MA611 – Fundamentals of Python Programming with SQL
(Lab 6)

SOFTWARE REQUIREMENTS SPECIFICATION

FERTIGuide

(Version 1.0)

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1. INTRODUCTION

Purpose:

The purpose of FERTIGuide is to create a web-based application that assists farmers in choosing the optimal fertilizer based on soil properties and crop needs. The system will provide a user-friendly platform for real-time, region-specific fertilizer recommendations to improve crop yield and minimize excess fertilizer usage. FERTIGuide aims to deliver a user-friendly web-based fertilizer recommendation system that provides region-specific, data-driven recommendations. It leverages soil health data and crop-specific requirements to minimize overuse of fertilizers and improve crop productivity.

Intended Audience:

- Farmers: For optimizing fertilizer usage in their crops.
- Agricultural Experts: To offer advisory services.
- Government Organizations: To improve service delivery related to soil health and crop production.
- Developers and Testers: For system implementation and validation.

Objective:

- Provide accurate, data-driven fertilizer recommendations based on soil and crop data.
- Minimize environmental damage from over-fertilization.
- Enable easy-to-use interfaces accessible via web and mobile.
- Integrate with local and regional databases for soil, weather, and crop data.
- Support agricultural advisory services through expert systems.

Scope:

This project aims to provide a recommendation system accessible through both web and mobile platforms, using machine learning to analyze soil properties (pH, NPK values, etc.), crop type, and weather conditions for optimal fertilizer selection. The FERTIGuide platform will integrate with external soil testing and weather databases to generate personalized recommendations. It will cover key crops across multiple regions, ensuring that advice is accurate, timely, and localized.

2. OVERALL DESCRIPTION

Product prescriptive:

FERTIGuide will integrate soil testing data, crop-specific requirements, and regional weather patterns into a recommendation engine powered by machine learning models, ensuring farmers receive real-time, region-specific recommendations. FERTIGuide will act as a recommendation engine powered by machine learning models, with a frontend accessible to users via both web and mobile applications. It will interface with government and local databases to provide up-to-date soil health data and offer recommendations that are based on a range of inputs, including soil NPK levels, pH, moisture, and local weather conditions.

Product Functions:

- Soil Data Input: Enables manual or automated entry of soil health data.
- Crop Selection: Users can input their current crop or select from a database of predefined crops.
- Fertilizer Recommendations: Based on soil and crop inputs, the system generates fertilizer suggestions.
- Report Generation: Users can generate and export a PDF report detailing recommendations.
- Feedback and Support: Users can submit feedback or consult with experts for additional guidance.

Users:

- Farmers, agricultural scientists, consultants, and government agencies.
- Users have varying levels of computer literacy, so the interface will need to be intuitive and localized in multiple languages.

Business Scenarios:

- Current State: Farmers often rely on generalized advice, which can lead to incorrect fertilizer usage.
- Future State: FERTIGuide automates the recommendation process, ensuring that every farmer receives data-driven and customized advice.

3. SPECIFIC REQUIREMENTS

External Interface Requirements:

- **User Interfaces:** A responsive web interface with support for low-latency areas. A simplified mobile interface for farmers with limited access to technology.
- **Hardware Interfaces:** Integration with soil testing devices via Bluetooth or USB connections. Interfacing with external databases such as Soil Health Card or regional crop yield datasets.
- **Software Interfaces:** Integration with APIs for local weather updates and regional agricultural data.
- **Communications Interfaces:** SMS and email-based notifications to provide fertilizer recommendations and system updates.

Product Features:

Use Case 1: Data Input

- Actors: Farmer
- Pre-condition: Farmer has soil test data or performs the test.
- Description: The user inputs soil test data (pH, NPK, moisture, etc.) via web/mobile interface.
- Post-condition: The data is validated and stored for processing.

Use Case 2: Fertilizer Recommendation

- Actors: Farmer, Agricultural Expert
- Pre-condition: Soil and crop data must be available.
- Description: Based on soil data and crop selection, the system provides fertilizer suggestions.
- Post-condition: A detailed report is generated, offering optimal fertilizer quantities and application timing.

Use Case 3: Report Generation

- Actors: Farmer, Agricultural Expert
- Description: After the recommendation is generated, a downloadable PDF report is created, summarizing the fertilizer application strategy.

4. LOGICAL DATA MODEL

Soil Data:

Soil characteristics play a critical role in determining which fertilizers to use and in what amounts. This data set typically includes pH level, Nitrogen, Phosphorous, Potassium, Moisture Content, Micronutrients. Soil pH influences nutrient availability and microbial activity. For instance, acidic soils may limit the availability of phosphorus, requiring adjustments in fertilizer composition. Monitoring nitrogen levels helps in deciding the need for fertilizers like urea. Farmers often use DAP (Diammonium Phosphate) to supplement phosphorus, but soil data can help avoid over-application, which can cause environmental harm. Understanding soil potassium levels can guide the application of potash-based fertilizers.

Crop Data:

Tailoring fertilizer to the specific crop being grown and its current needs is essential. The following crop-related factors need to be considered crop type, growth stage, desired yield. Different crops require varying levels of nutrients. For example, rice is a high nitrogen-demanding crop, while legumes require less due to their nitrogen-fixing abilities.

Fertilizer Database:

The recommendation system should be connected to a comprehensive fertilizer database, including list of fertilizers, chemical composition and costs. A categorized list of available fertilizers, such as nitrogen-based (urea), phosphorus-based (DAP), potassium-based (muriate of potash), and complex fertilizers that provide multiple nutrients. Each fertilizer's nutrient composition (e.g., urea contains 46% nitrogen) must be factored in to calculate exact application rates for balanced nutrition.

Weather Data:

Weather conditions significantly impact fertilizer effectiveness and should be integrated into the recommendation system. Real-time weather data can be accessed through external APIs and include temperature, rainfall, humidity, forecasting. For example, nitrogen volatilization can increase at higher temperatures, reducing its availability to crops.

Integration of Data for Fertilizer Recommendations:

By integrating soil, crop, fertilizer, and weather data, a comprehensive decision-support system can be developed for farmers:

1. **Soil Test Results** would guide baseline recommendations for fertilizers based on nutrient deficiencies or surpluses in the soil.
2. **Crop Type and Growth Stage** would modify those recommendations to fit the specific crop's nutrient requirements at a given stage of its lifecycle.
3. **Fertilizer Database** would ensure that the recommended fertilizer is both available and cost-effective.
4. **Weather Data** would be the final layer, ensuring that fertilizers are applied under optimal conditions, avoiding waste or environmental damage.

5. DATA COLLECTION TECHNIQUES

Interviews:

Interviews with local farmers revealed varied soil testing practices and significant challenges in the use of fertilizers. For instance, farmers from regions such as Palanpur and Ahmedabad predominantly rely on broadcasting methods for applying fertilizers like nitrogen (urea) and phosphorus (DAP). Common challenges include a lack of access to modern technology and the high cost of fertilizer application. Farmers, particularly in areas with smaller farms (less than 1 acre), mentioned the need for affordable technologies to improve the precision of fertilizer use. Those with larger farms, like in Pulivendula, also highlighted concerns over application costs but had access to retailers for information on fertilizer selection.

Background Readings:

A review of government guidelines on soil health management reinforced the need for region-specific fertilizer recommendations, especially given the diversity of soil types observed in the interviews. For example, sandy soils in areas like Palanpur and clay soils in Ahmedabad call for different management practices. Existing fertilizer recommendation systems often fail to account for the real-time variability in factors like water availability (which ranged from 1 to 5 on a scale), further complicating decision-making for farmers.

QUESTIONNAIRE:

(through Google Form Survey)

FERTIGuide Survey - Fertilizer Recommendation

Thank you for participating in the FERTIGuide survey. This survey aims to collect information about your agricultural practices and fertilizer usage to improve fertilizer recommendations based on local soil and crop conditions.

Survey Conducted by M.Sc. Agriculture Analytics, DAIICT

202419012@daiict.ac.in Switch account

Not shared

* Indicates required question

Name *

Your answer

Location *

Your answer

Contact Number *

Your answer

What is the size of your farm? *

- < 1 acre
- 1-5 acres
- > 5 acres

Which crops do you grow? *

- Rice
- Wheat
- Barley
- Maize
- Groundnut
- Vegetables
- Fruits
- Other:

What type of soil is present in your farm? *

- Sandy
- Clay
- Loamy
- Silt
- Mixed

Which fertilizers do you mostly use? *

- [ ] Nitrogen (Urea, etc.)
- [ ] Phosphorus (DAP, etc.)
- [ ] Potassium (MOP, etc.)
- [ ] Organic Manure
- [ ] Micronutrients - Zinc , Boron etc
- [ ] Other:

How do you apply fertilizers? *

- Broadcasting
- Band application
- Foliar application
- Fertigation
- Other:

How often do you apply fertilizers? *

- Once per season
- Twice per season
- > twice per season
- As required

Rate the water availability in your farm (On a scale of 5) *

Your answer

What challenges do you face in fertilizer application? *
(High cost availability, lack of technology, etc.)

Your answer

Where do you get information about fertilizers? *

- Scientists
- Other Farmers
- Government
- Retailers
- Online Sources
- Other:

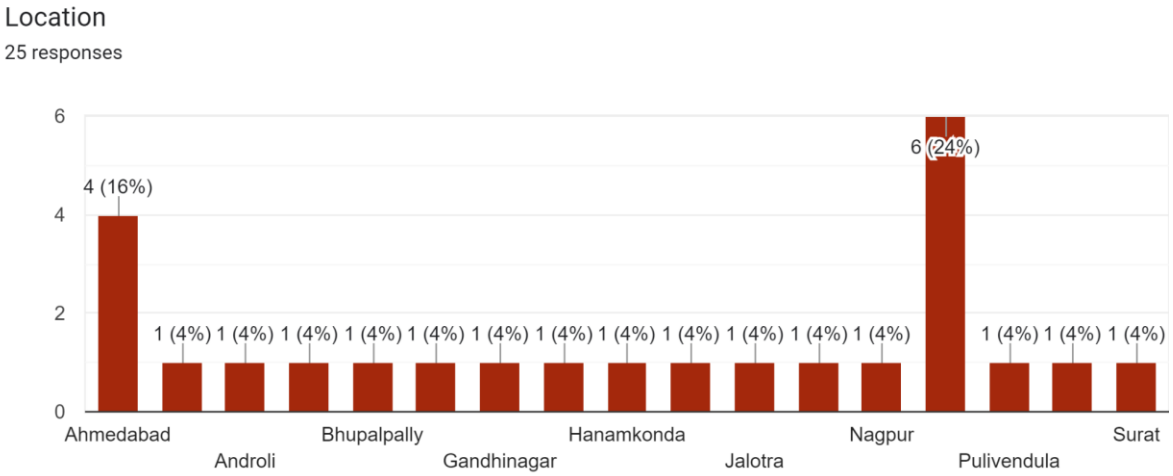
Any other suggestions or feedback regarding fertilizer usage? *

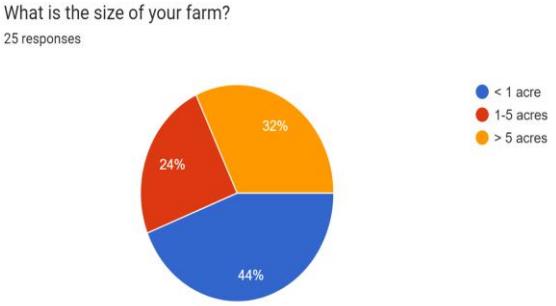
Your answer

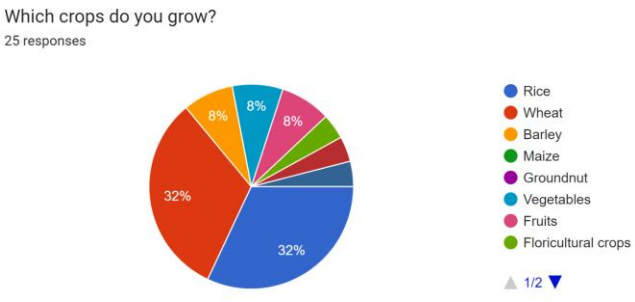
Submit Clear form

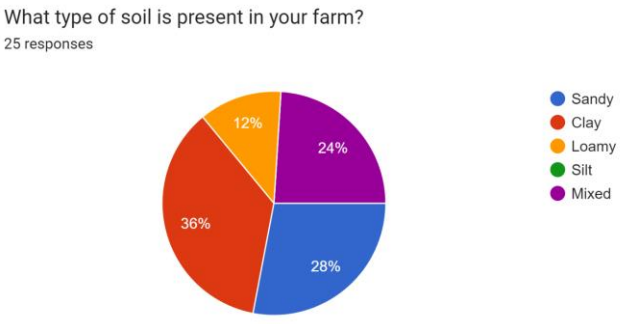
Observations:

During field observations, it became clear that while farmers are aware of crop-specific fertilizer needs, they often lack the tools or knowledge to implement optimal strategies. For instance, crops like rice and wheat are widely grown, but the reliance on traditional fertilizer application methods, such as broadcasting, limits efficiency. The survey data shows that twice-per-season applications are common, yet farmers struggle with the environmental impacts of over-fertilization due to insufficient soil data. The high cost of fertilizers and application methods further exacerbates the challenge, emphasizing the need for better-informed, data-driven decision-making tools in rural farming communities.



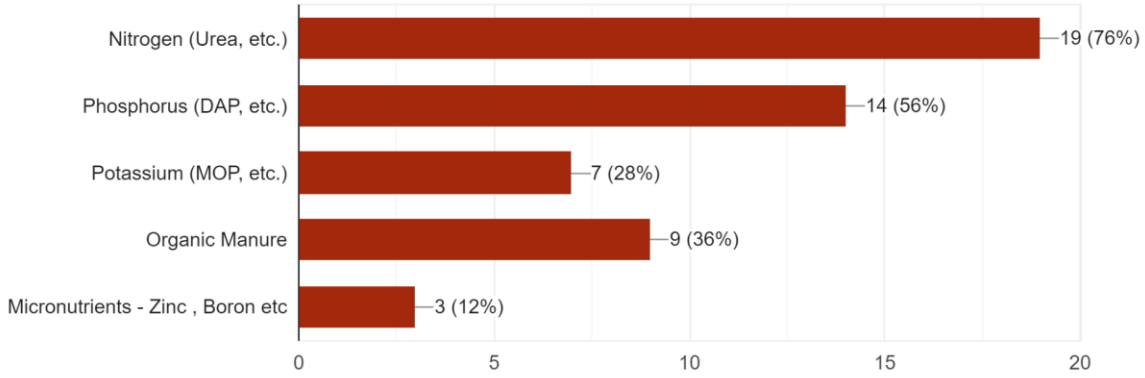






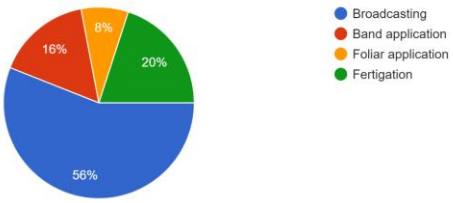
Which fertilizers do you mostly use?

25 responses



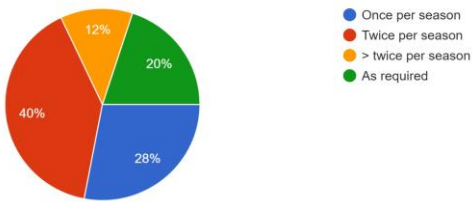
How do you apply fertilizers?

25 responses



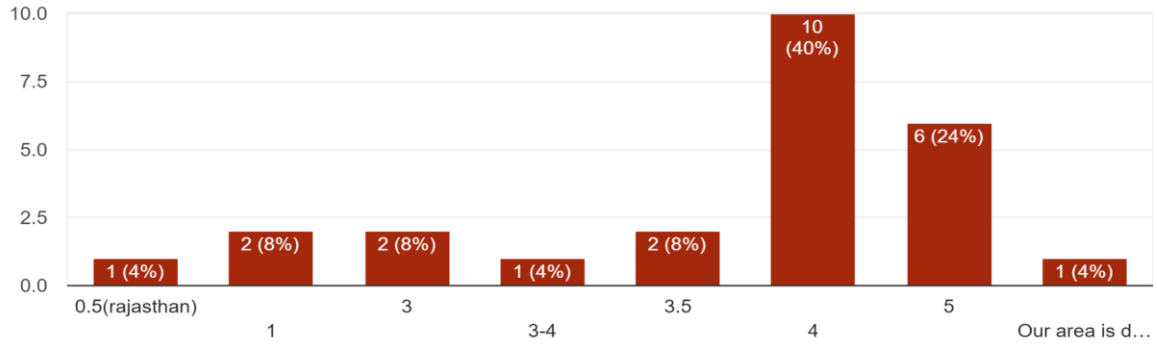
How often do you apply fertilizers?

25 responses



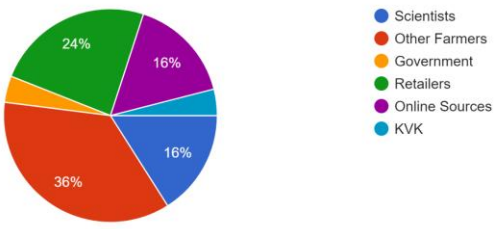
Rate the water availability in your farm (On a scale of 5)

25 responses



Where do you get information about fertilizers?

25 responses



6. OPERATING ENVIRONMENT

Hardware Requirements:

- **Client Devices:** Ensure the application is compatible with a range of devices including smartphones, tablets, and basic desktop systems, facilitating access for diverse user demographics.
- **Server Requirements:** Use a cloud-based infrastructure to guarantee high availability, allowing the system to handle varying loads and scale seamlessly as user demand grows.

Software Requirements:

- **Client Software:** The application should be accessible through standard web browsers and mobile applications on both Android and iOS platforms, enhancing user experience across devices.
- **Server Software:** Deploy on scalable cloud platforms like AWS or Azure, which provide robust support for APIs and databases. This architecture ensures efficient data handling and easy integration with various services.

External APIs:

- **Weather API:** Integrate a reliable weather API to offer real-time weather data, essential for the fertilizer recommendation engine. This feature will help tailor recommendations based on current environmental conditions.
- **Soil Health API:** Utilize a Soil Health API to retrieve regional soil data from national databases, enabling accurate assessments of soil conditions for improved fertilizer recommendations.

7. USER CLASSES AND CHARACTERISTICS

Farmers:

Farmers are the primary users of the FERTIGuide system. Many of them may have limited access to technology and minimal experience with software applications. They rely on simple, intuitive interfaces, often through mobile devices, and may require multi-language support. Their key need is to receive straightforward, actionable fertilizer recommendations based on local soil conditions and crop types. Given their limited technological familiarity, the system must support offline access via SMS or USSD,

enabling those in remote areas without reliable internet access to benefit from the platform.

Key Characteristics:

- Low-tech experience, minimal computer literacy.
- Need for simple, language-friendly interfaces.
- Likely using feature phones or basic smartphones.
- Require offline options via SMS or USSD.

Agricultural Experts:

Agricultural experts are secondary users who play a critical role in validating the fertilizer recommendations provided by the system. They are often extension officers or consultants with advanced knowledge of crop nutrition, soil health, and environmental factors. These users will review system-generated recommendations and provide further advice where needed. Additionally, they will respond to farmer queries and monitor the overall effectiveness of the recommendations. Experts require access to detailed data and analytical tools for tracking performance across regions.

Key Characteristics:

- High level of expertise in agriculture, soil science, and crop management.
- Act as advisors, validating recommendations and answering user queries.
- Require detailed access to analytical tools and data trends.
- Work with multiple regions, often consulting with multiple farmers.

Developers:

Developers are responsible for maintaining and updating the FERTIGuide system, ensuring that it operates efficiently and scales as needed. Their primary focus is on software development, integrating machine learning models, optimizing user interfaces, and ensuring compatibility across various devices. They also monitor system performance, making updates to improve usability, resolve bugs, and add new features. Developers need detailed documentation on system architecture and must ensure that the system meets security and scalability standards.

Key Characteristics:

- Skilled in software development, database management, and machine learning.
- Responsible for system updates, bug fixes, and feature enhancements.
- Monitor system performance and scalability.

- Ensure data security and privacy compliance.

Government Officials:

Government officials use FERTIGuide for monitoring purposes, ensuring that the recommendations align with agricultural policies and regional goals. Their role involves tracking how effectively farmers are using the system and ensuring that government-backed fertilizer programs or subsidies are being optimized. They will also review aggregated data to make decisions on broader agricultural initiatives and improvements in service delivery. These users require dashboards that provide insights into system usage and the outcomes of recommendations.

Key Characteristics:

- Policy-driven focus, requiring insights into large-scale data.
- Monitor the system's impact on regional agriculture and government programs.
- Require detailed dashboards and reporting tools.
- Influence policy and subsidies based on system performance.

8. PRODUCT FUNCTIONS

Soil Data Collection:

- Manual and automatic soil test data input.
- Integration with soil testing devices.
- Data validation to ensure accuracy and completeness.

Crop Recommendation Engine:

- Machine learning-based fertilizer recommendations.
- Region-specific adjustments based on weather and soil type.
- Real-time recommendations to optimize crop yield.
- Suggestions on nutrient dosage and application frequency.

User Feedback Mechanism:

- User feedback collection for continuous improvement of recommendations.
- Integration with expert advisory services for personalized support.
- Ability to track the effectiveness of recommendations over time.

9. ASSUMPTIONS AND CONSTRAINTS

Assumptions:

1. **Access to Soil Testing Equipment:** It is assumed that farmers using FERTIGuide either have direct access to soil testing equipment or nearby facilities for conducting soil tests. Government or private soil health centers may also play a role in providing these services. This assumption is crucial for generating accurate fertilizer recommendations, as soil data (pH, NPK levels, etc.) is central to the system's functionality.
2. **Internet Availability:** While FERTIGuide is designed primarily as an online platform, it assumes that users will have access to reliable internet connections, at least in urban and semi-urban areas. However, given the challenges of internet access in rural areas, the system will provide offline support via SMS, ensuring that critical recommendations can still reach users who lack regular or high-speed internet.

Constraints:

1. **Operation in Low-Resource Settings:** The system must be functional in low-resource environments where internet bandwidth is limited, and users may be operating basic smartphones or even feature phones. The platform must be lightweight and optimized to function smoothly under constrained conditions, such as slow internet speeds and minimal device memory. Features like image-heavy interfaces must be minimized for these users.
2. **Technical Constraints for Device Compatibility:** The mobile app must be compatible with a range of devices, including older smartphones and feature phones that are common in rural farming communities. This constraint limits the complexity of the graphical interface and requires the app to be highly efficient in terms of power and data usage, ensuring it remains accessible to all users regardless of their device capabilities.

10. BUSINESS CONSTRAINTS

Time:

FERTIGuide must be deployed by the next agricultural season to ensure its utility aligns with farmers' planting cycles. This demands rapid development and testing, with no delays, to avoid missing the critical planting window. Failure to deploy on time could lead to a loss of relevance, as fertilizer decisions need to be made early in the crop cycle.

Budget:

The project budget must stay within the limits approved by DAIICT and local government funding bodies. This requires efficient allocation of resources, cost-effective technologies, and maintaining close monitoring of expenses, especially for software development, cloud infrastructure, and mobile application development. If the budget exceeds its limit, it could jeopardize government support or require scaling down project features.

Geographical Limitations:

Initially, FERTIGuide will be deployed in specific pilot regions with high agricultural activity and demand for fertilizer recommendations. These regions will serve as test cases for assessing the system's performance. Based on pilot feedback, the system will be fine-tuned and gradually scaled up to more regions. However, expansion is subject to the system’s adaptability to various soil types, crops, and local conditions, which may necessitate further customization.