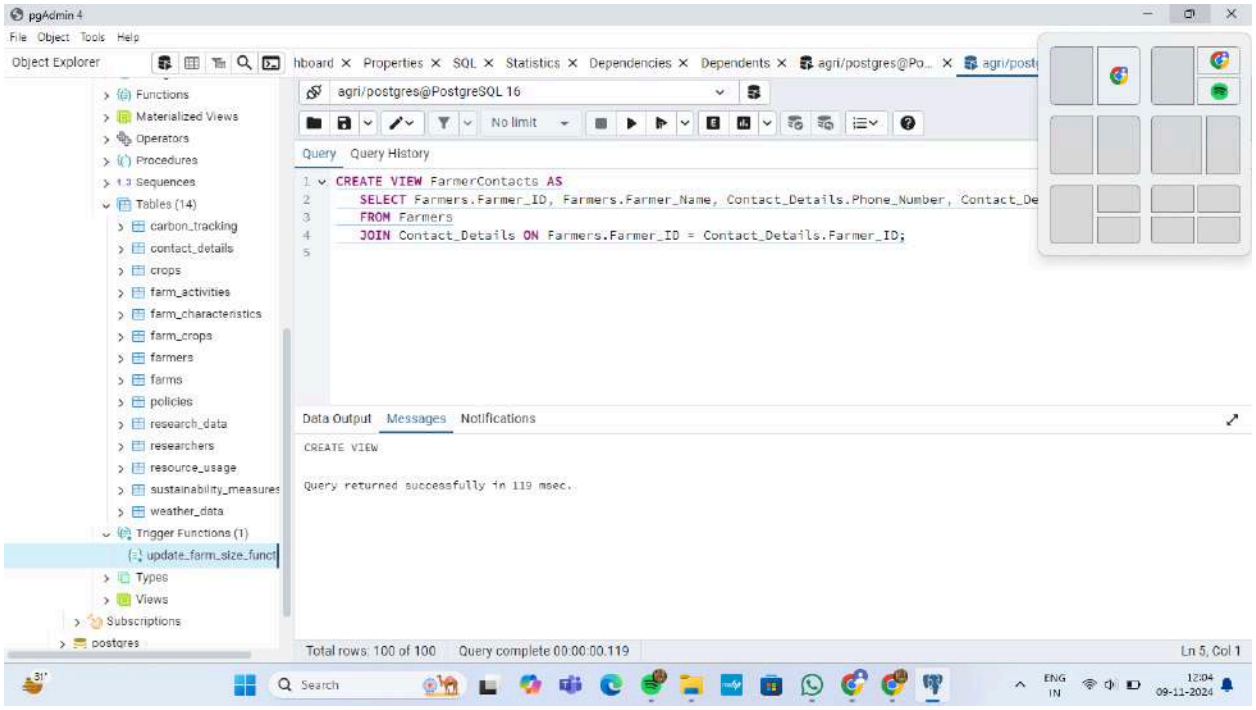
9) Problem: Create a procedure to count total crops by a given `Farm_ID`.

```
CREATE OR REPLACE FUNCTION CountCrops(farmID INT)
RETURNS INT AS $$
DECLARE
  crop_count INT;
BEGIN
  SELECT COUNT(*) INTO crop_count
  FROM Farm_Crops
  WHERE Farm_ID = farmID;
  RETURN crop_count;
END;
```



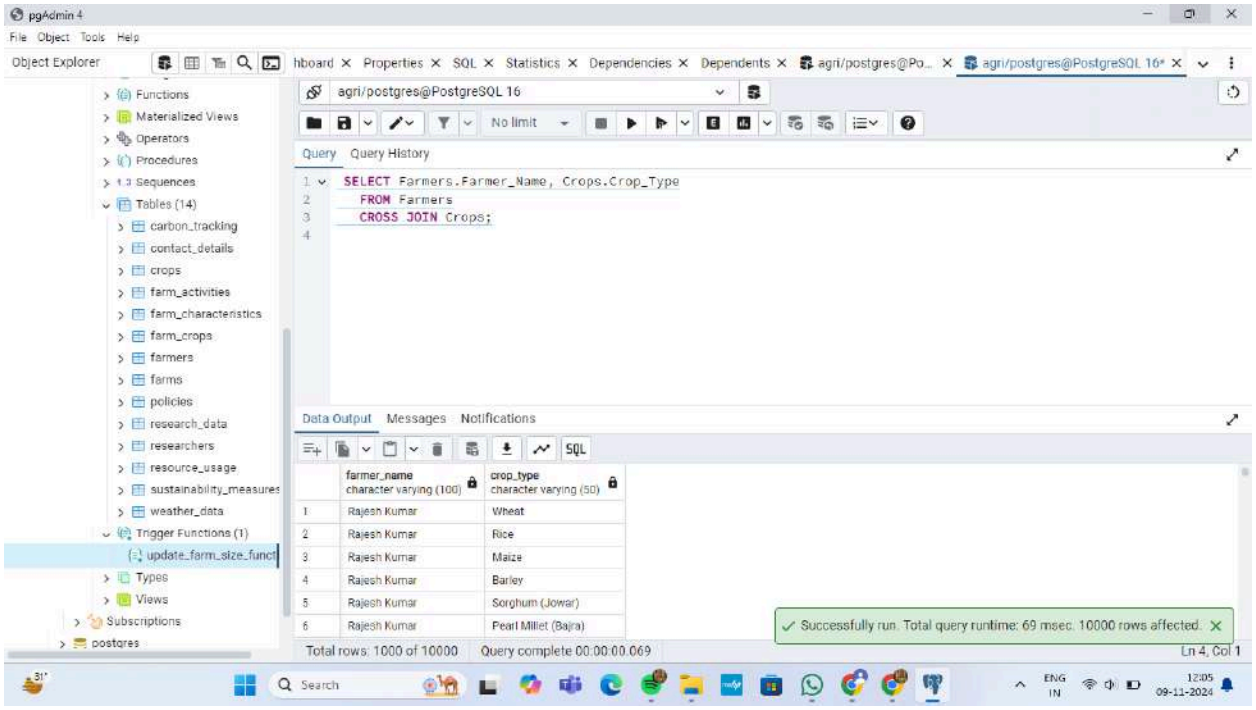
10) Problem: Create a view listing `Farmer_ID`, `Farmer_Name`, and their contact details.

```
  CREATE VIEW FarmerContacts AS
  SELECT Farmers.Farmer_ID, Farmers.Farmer_Name,
Contact_Details.Phone_Number, Contact_Details.Email_Address
  FROM Farmers
  JOIN Contact_Details ON Farmers.Farmer_ID =
Contact_Details.Farmer_ID;
```



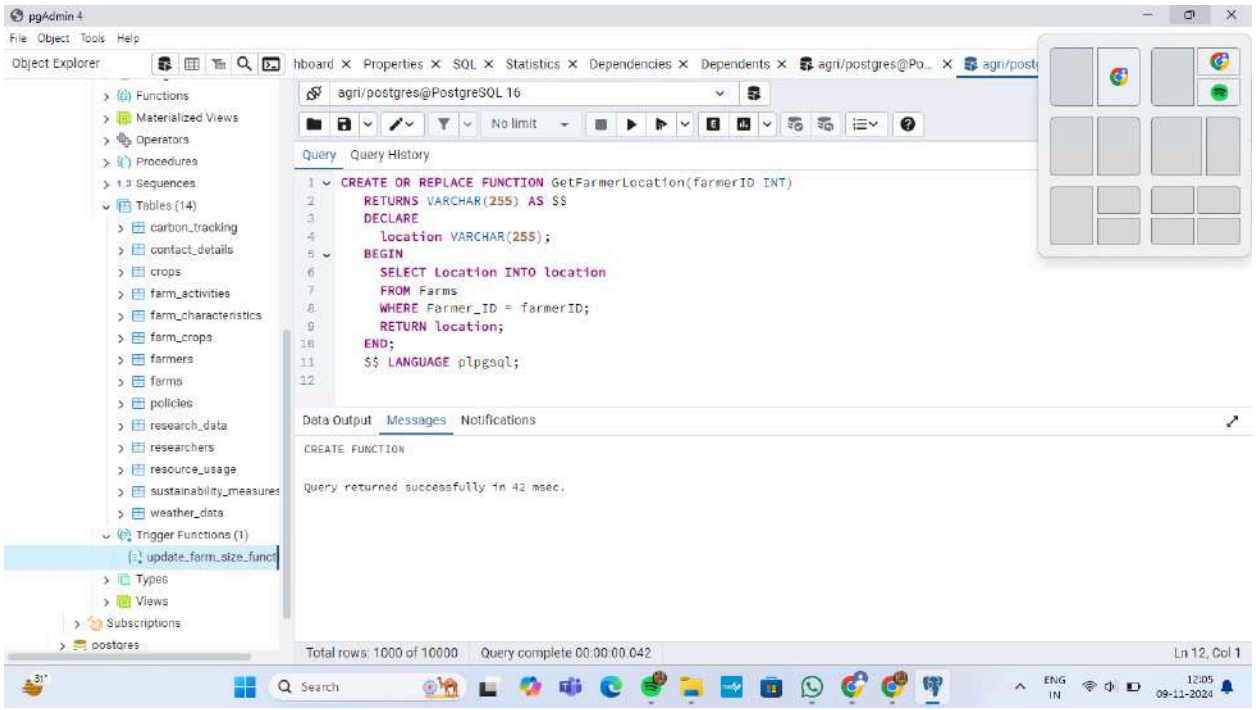
11) Problem: Use CROSS JOIN to get combinations of all Farmers and Crops.

```
SELECT Farmers.Farmer_Name, Crops.Crop_Type
FROM Farmers
CROSS JOIN Crops;
```



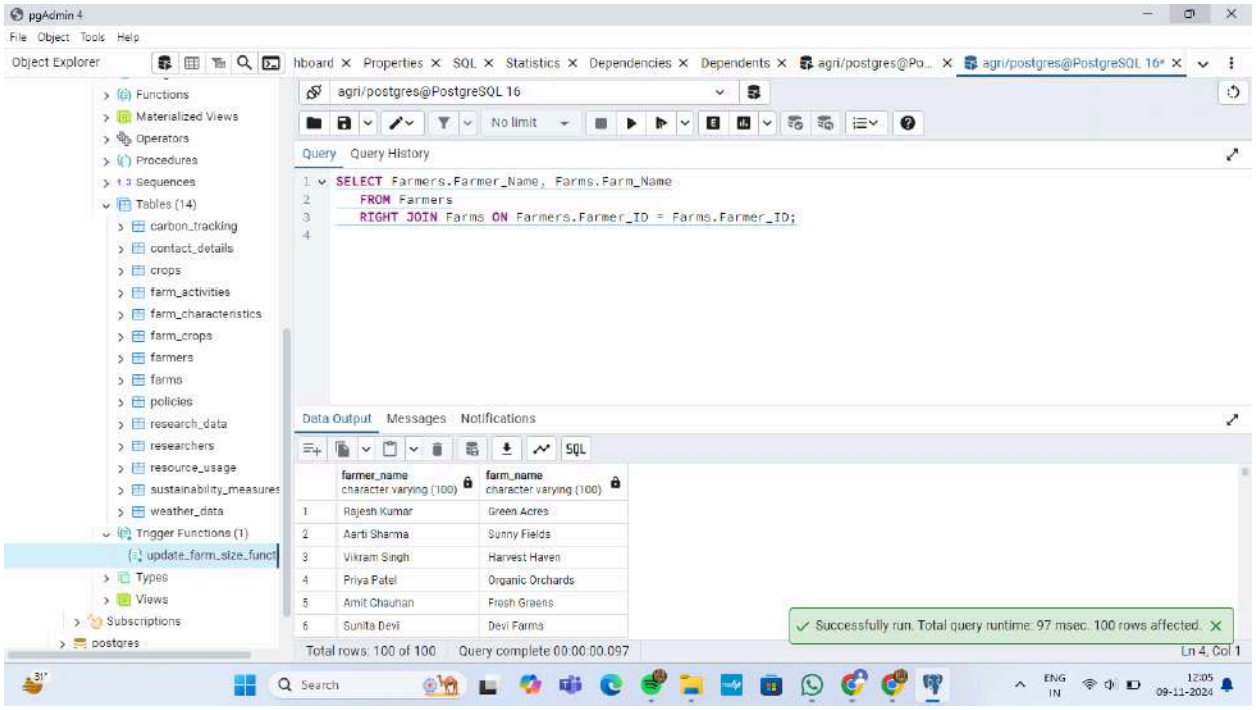
12) Problem: Write a function to return `Farmer_Name` and their farm `Location` based on `Farmer_ID`.

```
CREATE OR REPLACE FUNCTION GetFarmerLocation(farmerID INT)
RETURNS VARCHAR(255) AS $$
DECLARE
  location VARCHAR(255);
BEGIN
  SELECT Location INTO location
  FROM Farms
  WHERE Farmer_ID = farmerID;
  RETURN location;
END;
```



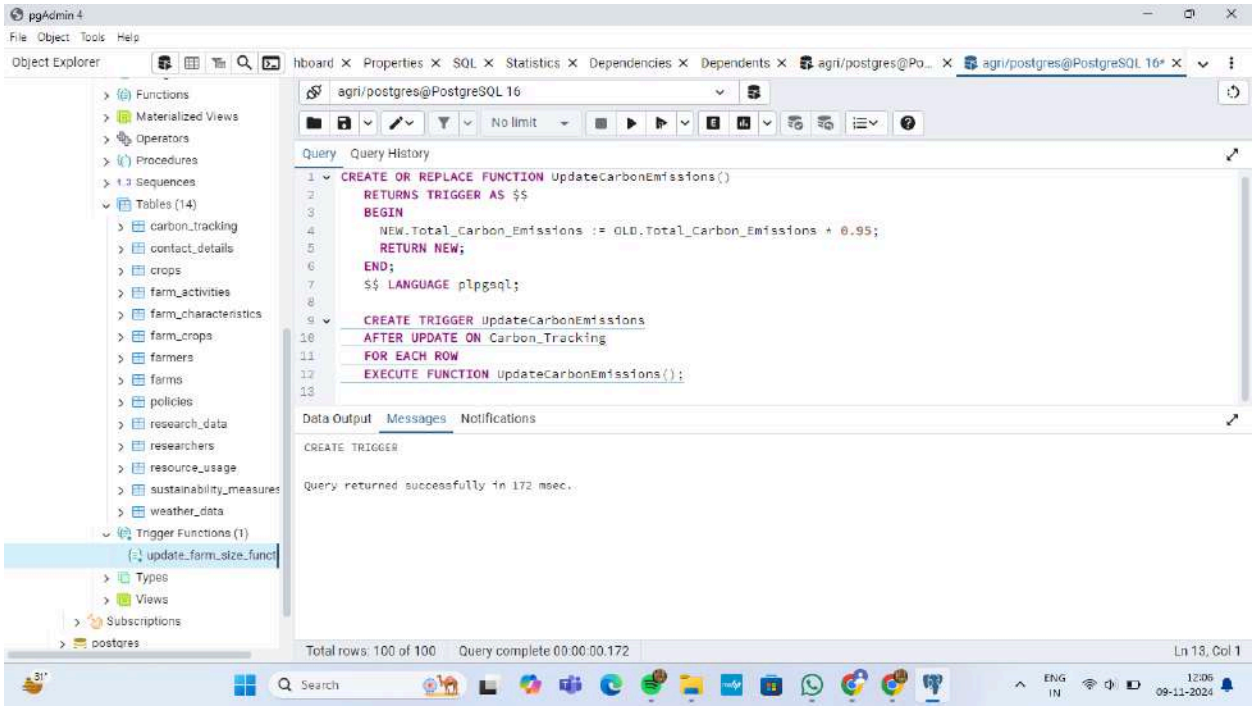
13) Problem: Use a RIGHT JOIN to list `Farmer_Name` for each Farm.

```
SELECT Farmers.Farmer_Name, Farms.Farm_Name
FROM Farmers
RIGHT JOIN Farms ON Farmers.Farmer_ID = Farms.Farmer_ID;
```



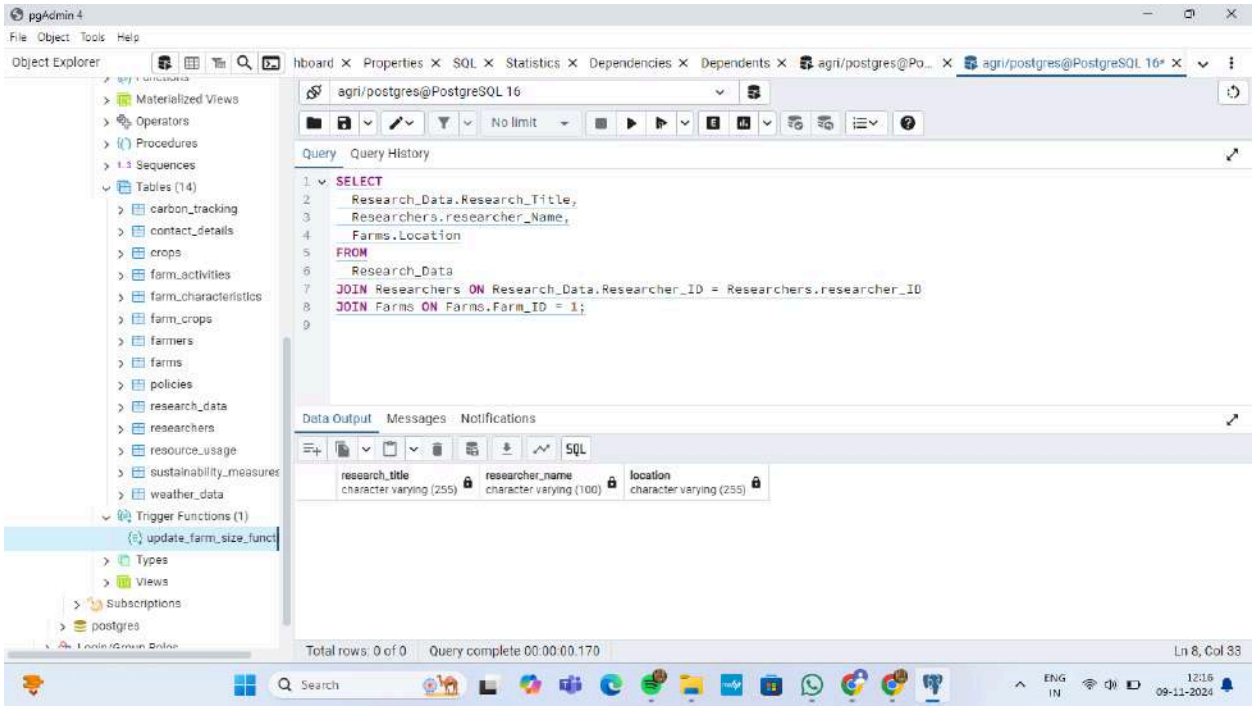
14) Problem: Create a trigger to update `Total_Carbon_Emissions` when a record in `Carbon_Tracking` is modified.

```
CREATE OR REPLACE FUNCTION UpdateCarbonEmissions()
RETURNS TRIGGER AS $$
BEGIN
  NEW.Total_Carbon_Emissions := OLD.Total_Carbon_Emissions * 0.95;
  RETURN NEW;
END;


CREATE TRIGGER UpdateCarbonEmissions
AFTER UPDATE ON Carbon_Tracking
FOR EACH ROW
EXECUTE FUNCTION UpdateCarbonEmissions();
```



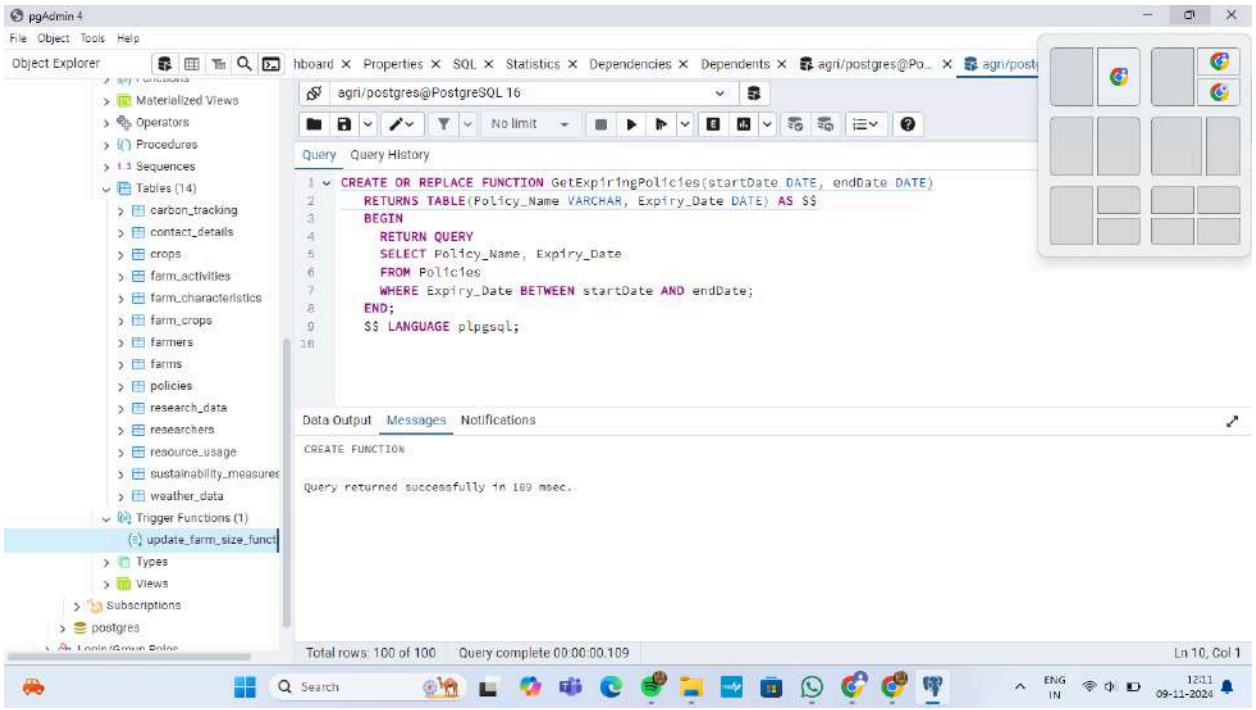
15) Problem:**list the research titles along with the researchers' names** and the **farm locations**. .

```
 SELECT
  Research_Data.Research_Title,
  Researchers.researcher_Name,
  Farms.Location
FROM
  Research_Data
JOIN Researchers ON Research_Data.Researcher_ID =
Researchers.researcher_ID
JOIN Farms ON Farms.Farm_ID = 1; -- Assuming research is conducted
on Farm 1
```



16) Problem: Create a procedure to retrieve all policies that expire within a specified date range.

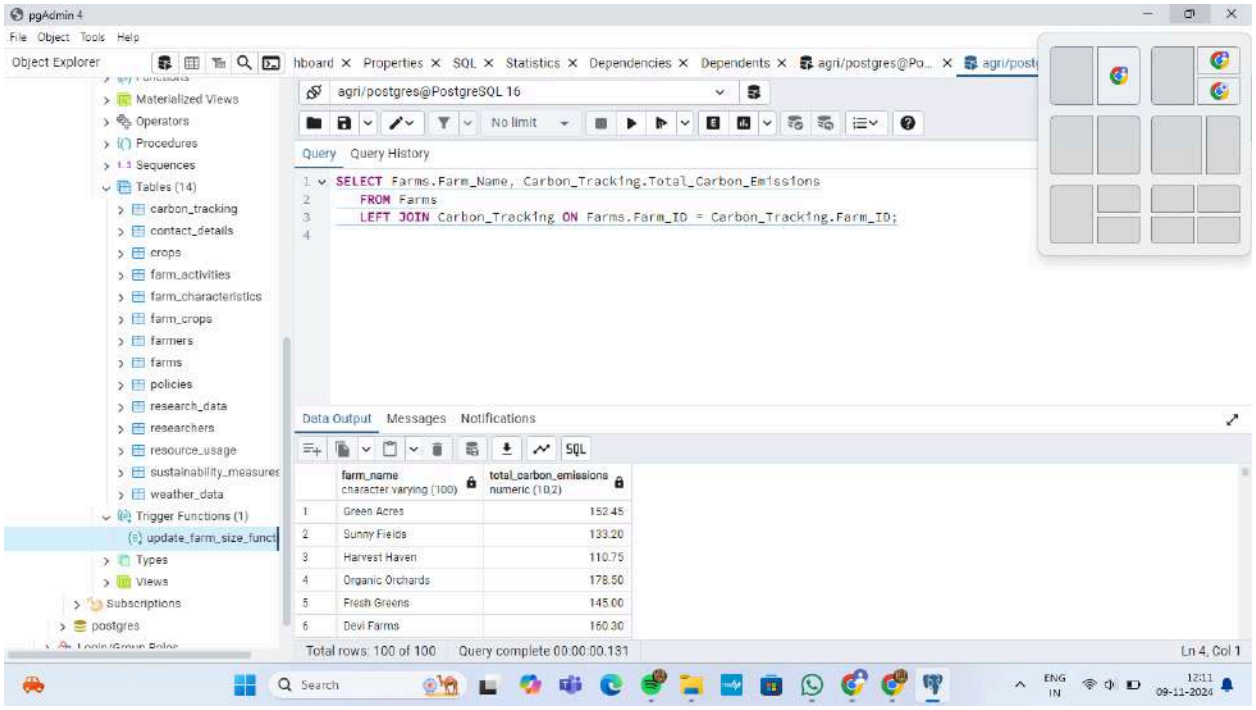
```
  CREATE OR REPLACE FUNCTION GetExpiringPolicies(startDate
DATE, endDate DATE)
  RETURNS TABLE(Policy_Name VARCHAR, Expiry_Date DATE) AS $$
  BEGIN
    RETURN QUERY
    SELECT Policy_Name, Expiry_Date
    FROM Policies
    WHERE Expiry_Date BETWEEN startDate AND endDate;
  END;
```



---

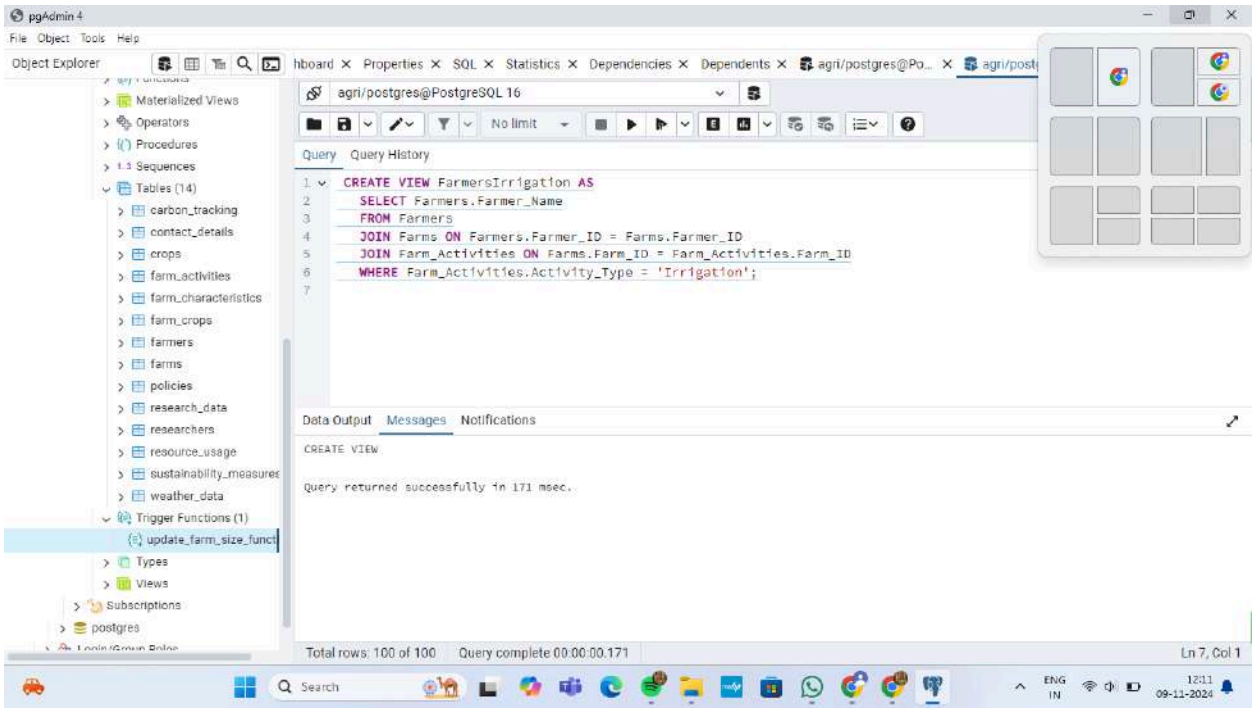
17) Problem: List all farms and `Carbon_Tracking` data using an OUTER JOIN.

```
SELECT Farms.Farm_Name, Carbon_Tracking.Total_Carbon_Emissions
FROM Farms
LEFT JOIN Carbon_Tracking ON Farms.Farm_ID =
Carbon_Tracking.Farm_ID;
```



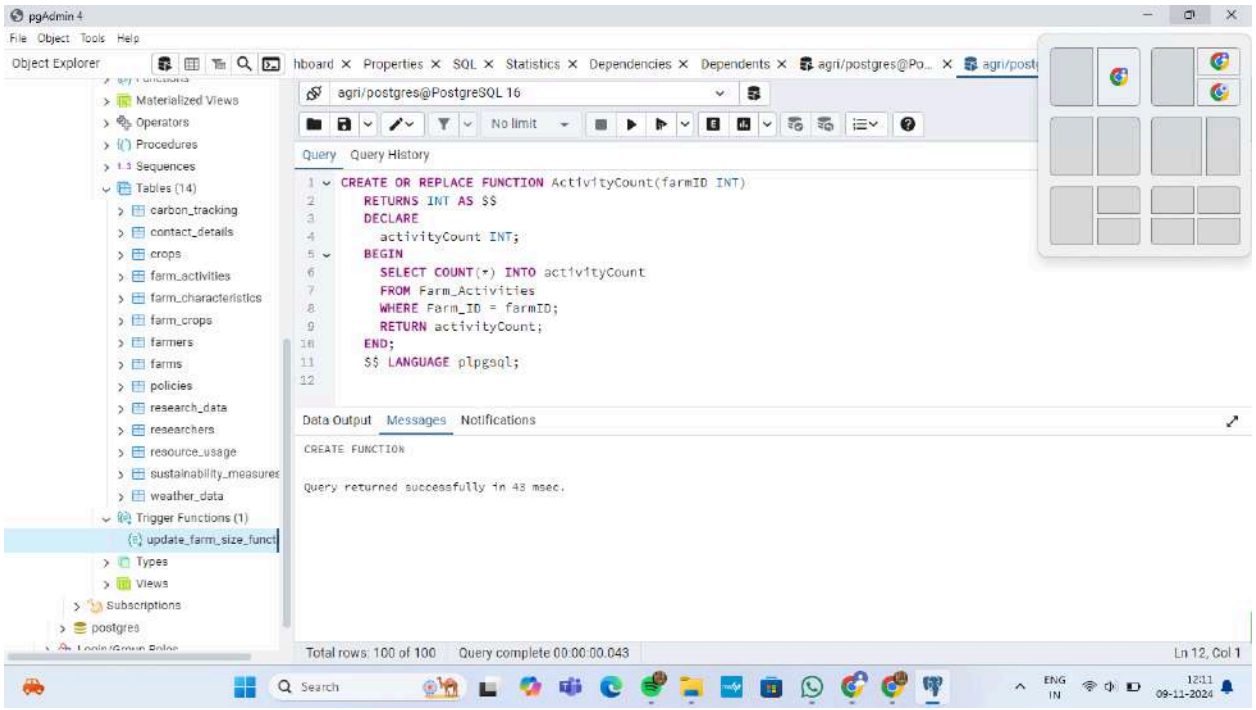
18) Problem: Create a view listing all Farmers who have engaged in "Irrigation" activity.

```
CREATE VIEW FarmersIrrigation AS
SELECT Farmers.Farmer_Name
FROM Farmers
JOIN Farms ON Farmers.Farmer_ID = Farms.Farmer_ID
JOIN Farm_Activities ON Farms.Farm_ID = Farm_Activities.Farm_ID
WHERE Farm_Activities.Activity_Type = 'Irrigation';
```



19) Problem: Create a function to get the count of activities by `Farm_ID`.

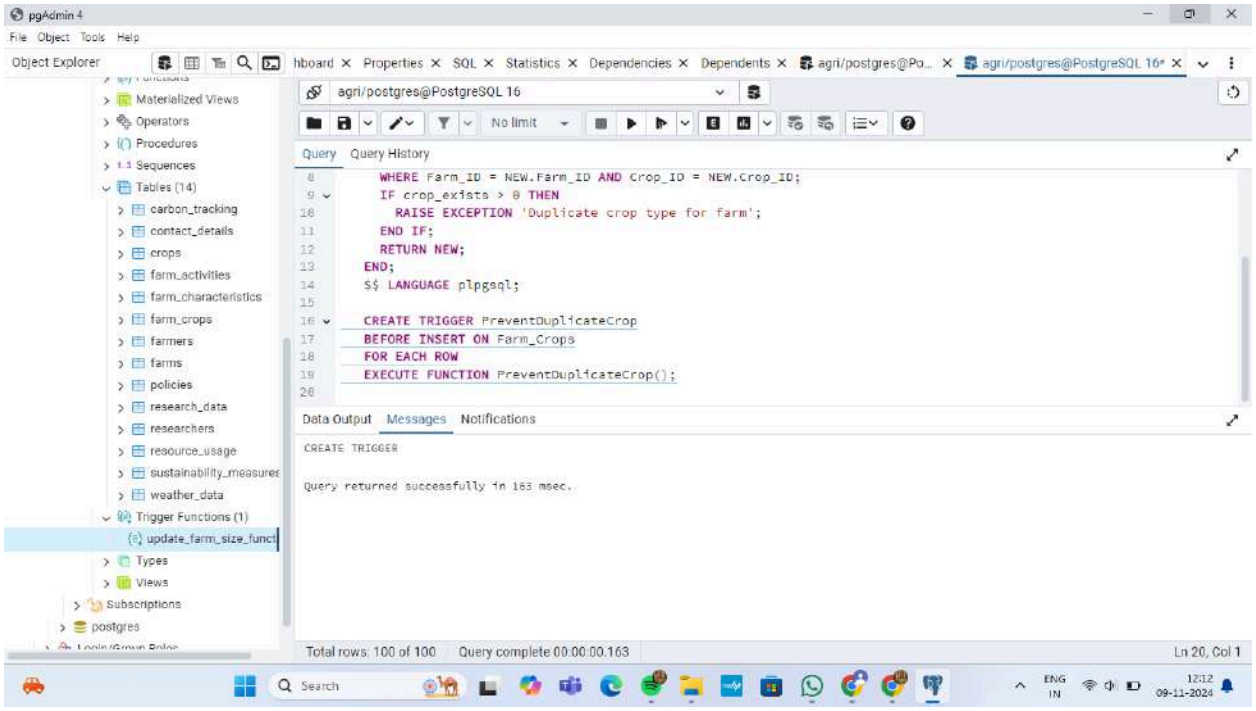
```
CREATE OR REPLACE FUNCTION ActivityCount(farmID INT)
RETURNS INT AS $$
DECLARE
  activityCount INT;
BEGIN
  SELECT COUNT(*) INTO activityCount
  FROM Farm_Activities
  WHERE Farm_ID = farmID;
  RETURN activityCount;
END;
```



20) Problem: Create a trigger to prevent inserting duplicate crop types for the same farm.

```
CREATE OR REPLACE FUNCTION PreventDuplicateCrop()
RETURNS TRIGGER AS
DECLARE
  crop_exists INT;
BEGIN
  SELECT COUNT(*) INTO crop_exists
  FROM Farm_Crops
  WHERE Farm_ID = NEW.Farm_ID AND Crop_ID = NEW.Crop_ID;
  IF crop_exists > 0 THEN
    RAISE EXCEPTION 'Duplicate crop type for farm';
  END IF;
  RETURN NEW;
END;
```

```
CREATE TRIGGER PreventDuplicateCrop
BEFORE INSERT ON Farm_Crops
FOR EACH ROW
EXECUTE FUNCTION PreventDuplicateCrop();
```



Chapter 5: Interface Implementation

JDBC Setup Step 1: Set Up Your Environment

I. Ensure JDK and PostgreSQL are Installed: You need Java Development Kit (JDK) and PostgreSQL installed.

II. Download JDBC Driver: Download the PostgreSQL JDBC driver (postgresql-42.7.4.jar) from the https://jdbc.postgresql.org/download/.

Step 2: Create the Java Project Structure

I. Create a New Project Directory: A. Create a directory for your project, e.g., PostgreSQLCRUDApp.

II. Create Subdirectory for Your Code: A. Inside the project folder, created a src folder for Java code.

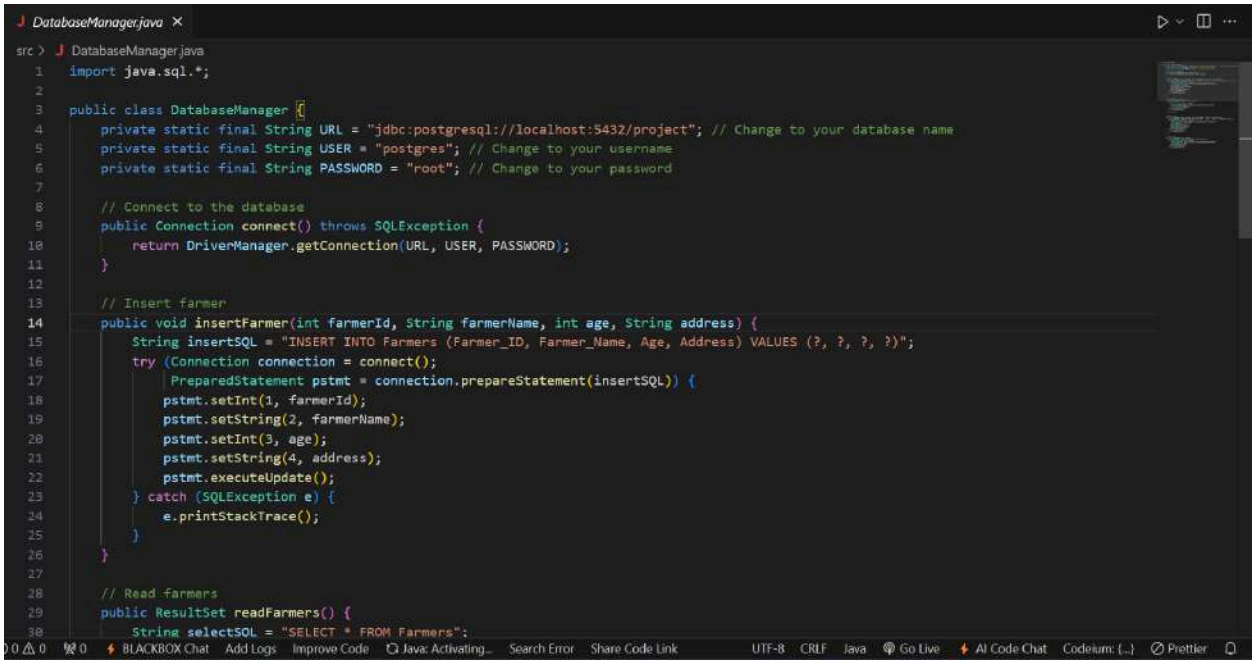
III. Place the JDBC Driver: A. Put the postgresql-42.7.4.jar file inside the project folder (src).

Step 3: Write the Java Code

I. Created a Class for Database Operations

II. Created a new Java file named DatabaseManager.java in the src directory with the code containing classes that api will execute as commands in the pgadmin.

III. Created another Java file named AgricultureManagerGUI.java in the same directory with the code for GUI buttons, frame and Window for CRUD operations.



Crud operation

1:sustainability_measures

```
import java.sql.*;

public class DatabaseManager {
    private static final String URL = "jdbc:postgresql://localhost:5432/project";
// Change to your database name
    private static final String USER = "postgres"; // Change to your username
    private static final String PASSWORD = "root"; // Change to your
password

    // Connect to the database
    public Connection connect() throws SQLException {
        return DriverManager.getConnection(URL, USER, PASSWORD);
    }

    // Insert sustainability measure (now including measure_id)
```

```
    public void insertSustainabilityMeasure(int measureId, int farmId, String
sustainability_Type, Date implementationDate, String effectiveness) {
        String insertSQL = "INSERT INTO sustainability_measures
(measure_id, farm_id, sustainability_type, implementation_date,
effectiveness) VALUES (?, ?, ?, ?, ?)";
        try (Connection connection = connect();
             PreparedStatement pstmt =
connection.prepareStatement(insertSQL)) {
            pstmt.setInt(1, measureId);  // Set the measure_id explicitly
            pstmt.setInt(2, farmId);
            pstmt.setString(3, sustainability_Type); // sustainability_type
            pstmt.setDate(4, implementationDate);
            pstmt.setString(5, effectiveness); // Effectiveness
            pstmt.executeUpdate();
        } catch (SQLException e) {
            e.printStackTrace();
        }
    }

    // Read sustainability measures
    public ResultSet readSustainabilityMeasures() {
        String selectSQL = "SELECT * FROM sustainability_measures";
        try {
            Connection connection = connect();
            PreparedStatement pstmt =
connection.prepareStatement(selectSQL);
            return pstmt.executeQuery();
        } catch (SQLException e) {
            e.printStackTrace();
```

```
        }
        return null;
    }

    // Update sustainability measure (including measure_id in WHERE
clause)
    public void updateSustainabilityMeasure(int measureId, int farmId, String
sustainability_Type, Date implementationDate, String effectiveness) {
        String updateSQL = "UPDATE sustainability_measures SET farm_id =
?, sustainability_type = ?, implementation_date = ?, effectiveness = ?
WHERE measure_id = ?";
        try (Connection connection = connect();
             PreparedStatement pstmt =
connection.prepareStatement(updateSQL)) {
            pstmt.setInt(1, farmId);
            pstmt.setString(2, sustainability_Type); // sustainability_type
            pstmt.setDate(3, implementationDate);
            pstmt.setString(4, effectiveness); // Effectiveness
            pstmt.setInt(5, measureId); // Where measure_id is used to identify
the record
            pstmt.executeUpdate();
        } catch (SQLException e) {
            e.printStackTrace();
        }
    }

    // Delete sustainability measure (including measure_id for deletion)
    public void deleteSustainabilityMeasure(int measureId) {
```

```
        String deleteSQL = "DELETE FROM sustainability_measures WHERE
measure_id = ?";
        try (Connection connection = connect();
             PreparedStatement pstmt =
connection.prepareStatement(deleteSQL)) {
            pstmt.setInt(1, measureId); // The measure_id is used to identify the
record to be deleted
            pstmt.executeUpdate();
        } catch (SQLException e) {
            e.printStackTrace();
        }
    }
}

import javax.swing.*;
import javax.swing.table.DefaultTableModel;
import java.awt.*;
import java.awt.event.ActionEvent;
import java.awt.event.ActionListener;
import java.sql.ResultSet;
import java.sql.SQLException;
import java.sql.Date;

public class SustainabilityMeasuresGUI extends JFrame {
    private JTextField measureIdField, farmIdField, sustainabilityTypeField, implementationDateField,
effectivenessField;
    private JButton addButton, updateButton, deleteButton, loadButton;
    private JTable measuresTable;
    private DefaultTableModel tableModel;
    private DatabaseManager dbManager;

    public SustainabilityMeasuresGUI() {
        dbManager = new DatabaseManager();
        setTitle("Sustainability Measures Management");
        setLayout(new BorderLayout());
```

```
        // Input panel
        JPanel inputPanel = new JPanel(new GridLayout(5, 2));
        inputPanel.add(new JLabel("Measure ID:"));
        measureIdField = new JTextField();
        inputPanel.add(measureIdField);
        inputPanel.add(new JLabel("Farm ID:"));
        farmIdField = new JTextField();
        inputPanel.add(farmIdField);
        inputPanel.add(new JLabel("Sustainability Type:"));
        sustainabilityTypeField = new JTextField();
        inputPanel.add(sustainabilityTypeField);
        inputPanel.add(new JLabel("Implementation Date (YYYY-MM-DD):"));
        implementationDateField = new JTextField();
        inputPanel.add(implementationDateField);
        inputPanel.add(new JLabel("Effectiveness:"));
        effectivenessField = new JTextField();
        inputPanel.add(effectivenessField);

        // Button panel
        JPanel buttonPanel = new JPanel();
        addButton = new JButton("Add");
        updateButton = new JButton("Update");
        deleteButton = new JButton("Delete");
        loadButton = new JButton("Load");
        buttonPanel.add(addButton);
        buttonPanel.add(updateButton);
        buttonPanel.add(deleteButton);
        buttonPanel.add(loadButton);

        // Table
        tableModel = new DefaultTableModel(new String[]{"Measure ID", "Farm ID", "Sustainability
Type", "Implementation Date", "Effectiveness"}, 0);
        measuresTable = new JTable(tableModel);
        JScrollPane scrollPane = new JScrollPane(measuresTable);

        // Add components to the frame
        add(inputPanel, BorderLayout.NORTH);
        add(scrollPane, BorderLayout.CENTER);
```

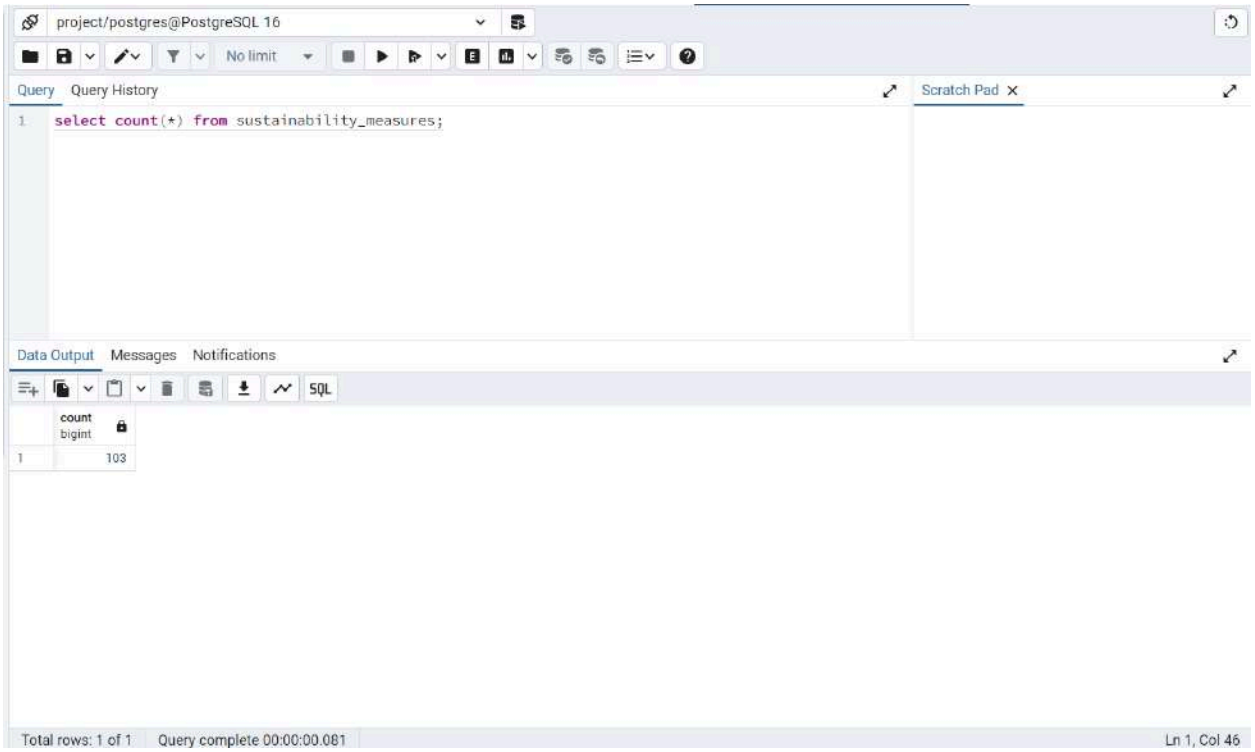
```
        add(buttonPanel, BorderLayout.SOUTH);

        // Action listeners
        addButton.addActionListener(new ActionListener() {
            @Override
            public void actionPerformed(ActionEvent e) {
                try {
                    int measureId = Integer.parseInt(measureIdField.getText());
                    int farmId = Integer.parseInt(farmIdField.getText());
                    String sustainabilityType = sustainabilityTypeField.getText();
                    Date implementationDate = Date.valueOf(implementationDateField.getText());
                    String effectiveness = effectivenessField.getText();
                    dbManager.insertSustainabilityMeasure(measureId, farmId, sustainabilityType,
implementationDate, effectiveness);
                    loadMeasures();  // Refresh table after insert
                } catch (NumberFormatException ex) {
                    JOptionPane.showMessageDialog(SustainabilityMeasuresGUI.this, "Please enter valid
numbers for Measure ID and Farm ID.", "Input Error", JOptionPane.ERROR_MESSAGE);
                }
            }
        });

        updateButton.addActionListener(new ActionListener() {
            @Override
            public void actionPerformed(ActionEvent e) {
                try {
                    int measureId = Integer.parseInt(measureIdField.getText());
                    int farmId = Integer.parseInt(farmIdField.getText());
                    String sustainabilityType = sustainabilityTypeField.getText();
                    Date implementationDate = Date.valueOf(implementationDateField.getText());
                    String effectiveness = effectivenessField.getText();
                    dbManager.updateSustainabilityMeasure(measureId, farmId, sustainabilityType,
implementationDate, effectiveness);
                    loadMeasures();  // Refresh table after update
                } catch (NumberFormatException ex) {
                    JOptionPane.showMessageDialog(SustainabilityMeasuresGUI.this, "Please enter valid
numbers for Measure ID and Farm ID.", "Input Error", JOptionPane.ERROR_MESSAGE);
                }
            }
```

```
        });

        deleteButton.addActionListener(new ActionListener() {
            @Override
            public void actionPerformed(ActionEvent e) {
                try {
                    int measureId = Integer.parseInt(measureIdField.getText());
                    dbManager.deleteSustainabilityMeasure(measureId);
                    loadMeasures();  // Refresh table after deletion
                } catch (NumberFormatException ex) {
                    JOptionPane.showMessageDialog(SustainabilityMeasuresGUI.this, "Please enter a
valid Measure ID to delete.", "Input Error", JOptionPane.ERROR_MESSAGE);
                }
            }
        });

        loadButton.addActionListener(new ActionListener() {
            @Override
            public void actionPerformed(ActionEvent e) {
                loadMeasures();  // Load data when 'Load' button is clicked
            }
        });

        setSize(800, 500);
        setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
        setVisible(true);
    }

    // Load sustainability measures into the table
    private void loadMeasures() {
        try {
            ResultSet resultSet = dbManager.readSustainabilityMeasures();
            tableModel.setRowCount(0); // Clear existing data

            if (resultSet == null || !resultSet.next()) {
                JOptionPane.showMessageDialog(this, "No data found!", "Info",
JOptionPane.INFORMATION_MESSAGE);
            } else {
                do {
```

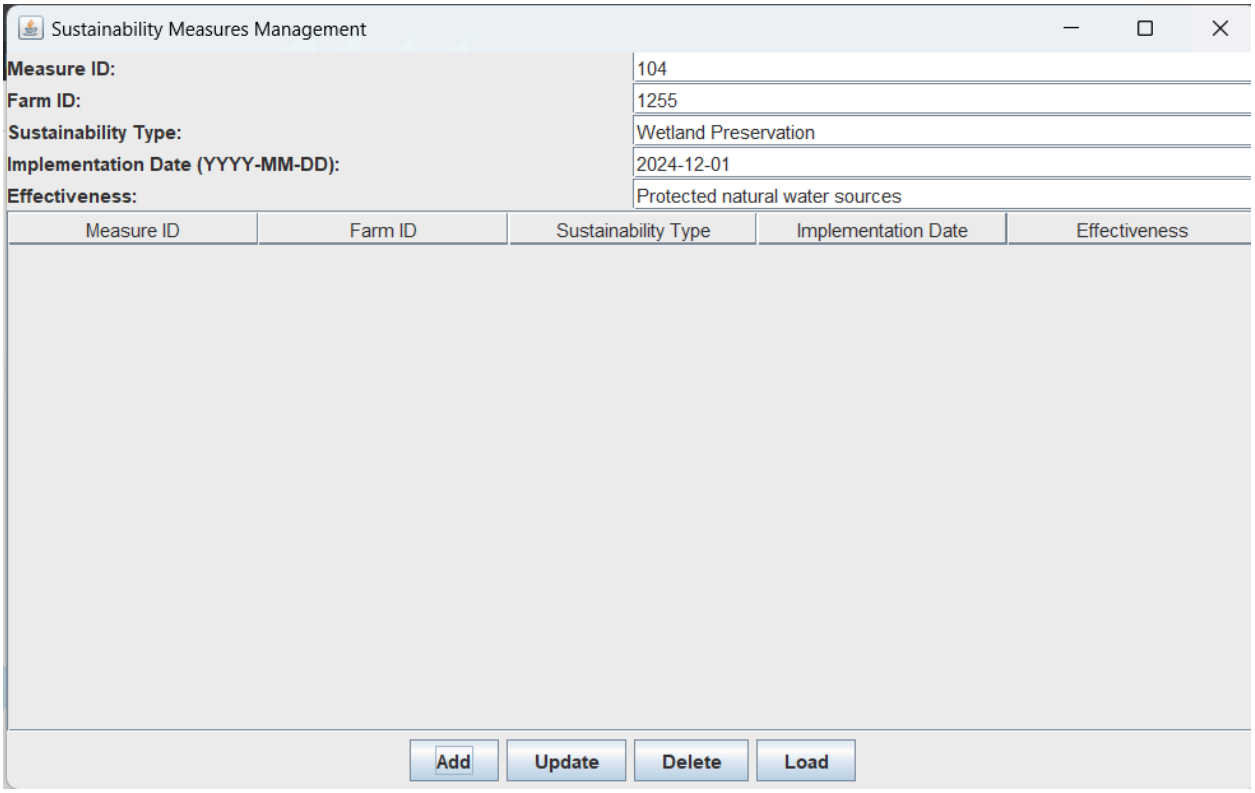
```
                int measureId = resultSet.getInt("measure_id");
                int farmId = resultSet.getInt("farm_id");
                String sustainabilityType = resultSet.getString("sustainability_type");
                Date implementationDate = resultSet.getDate("implementation_date");
                String effectiveness = resultSet.getString("effectiveness");
                tableModel.addRow(new Object[]{measureId, farmId, sustainabilityType,
implementationDate, effectiveness});
            } while (resultSet.next());
        }
    } catch (SQLException e) {
        e.printStackTrace();
        JOptionPane.showMessageDialog(this, "Error loading data from the database.", "Error",
JOptionPane.ERROR_MESSAGE);
    }
  }

  public static void main(String[] args) {
    new SustainabilityMeasuresGUI();
  }
}
```

Add opperation:

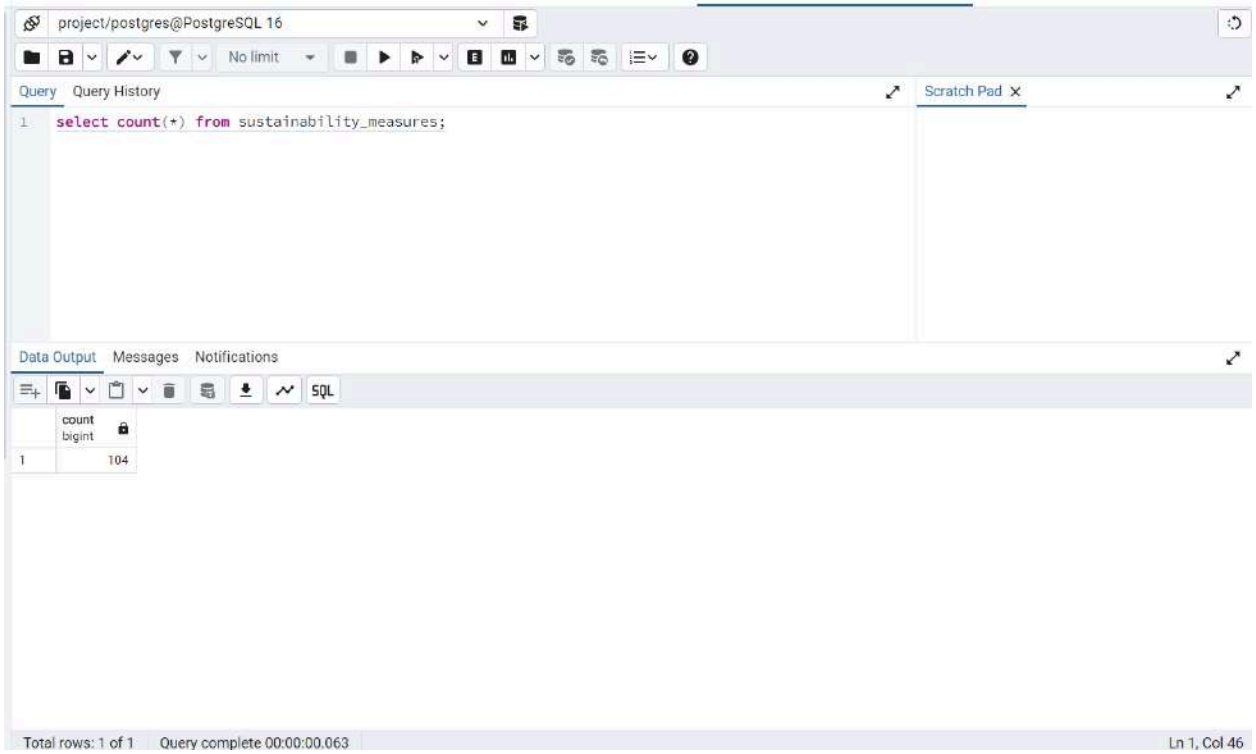
Count of records before add :



Add operation :

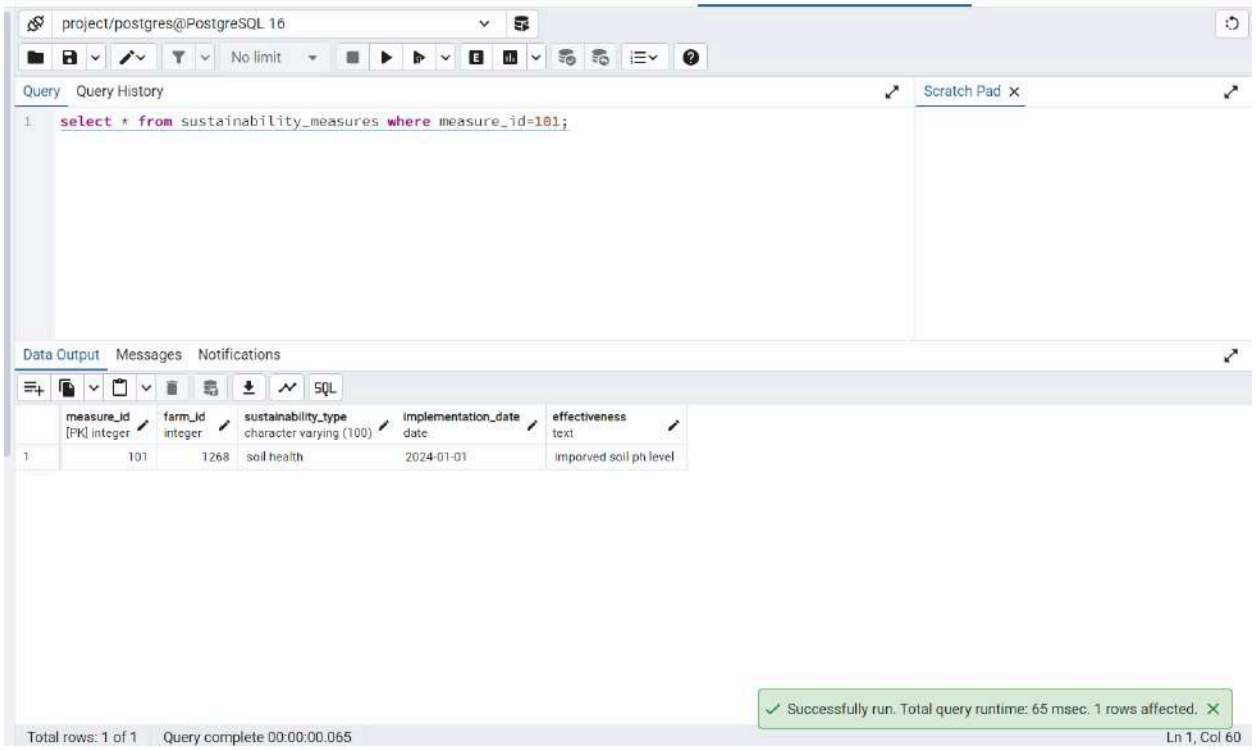


Count after add

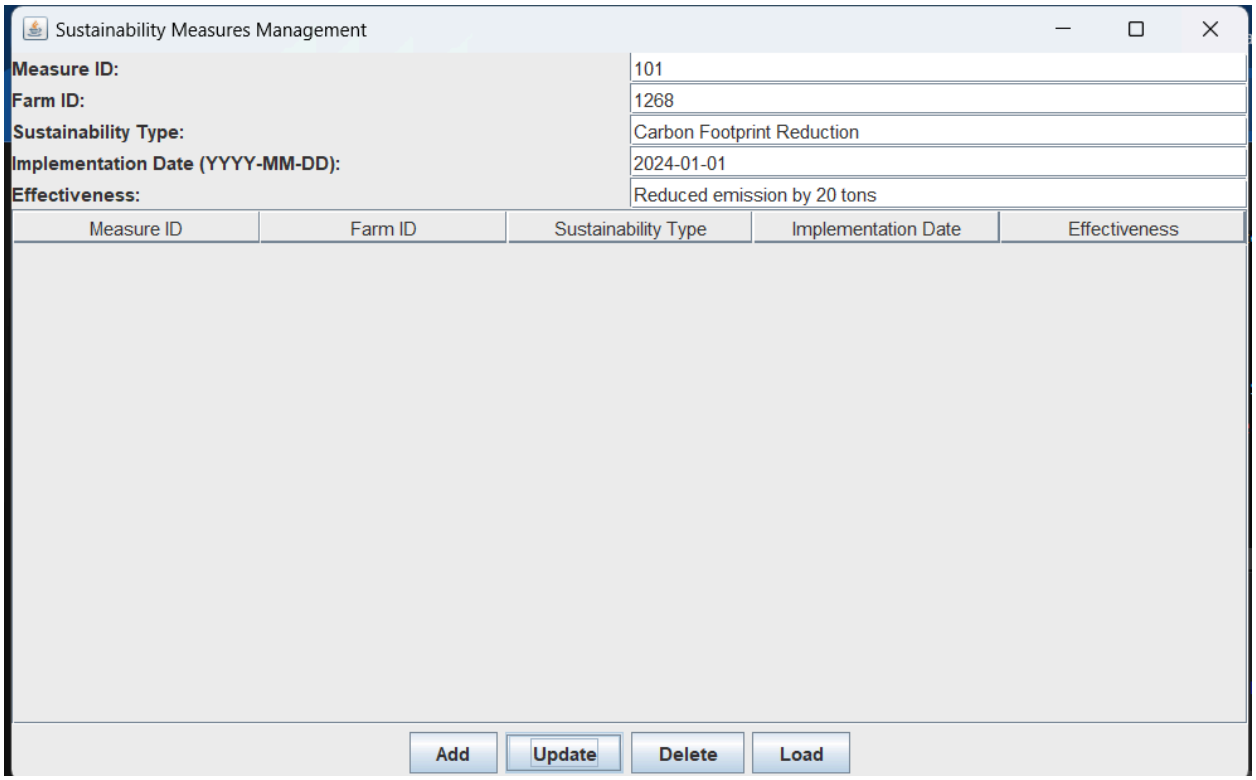


Update operation

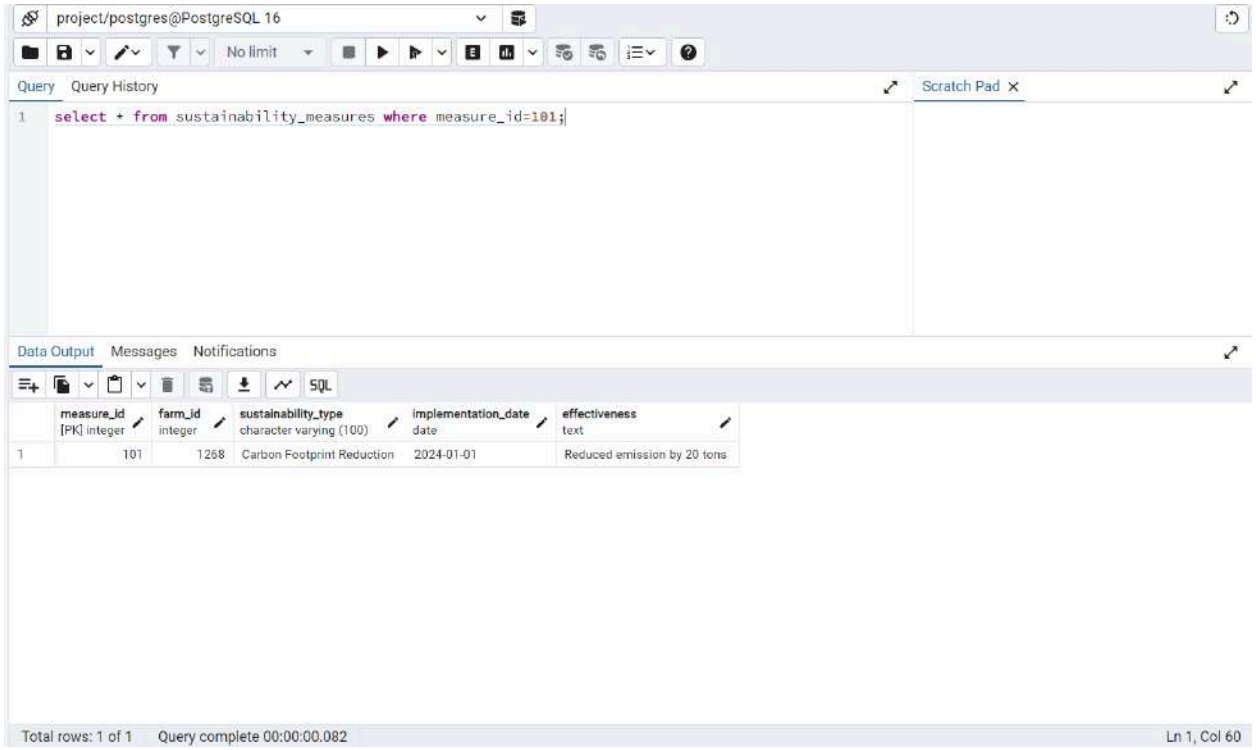
Record before update



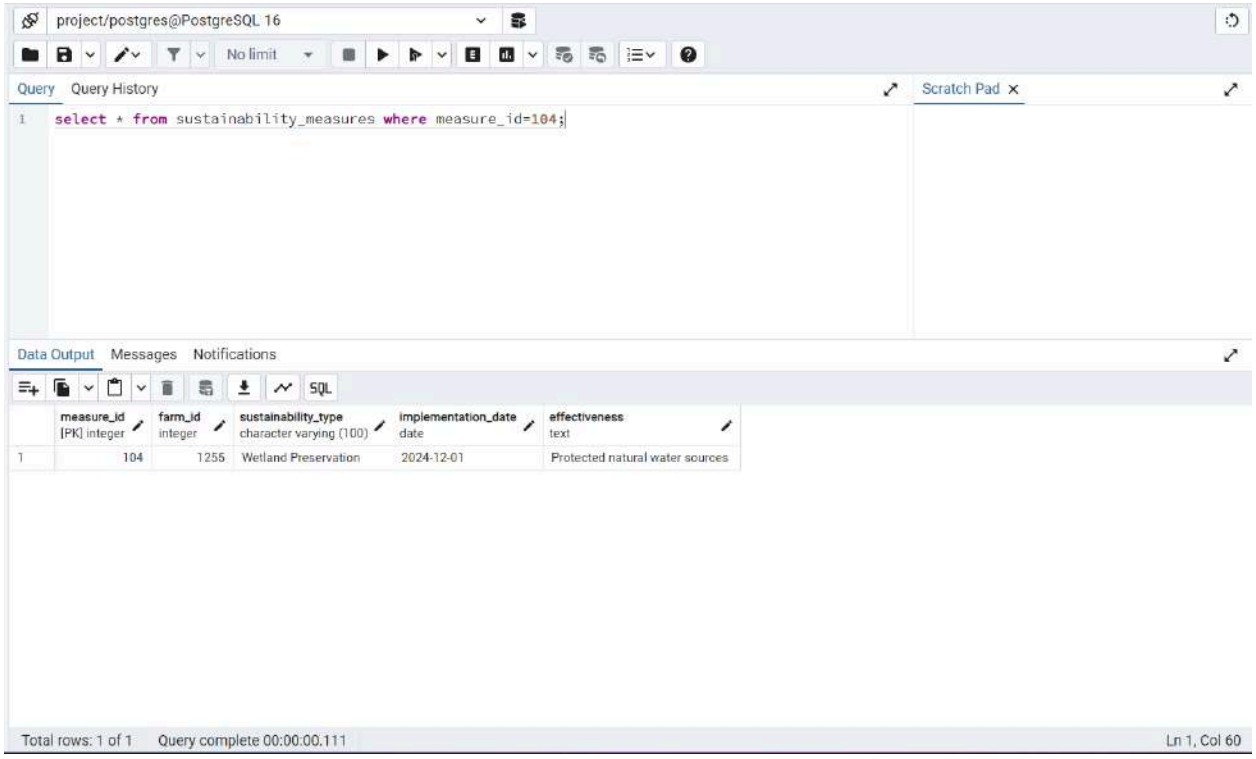
Update



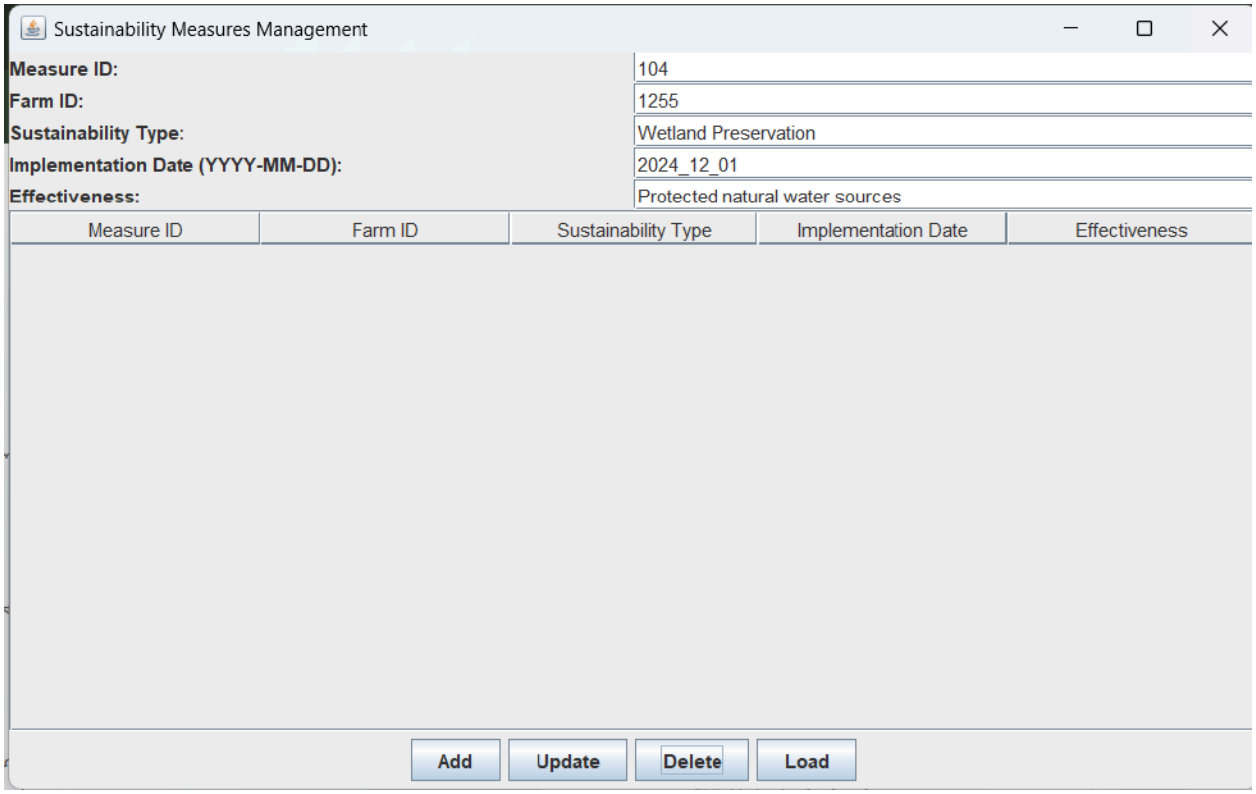
Record after update



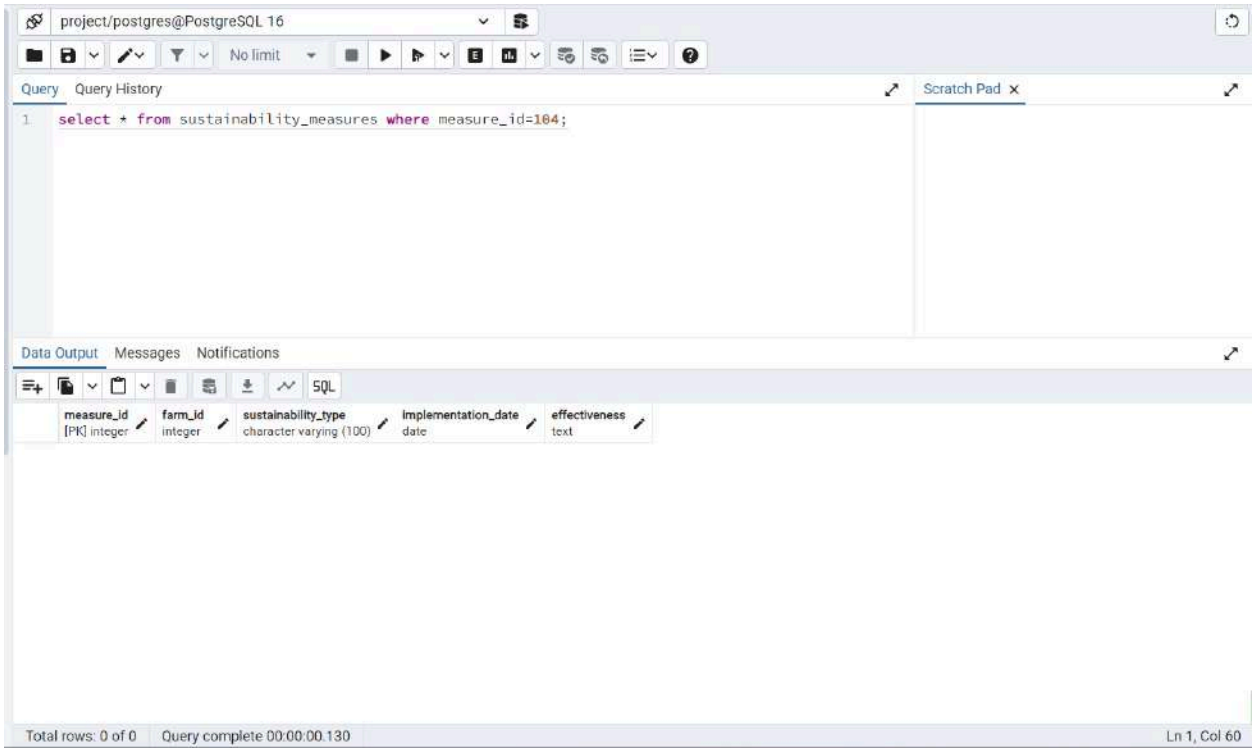
Delete operation
Record to be deleted



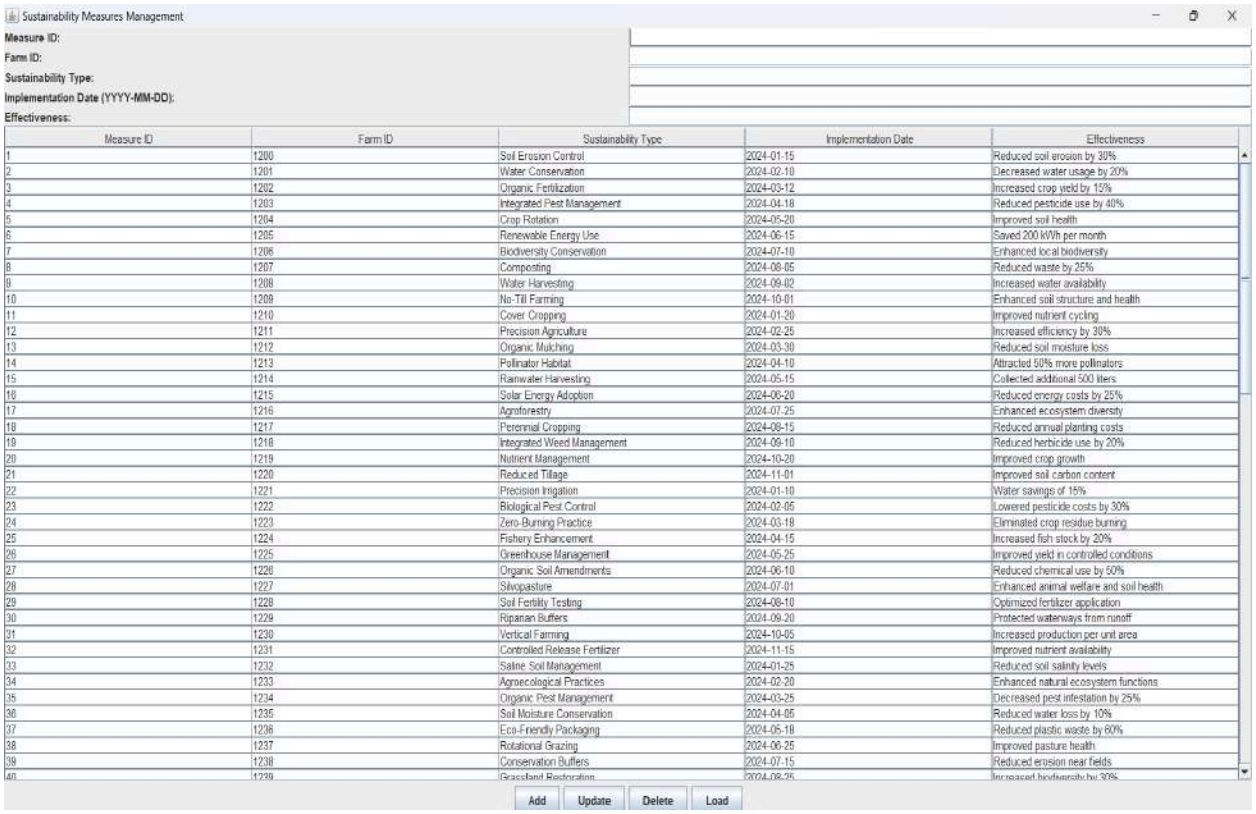
Delete operation:



After delete operation

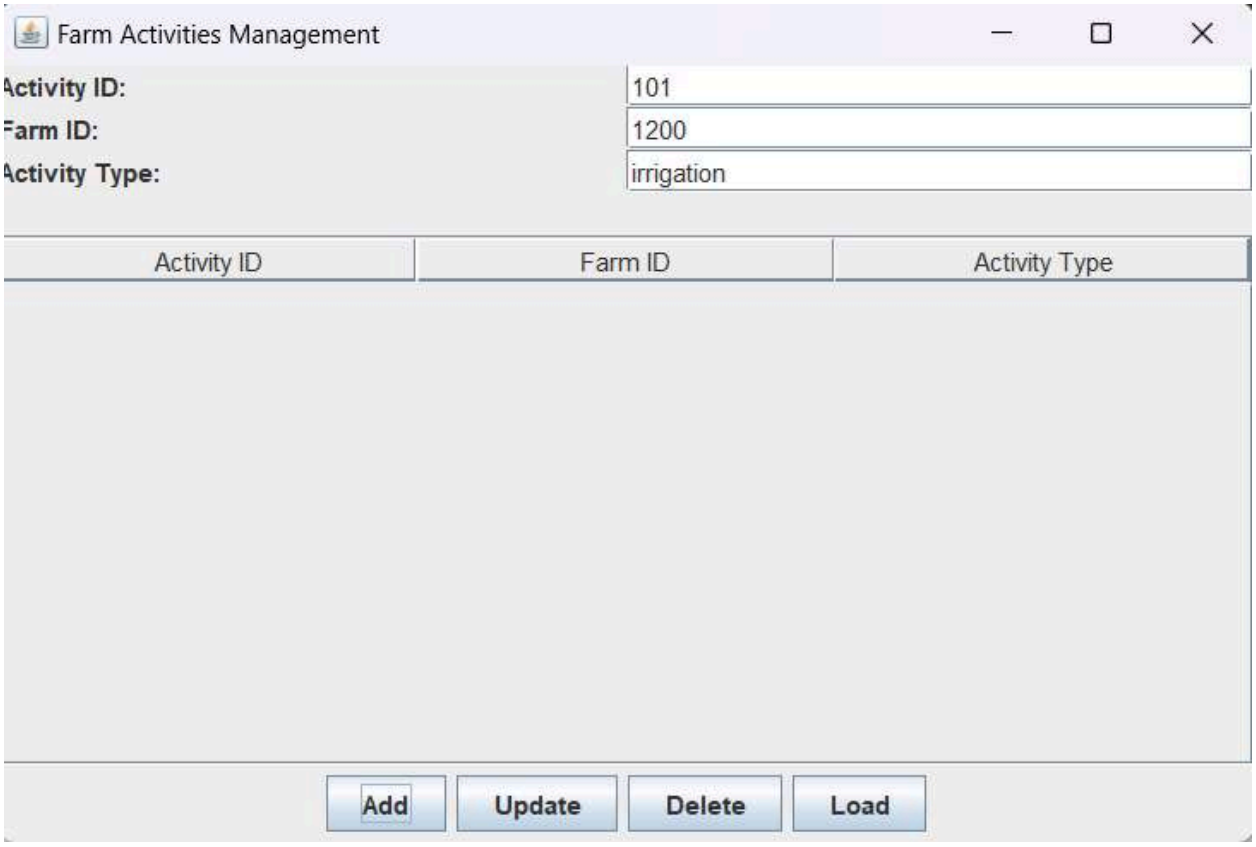


Load operation

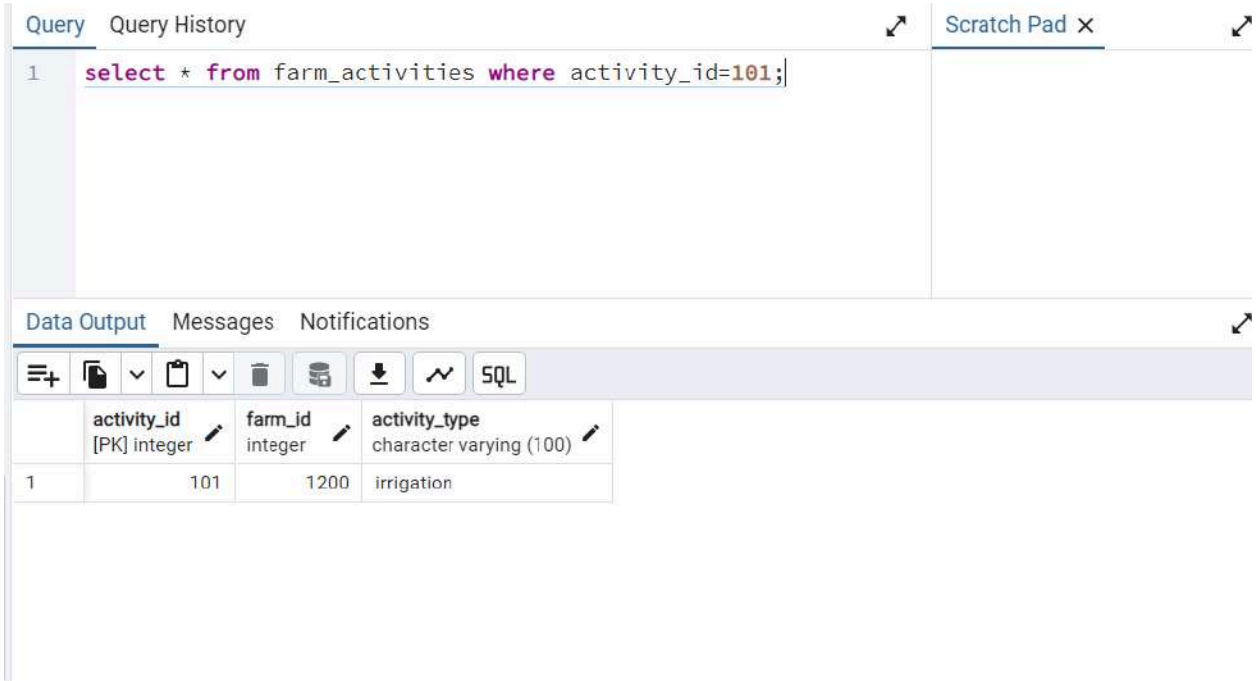


Measure ID	Farm ID	Sustainability Type	Implementation Date	Effectiveness
1	1200	Soil Erosion Control	2024-01-15	Reduced soil erosion by 30%
2	1201	Water Conservation	2024-02-10	Decreased water usage by 20%
3	1202	Organic Fertilization	2024-03-12	Increased crop yield by 15%
4	1203	Integrated Pest Management	2024-04-18	Reduced pesticide use by 40%
5	1204	Crop Rotation	2024-05-20	Improved soil health
6	1205	Renewable Energy Use	2024-06-15	Saved 200 kWh per month
7	1206	Biodiversity Conservation	2024-07-10	Enhanced local biodiversity
8	1207	Composting	2024-08-05	Reduced waste by 25%
9	1208	Water Harvesting	2024-09-02	Increased water availability
10	1209	No-Till Farming	2024-10-01	Enhanced soil structure and health
11	1210	Cover Cropping	2024-01-20	Improved nutrient cycling
12	1211	Precision Agriculture	2024-02-25	Increased efficiency by 30%
13	1212	Organic Mulching	2024-03-30	Reduced soil moisture loss
14	1213	Pollinator Habitat	2024-04-10	Attracted 50% more pollinators
15	1214	Rainwater Harvesting	2024-05-15	Collected additional 500 liters
16	1215	Solar Energy Adoption	2024-06-20	Reduced energy costs by 25%
17	1216	Agroforestry	2024-07-25	Enhanced ecosystem diversity
18	1217	Perennial Cropping	2024-08-15	Reduced annual planting costs
19	1218	Integrated Weed Management	2024-09-10	Reduced herbicide use by 20%
20	1219	Nutrient Management	2024-10-20	Improved crop growth
21	1220	Reduced Tillage	2024-11-01	Improved soil carbon content
22	1221	Precision Irrigation	2024-01-10	Water savings of 15%
23	1222	Biological Pest Control	2024-02-05	Lowered pesticide costs by 30%
24	1223	Zero-Burning Practice	2024-03-18	Eliminated crop residue burning
25	1224	Fishery Enhancement	2024-04-15	Increased fish stock by 20%
26	1225	Greenhouse Management	2024-05-25	Improved yield in controlled conditions
27	1226	Organic Soil Amendments	2024-06-10	Reduced chemical use by 50%
28	1227	Silvopasture	2024-07-01	Enhanced animal welfare and soil health
29	1228	Soil Fertility Testing	2024-08-10	Optimized fertilizer application
30	1229	Riparian Buffers	2024-09-20	Protected waterways from runoff
31	1230	Vertical Farming	2024-10-05	Increased production per unit area
32	1231	Controlled Release Fertilizer	2024-11-15	Improved nutrient availability
33	1232	Saline Soil Management	2024-01-25	Reduced soil salinity levels
34	1233	Agroecological Practices	2024-02-20	Enhanced natural ecosystem functions
35	1234	Organic Pest Management	2024-03-25	Decreased pest infestation by 25%
36	1235	Soil Moisture Conservation	2024-04-05	Reduced water loss by 10%
37	1236	Eco-Friendly Packaging	2024-05-18	Reduced plastic waste by 60%
38	1237	Rotational Grazing	2024-06-25	Improved pasture health
39	1238	Conservation Buffers	2024-07-15	Reduced erosion near fields
40	1239	Grassland Restoration	2024-08-25	Increased biodiversity by 30%

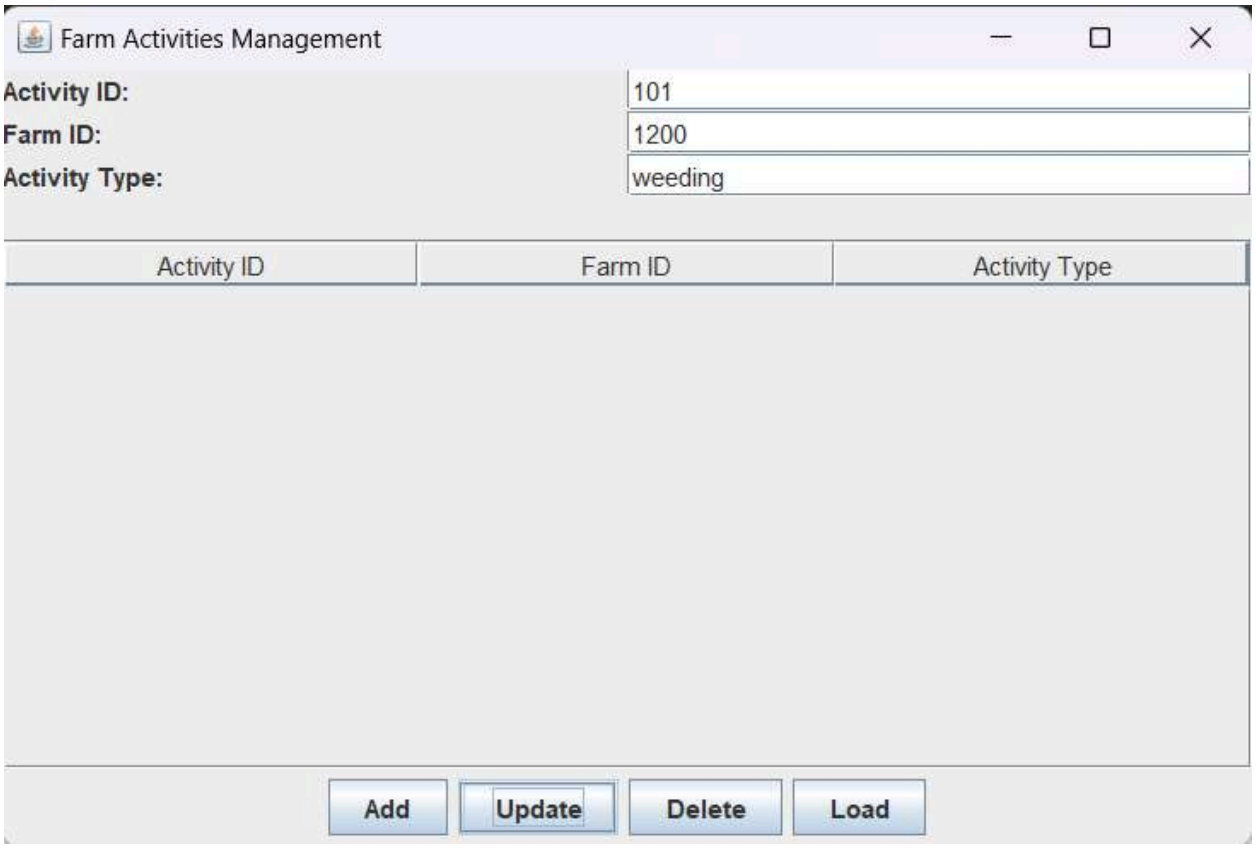
2. Farm_activities table



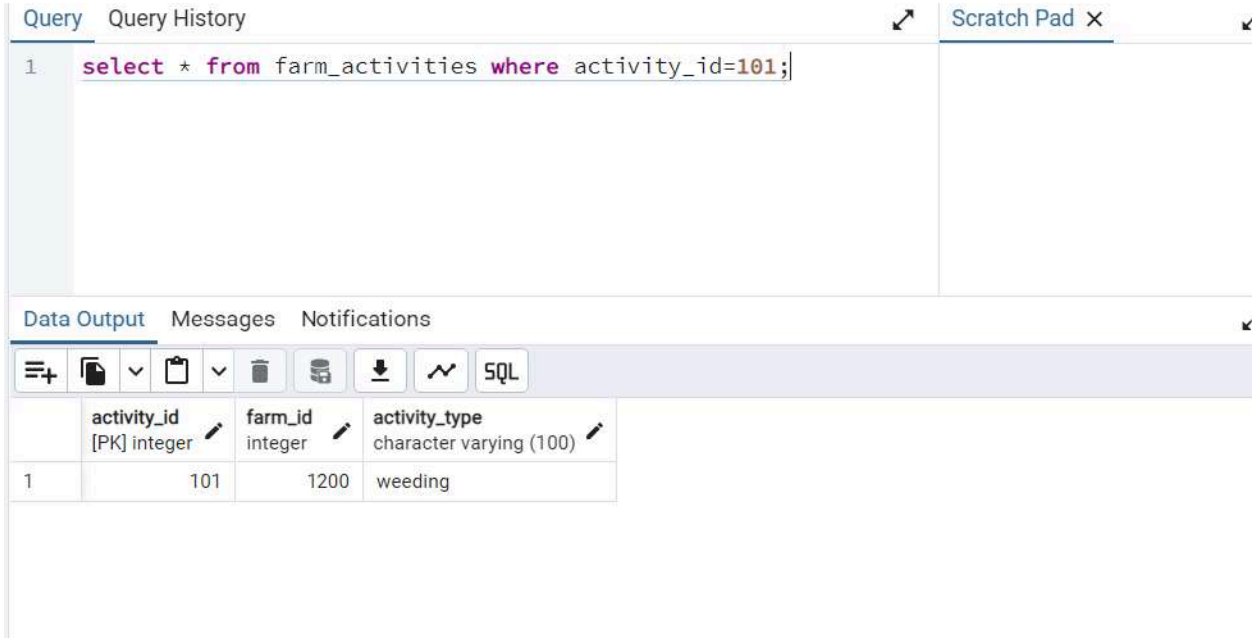
Successfully added records with Activity ID 101



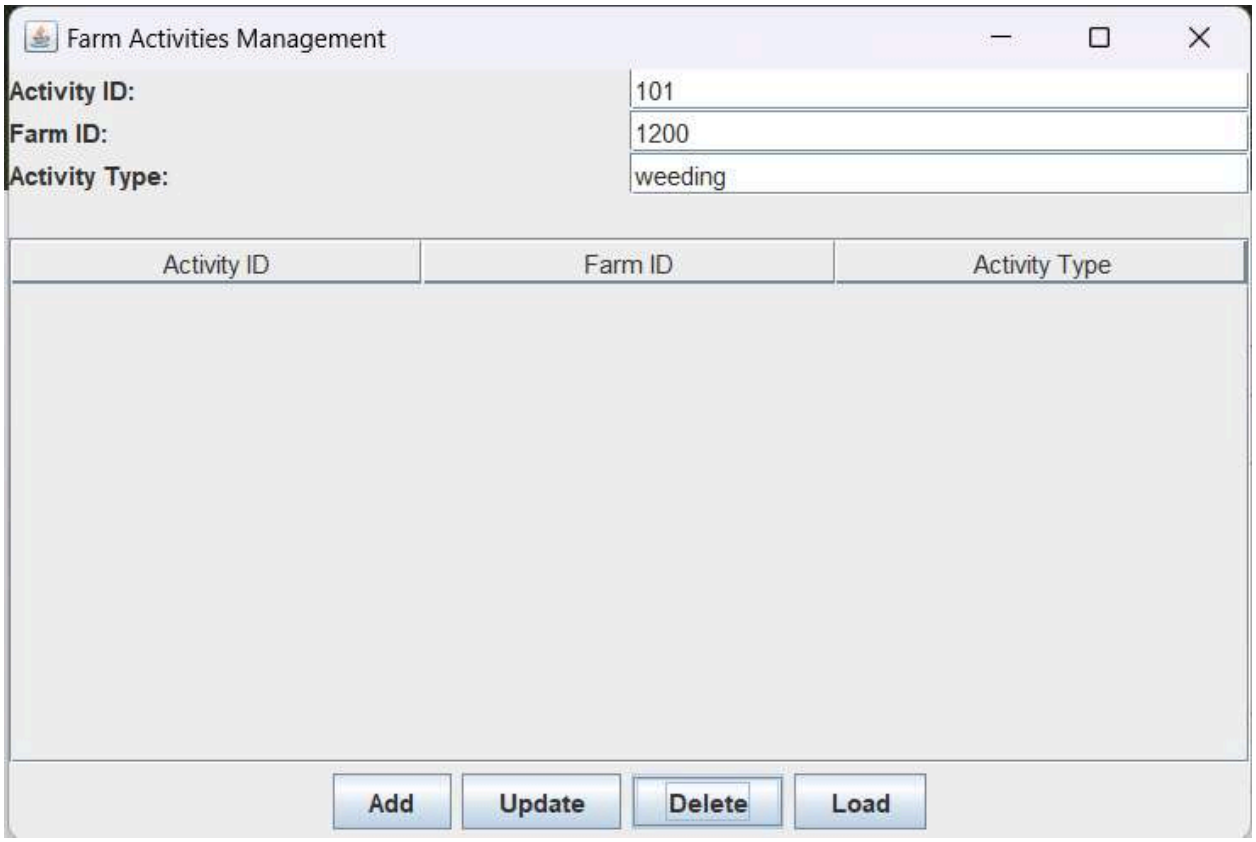
Update operation



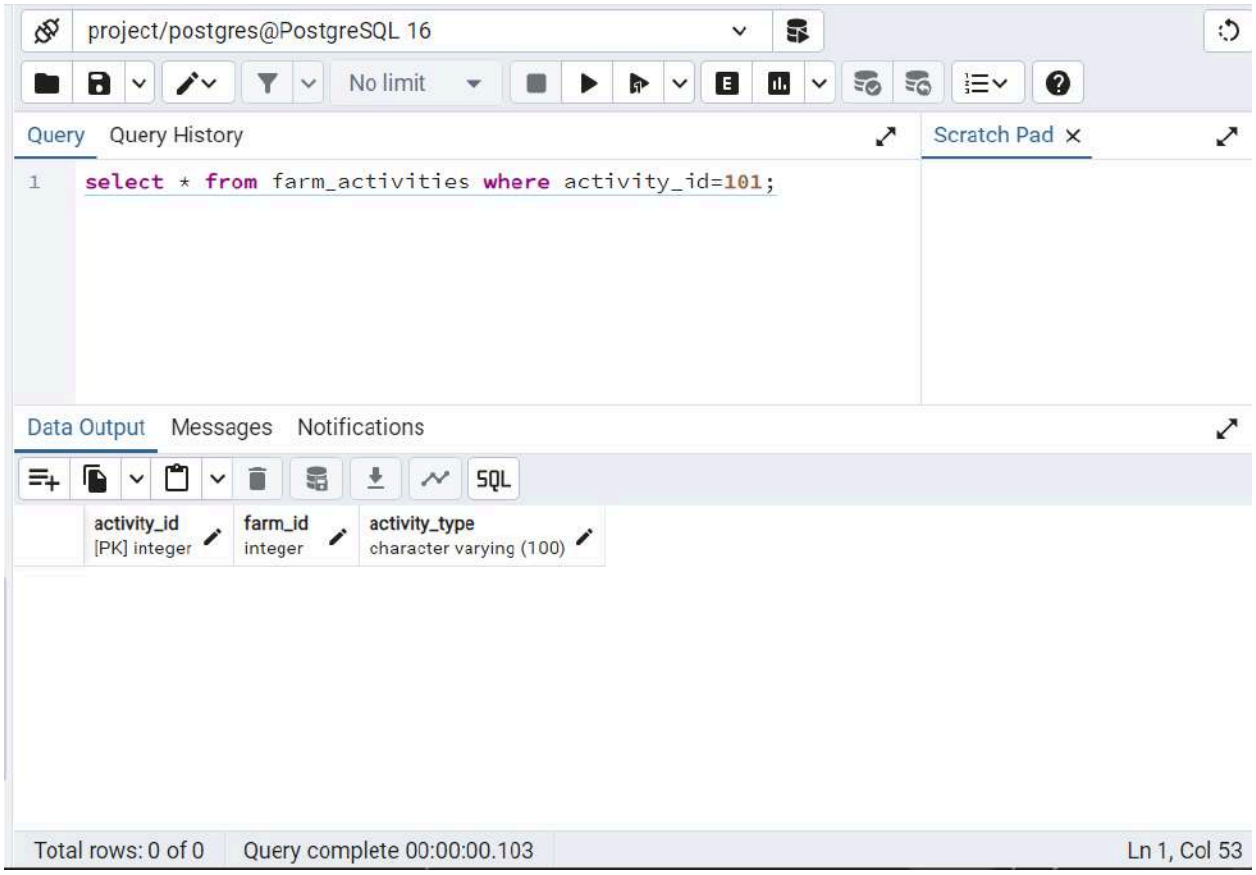
Successfully updated record with activity id 101



Delete operation



Successfully deleted record with activity_id=101;


project/postgres@PostgreSQL 16
No limit
Query
Query History
Scratch Pad
1
select * from farm_activities where activity_id=101;
Data Output
Messages
Notifications
SQL
activity_id
[PK] integer
farm_id
integer
activity_type
character varying (100)
Total rows: 0 of 0
Query complete 00:00:00.103
Ln 1, Col 53

Chapter 6: Technical Issues and Solutions

6.1 Technical Issues

In this section, we outline the significant technical challenges faced during the development and execution of the database system. These challenges impacted the project's progress and efficiency. The primary issues are as follows:

1. **Data Redundancy and Duplication**
    - *Impact*: Redundant data led to inefficiencies in storage and potential inconsistencies, complicating updates and maintenance.
    - *Description*: Overlapping attributes across multiple tables, particularly in the *Farm_Activities* and *Research_Data* tables, resulted in repeated entries.
2. **Managing Complex Relationships**
    - *Impact*: The complexity of relationships, especially ternary ones involving *Researchers*, *Research_Data*, *Carbon_Footprint_Tracking*, and *Carbon_Tracking*, presented challenges in maintaining clarity and consistency.
    - *Description*: Effectively managing and representing these relationships in the database schema required careful design to prevent integrity issues.
3. **Scalability and Performance**
    - *Impact*: As the database grew, queries that accessed large tables, like *Farm_Activities*, became sluggish, affecting response times.
    - *Description*: The performance of queries, especially those dealing with historical data or large aggregations, was impacted as the data volume increased.
4. **Ensuring Data Integrity**

- *Impact*: Maintaining accurate and consistent data, particularly dynamic values such as *Carbon_Emissions*, proved challenging.
- *Description*: Inconsistent data entry or incorrect relationships among tables led to data errors and discrepancies.

5. **Security and Access Control**
   - *Impact*: Securing sensitive data and managing access privileges for different user roles, such as researchers and policymakers, was a critical issue.
   - *Description*: Defining roles and enforcing appropriate data access controls to protect sensitive information was an ongoing challenge.

6.2 Solution

Approaches and Tools Used for Resolving Issues

This section outlines the strategies, tools, and methodologies applied to resolve the challenges mentioned earlier.

1. **Normalization and Validation of Data**
   - *Solution*: The database schema was normalized to minimize redundancy, and data validation rules were incorporated to ensure consistency and integrity during data entry.
   - *Tools*: SQL constraints, stored procedures, and triggers were used to enforce validation and ensure data consistency across tables.
2. **Refinement of the Entity-Relationship (ER) Diagram**
   - *Solution*: The ER diagram was restructured to handle complex relationships more effectively, using intermediary tables for ternary relationships and foreign keys to maintain data integrity.
   - *Tools*: Tools such as MySQL Workbench were used to visualize and refine the database design, improving clarity and reducing redundancy.
3. **Query Optimization and Indexing**

    - *Solution*: Indexes were implemented on frequently queried fields (e.g., *Farm_ID*, *Crop_ID*, *Research_ID*) to improve query performance and reduce response times.
    - *Tools*: Database management systems like MySQL and PostgreSQL query optimizers were used to identify slow-performing queries and optimize them for better efficiency.
4. **Data Integrity Enforcement**
    - *Solution*: Automated scripts were developed to detect and fix inconsistencies in data. Foreign key constraints were applied to ensure referential integrity across related tables.
    - *Tools*: Built-in data integrity mechanisms in the DBMS, such as foreign keys and triggers, were employed to keep the data consistent and accurate.
5. **Implementation of Role-Based Access Control (RBAC)**
    - *Solution*: A role-based access control system was implemented to restrict user access based on their roles (e.g., farmers, researchers, policymakers), ensuring that only authorized users could modify or view sensitive data.
    - *Tools*: MySQL's user management system and custom scripts were used to enforce security policies and manage permissions.

Alternative Solutions Considered

In addition to the solutions adopted, several alternative approaches were evaluated for addressing the technical challenges:

1. **NoSQL Database for Flexibility and Scalability**
    - *Considered Solution*: A NoSQL database like MongoDB was considered to handle the unstructured or semi-structured nature of some data, which could provide more flexibility and scalability.
    - *Reason for Rejection*: Although NoSQL could offer flexibility, it was rejected due to the structured nature of the project and the

need for strong data integrity, which is better maintained in a relational database.

2. **Data Warehousing for Analytics**
    - *Considered Solution*: Implementing a separate data warehouse to store historical data, making it easier to analyze large volumes of data without affecting the operational database.
    - *Reason for Rejection*: This approach was not adopted as the project's focus was on real-time data management rather than on complex data analysis.
3. **Cloud Database Solutions for Scalability**
    - *Considered Solution*: Using cloud services like AWS RDS or Google Cloud SQL for hosting the database to improve scalability and security.
    - *Reason for Rejection*: The project opted for a local database server to control costs and simplify development, with cloud solutions considered for future scalability.