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“Crop Recommendation and Supervision System”

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A Senior Project Proposal

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List of Abbreviations

MERN -- *MongoDB, Express.js, React, Node.js*

ML -- *Machine learning*

UML --- *Unified Modeling Language*

PC -- *Personal Computer*

ABSTRACT

Agriculture is the cornerstone of Ethiopia's economy, with a significant portion of the population relying on farming for their livelihoods (Ministry of Agriculture [MoA], 2018). In regions like Arba Minch, agriculture not only sustains local communities but also contributes substantially to national food production (Bekele & Tadesse, 2020). Despite its critical importance, traditional farming practices in the area often face challenges such as unpredictable weather patterns, soil degradation, and inefficient resource management. These issues are further compounded by the impacts of climate change, which result in erratic rainfall, prolonged droughts, and other adverse environmental conditions (Admasu & Fikre, 2019).

Crop recommendation and supervision system is a technological solution that tries to enhance agricultural productivity by availing real-time user input-based crop recommendations. The system is developed using the MERN stack, and Jupyter. The platform involves two main components. The admin dashboard where agricultural experts can monitor users, manage feedbacks and post blogs and user dashboard where the user gets crop recommendation based on the given input. We train the machine using Jupyter notebook and make crop recommendations better according to user inputs.

Advancements in information and communication technology (ICT) and data analytics have opened new avenues for supporting farmers in making more informed decisions. By integrating modern web technologies, it is now possible to develop decision-support systems that provide precise, data-driven recommendations tailored to local conditions (Kebede & Alemu, 2022). A crop recommendation system that takes into account user inputs—such as temperature, humidity, soil pH, and nutrient content—can offer significant benefits. It enables farmers to choose the most appropriate crops for their land, optimize water and nutrient usage, and mitigate risks associated with adverse climatic events (Smith & Jones, 2021)

CHAPTER ONE

Introduction

Agriculture remains one of the most critical sectors for African economies, and its success is heavily influenced by soil and water management, among other factors. In many parts of Africa, inappropriate land use, poor land management, and lack of appropriate inputs have led to soil erosion, biodiversity loss, declining productivity, and food insecurity. Like many other African countries, Ethiopia's economy depends mainly on subsistence rainfed agriculture. Traditional cultivation practice is an essential livelihood source for over 80% of the population, contributing about 42% of the gross domestic product (GDP) and more than 80% of its exports. Using a small parcel of land, smallholders produce over 90% of the main crops for the nation. Despite its role, with an average population growth rate of 2.6%, most smallholders suffer from food insecurity and poverty due to excessive reliance on traditional, nature-dependent, and low-productive agriculture. Eradicating extreme poverty without adequately addressing land degradation is highly unlikely (Lemlem Tajebe Lejissa,2023).

We hope to contribute this system to solve the problems farmers and agricultural institutions face. Crop recommendation and supervision aims to increase productivity by the incorporation of technology in farming. Our system represents an approach that could improve agricultural productivity through real-time recommendations on crop cultivation by using user inputs and gives learning tips using our blog page. It uses the MERN stack technologies to ensure the system is accessible and user-friendly for farmers and also uses Jupyter to train the machine for better crop recommendations.

This system is designed to be flexible and adaptive. The algorithm works quite efficiently without the use of special hardware sensors but rather uses user input data to give insights into the selection of crops. With an easy-to-use interface and user input managed recommendation system, it allows farmers and agricultural experts to make data-driven decisions leading to better productivity and resource optimization.

This system fills the gap between traditional farming techniques and modern technological advancements in addressing the agricultural challenges like efficient crop recommendations. Beyond improving farm efficiency and productivity, it contributes to environmental conservation by minimizing resource wastage. By filtering which crops are suitable and comfortable to grow in and around Arbaminch and managing the water usage by recommendation of the best practices and tips for farming.

Population growth, however, in various parts of the world has led for the increased dependence on improving agricultural production and productivity. World's population has reached 7.3 billion in 2015, 6.9 billion in 2010, up from 2.5 billion in 1950 and 3.7 billion in 1970. The UN also projected as the total world population will reach 9.15 billion in 2050. Many of the developing countries are still struggling to feed their people as a result of the increased competition for the available natural resources coupled with poverty and the devastating effects of climate change. Hence, the development of digital agricultural platforms is taken as a tool to increase production and productivity of the sector (Alemu, M. (2017).

1.1 Background Information of the Organization

The Arba Minch Agricultural Research Center, located in Arba Minch, Ethiopia, is a prominent institution dedicated to advancing agricultural research and innovation in the region. This center plays a vital role in addressing the unique agricultural challenges faced by local farmers and communities, particularly in the Southern Nations, Nationalities, and Peoples' Region of Ethiopia.

The center focuses on a wide range of agricultural research areas, including crop production, pest management, and sustainable farming practices. It aims to enhance food security and improve livelihoods through the development of high-yielding crop varieties and effective agricultural techniques. The research conducted at the center is not only relevant to local agricultural practices but also contributes to broader scientific knowledge in the field.

In addition to its research initiatives, the Arba Minch Agricultural Research Center actively engages with local communities, promoting knowledge transfer and capacity building. By collaborating with farmers, the center ensures that its research findings are practical and applicable, fostering innovation in agricultural practices at the grassroots level.

The center is also involved in various partnerships and collaborations with national and international research organizations, enhancing its research capabilities and outreach. Through these collaborations, the Arba Minch Agricultural Research Center continues to contribute significantly to the agricultural development of Ethiopia, supporting sustainable practices that benefit both the environment and local economies.

1.1.1 Vision

The Arba Minch Agricultural Research Center envisions becoming a leading hub for agricultural innovation and research in Ethiopia, dedicated to enhancing food security, improving farmer livelihoods, and promoting sustainable and climate-resilient farming practices. Through cutting-edge research and technology-driven solutions, the center aims to transform agriculture in the region, ensuring long-term environmental sustainability and economic growth for local communities.

1.1.2 Mission

The center is committed to conducting high-impact agricultural research focused on crop production, pest management, and sustainable farming techniques. By developing high-yielding, climate-adaptive crop varieties and effective farming strategies, it seeks to empower local farmers with practical, science-backed solutions. Through strong collaborations with national and international institutions, as well as active engagement with local communities, the center facilitates knowledge transfer and capacity building, ensuring that its research contributes to both immediate agricultural improvements and long-term sustainability.

1.2 Background of the Project

Agriculture remains the backbone of the Ethiopian economy, and regions like Arba Minch contribute to national food production. Traditional farming in this region is characterized by inefficient water use, low production, and resource depletion under variable climate conditions. These are further intensified by unpredictable rainfall, prolonged droughts, and poor irrigation methods. Innovations that are technological in nature are increasingly required to ensure farming is both sustainable and productive (Ministry of Agriculture, 2018).

In Arba Minch, where agricultural practices are heavily influenced by environmental variability, the development of a crop recommendation system represents a critical step toward sustainable agriculture. By providing farmers and agricultural experts with personalized, timely advice through accessible platforms (such as mobile phones), this system aims to enhance productivity, improve resource management, and contribute to the broader goals of agricultural transformation and climate resilience in Ethiopia.

Recent research has significantly advanced the development of crop recommendation systems by integrating environmental data and modern technologies. For example, Kumar and Patel (2020) demonstrated a machine learning framework that utilizes key environmental parameters such as temperature, humidity, soil pH, and nutrient content to optimize crop selection across diverse agroecological zones. Similarly, Verma and Sharma (2021) developed an IoT-based system that leverages real-time sensor data to enhance sustainable agriculture practices, while Zhang and Chen (2019) provided a comprehensive review of decision support systems in crop management, emphasizing the integration of various environmental sensors and data inputs. In the Ethiopian context, Tadesse and Abebe (2018) showcased the benefits of combining real-time weather data with soil analysis for improving crop recommendation accuracy, a finding echoed by Ochieng and Mwangi (2022), who highlighted the impact of data-driven decision-making on crop yield across African regions. Moreover, Bekele and Desta (2021) integrated soil, weather, and crop performance data into a decision-support tool specifically tailored to address the complex agricultural challenges in Ethiopia, making these approaches particularly relevant for regions like Arba Minch.

1.3 Team Composition

Crop recommendation and supervision development is guided by a team of enthusiastic students, each contributing their unique skills and dedication to the project.

Table 1: *Team composition of the project*

Crop recommendation and supervision				
No	Group Member	ID No	Email/phone No	Responsibilities
1.	Bereket Kindie	NSR/478/13	0923645456	All activities
2.	Lidiya Fisshа	NSR/1502/13	0935032148	All activities

3.	Oli Chimdessa	NSR/1928/13	0925777765	All activities
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Advisor : Mr. Gashaw Alemu				

1.4 Statement of the Problem

Agriculture is the cornerstone of Ethiopia's economy, particularly in rural areas such as Arba Minch, where the majority of the population depends on smallholder farming for their livelihoods (Ethiopian Ministry of Agriculture, 2019; World Bank, 2019). Despite its critical role, traditional farming methods in this region rely predominantly on local knowledge and experience rather than systematic, data-driven approaches. This reliance has become increasingly problematic due to the rapidly changing climate and evolving soil conditions, which traditional practices are ill-equipped to manage. As a result, farmers often face suboptimal crop selection and inefficient resource use, leading to reduced productivity and economic instability.

Agriculture in Ethiopia, especially around Arba Minch, is still highly characterized by traditional farming styles that have not been responsive to the rapidly increasing challenges due to lack of water supply, unpredictable meteorological conditions, and inefficient handling of resources. The non-availability of data-informed decisions in crop selection and irrigation planning has led to a low yield of crops, land degradation, and economic losses on the part of the farmers. With such modern agricultural technologies available, adoption remains low due to high costs, limited technical knowledge, and inadequate access to real-time weather and crop data. Farmers in this region still rely on intuition and old methods of farming, many a time applying irrigation water inefficiently or choosing crops unsuitable for prevailing conditions. An added problem to these is the issue of climate variability that impacts rainfall, soil moisture levels, and farming productivity as a whole. Lacking an easily usable, affordable, and adaptive system, these challenges will persist and threaten both food productivity and environmental sustainability in this region.

This project tries to bridge this gap by developing a Crop recommendation and supervision system that provides crop suggestions and irrigation-related information based on the parameters such as, temperature, humidity, soil pH, and nutrient content the user provides and rules defined by agriculture experts.

The system ensures continuity and accessibility through customized recommendation and providing informative blogs and new trends for the farmers and the agricultural officers. This would enable the capability of making fairly accurate estimations using the user data for crop recommendations, thus assuring reliable and efficient farming even in resource-constrained environments. The integration of modern technology with traditional farming knowledge will support farmers and agricultural experts in making informed decisions that improve productivity and ensure sustainable agriculture in Arba Minch and beyond.

1.5 Objectives of the Project

1.5.1 General Objective

The primary objective of this project is to develop a data-driven crop recommendation system that integrates real-time environmental data specifically temperature, humidity, soil pH, and nutrient levels (nitrogen, potassium, and phosphorus) and blogs to provide adequate knowledge for farmers and agricultural experts on new agricultural trends, farming and irrigation advices and pest control to enhance crop selection, improve resource management, and promote sustainable farming practices among smallholder farmers in Arba Minch, Ethiopia. This system is supposed to bridge the gap between traditional farming methods and modern technology so as to ensure efficient resource utilization and data-driven decision-making for farmers, especially in agricultural offices where research is conducted around the crops in Arbaminch.

1.5.2 Specific Objectives

- ***Data Collection and Analysis:*** To systematically collect and analyze environmental parameters (temperature, humidity, soil pH, and N, K, P levels) from representative agricultural research office in Arba Minch.
- ***Informative Blogs:*** To help the farmers and agricultural experts get new and trendy farming practices we aim to integrate a blog page to help them learn more know more and act accordingly with farmers and researchers in other areas.

- ***Algorithm Development:*** To design and implement a decision-support algorithm that processes the collected environmental data and farmer inputs to generate optimal crop recommendations tailored to the specific conditions of Arba Minch.
- ***Interface Design and Implementation*:** To develop a user-friendly platform (e.g., web application) that spreads personalized crop recommendations to farmers, ensuring accessibility regardless of technological literacy or internet connectivity.

1.6 Feasibility Analysis of the Project

1.6.1 Operational Feasibility

Crop recommendation and supervision system is operationally feasible because it relies on user-provided data such as temperature, humidity, soil pH, and nutrient levels (N, K, P) eliminating the need for costly hardware or complex technological infrastructure. The system is designed with an intuitive interface, allowing farmers and agricultural experts in Arba Minch with limited technical expertise to easily input their data and receive tailored crop recommendations. Additionally, integration with local agricultural support networks ensures that the system can be sustainably maintained and adapted to the evolving needs of the community.

1.6.2 Technical Feasibility

The technical feasibility of Crop recommendation and supervision is high, as it leverages mature web development frameworks and open-source tools to build a lightweight application that processes user-provided data such as temperature, humidity, soil pH, and nutrient levels to generate crop recommendations by using ML(random forest). Additionally, the system includes a blog page designed to keep farmers and agricultural experts informed about current farming trends, ensuring the platform serves as both a decision-support tool and a valuable source of up-to-date agricultural knowledge. This integrated approach ensures that the application remains scalable, easily maintainable, and well-suited to the needs of the local community in Arba Minch.

1.6.3 Political Feasibility

The political feasibility of Crop recommendation and supervision is strong, as it aligns with Ethiopia’s national priorities for agricultural modernization, food security, and sustainable development. By providing a data-driven crop recommendation tool and an educational blog page, the project supports government initiatives aimed at boosting agricultural productivity and resilience in rural communities like Arba Minch. This alignment with current policy objectives is likely to get support from local authorities, agricultural extension services, and other stakeholders invested in advancing technology-based solutions in the agricultural sector.

1.6.4 Economic Feasibility

The economic feasibility of Crop recommendation and supervision is strong due to its low operational and development costs, making it a cost-effective solution for farmers in Arba Minch. By relying on user-provided data (temperature, humidity, soil pH, and nutrient levels), the system avoids expensive hardware or continuous external data inputs, keeping ongoing expenses minimal. Additionally, using open-source software and established web development frameworks further reduces initial development costs. The integrated blog page adds value by disseminating current farming trends without incurring significant extra expenses. Ultimately, by improving crop selection and resource management, the project has the potential to boost yields and support economic stability, which may also attract support and funding from government and development organizations focused on agricultural innovation and rural development.

1.6.5 Feasibility of Scheduling

All the members are supposed to execute each and every activity within the defined time frame so that the project can be finalized and the system will become feasible regarding the schedule. In order to achieve the proposed system, we will follow the schedule that is presented in the below Gantt chart.

1.6.5.1 Cost Of The Project

Tangible costs

- ❖ Hardware cost
- ❖ Software cost

Intangible costs

- ❖ Development time
- ❖ Energy consumption

Table 2: *hardware cost*

Purpose	Amount	Unit price	Total price
Personal computer	3	40,000	120000
Total			120000

Table 3: *Software cost*

Items	Price
React js	free
Node js	free
Ms- window	free
Mongo db	free
Visual studio	free
Google chrome	free
Data Connection	free
Power point	free
SMS API	free
Weather API	free
Jupyter notebook	free
Total	………..

Table 4: *Time Schedule of the project*

Gantt Chart Project Schedule							
NO	Task Name	1stQuarter	2stQuarter	3stQuarter	4stQuarter	5stQuarter	6stQuarter

		1st Jan - 25th Jan	25th Jan – 5th Feb	5th Feb – 21th Feb	21th Feb – 30th April	30th April – 30th May	30th May – 10th June
1	Project proposal	■					
2	Requirement analysis		■				
3	System design			■			
4	Coding & Implementation				■		
5	Installation and Testing					■	
6	Project Closure						■

1.7 Scope, significance, limitation of the project

1.7.1 Scope of the Project

Crop recommendation and supervision aims to develop a data-driven crop recommendation system tailored to the needs of smallholder farmers in Arba Minch, Ethiopia. By using user-inputted environmental parameters, the system will provide personalized crop suggestions to improve agricultural productivity and resource management. Additionally, an integrated blog page will offer educational content to keep farmers and agricultural experts informed about current farming trends and best practices. The project focuses on accessibility, sustainability, and practical implementation within the local farming community.

- ***User Data Input:*** The system will allow farmers to manually input key environmental parameters such as temperature, humidity, soil pH, and nutrient levels (N, K, P) relevant to their specific conditions.

- ***Crop Recommendation Engine:*** An random forest algorithm will process the user-provided data to generate crop recommendations optimized for the local environmental and soil conditions in Arba Minch.
- ***User Interface:*** A simple, intuitive web interface will be developed to ensure that farmers, regardless of technical expertise, can easily enter data and receive actionable recommendations.
- ***Educational Blog Page:*** The platform will include a blog page that shares up-to-date farming trends, expert advice, and best practices to support continuous learning and knowledge sharing among farmers and agricultural professionals.
- ***Exclusions:*** The project will not include hardware-based data collection (e.g., sensors) or real-time weather API integrations, as it focuses solely on manual data inputs from users.

1.7.2 Significance of the Project

It is a much-ambitious initiative that can support sustainable agriculture and economic growth as well as technology empowerment of communities:

- ***Improved Agricultural Productivity*:** Crop recommendation and supervision enables farmers to make data-driven decisions by using key parameters like temperature, humidity, soil pH, and nutrient levels (N, K, P), leading to optimized crop yields and efficient resource use.
- ***Enhanced Resource Management:*** By recommending crops suited to specific environmental conditions, Crop recommendation and supervision helps reduce the misuse of water, fertilizers, and other resources, promoting sustainable farming practices.
- ***Reduction of Trial-and-Error Farming:*** Crop recommendation and supervision minimizes farmers' reliance on traditional trial-and-error methods, which can be inefficient and costly, by providing accurate, science-based crop recommendations.
- ***Knowledge Sharing and Continuous Learning:*** The integrated blog page offers up-to-date information on modern farming techniques, climate adaptation strategies, and best practices, fostering learning among farmers and agricultural experts.
- ***Increased Resilience to Climate Variability:*** By guiding farmers on suitable crops based on environmental data, Crop recommendation and supervision enhances their ability to adapt to unpredictable weather patterns and climate-related challenges.

- ***Support for National Agricultural Goals:*** Crop recommendation and supervision aligns with Ethiopia's agricultural development policies, promoting the adoption of technology-driven solutions to boost productivity and sustainability.
- ***Environmental Conservation:*** Crop recommendation and supervision encourages sustainable farming practices that help mitigate soil degradation, reduce excessive fertilizer use, and conserve water resources.

1.7.3 Limitations of the Project

The system, despite its advantages, has a few drawbacks:

- ***Reliance on Accurate User Input:*** Crop recommendation and supervision depends on the accuracy of data provided by the users (e.g., temperature, humidity, soil pH, and nutrient levels). Inaccurate or inconsistent data inputs could lead to incorrect crop recommendations.
- ***Limited Access to Measurement Tools:*** Many smallholder farmers in Arba Minch may lack access to reliable tools for measuring soil pH, nutrient levels, and other critical parameters, which can affect the effectiveness of the system.
- ***Technological Barriers:*** Although the system is designed to be user-friendly, farmers with limited digital literacy may still face challenges in navigating the web interface, potentially affecting adoption rates.
- ***Scalability Challenges:*** While Crop recommendation and supervision is designed for Arba Minch, adapting it to other regions may require significant adjustments to accommodate different environmental conditions and agricultural practices.
- ***Maintenance and Updates:*** Continuous maintenance and updates are needed to keep Crop recommendation and supervision relevant, especially in terms of updating crop databases and refining recommendation algorithms. Limited resources for ongoing development could hinder long-term effectiveness.

1.8 Target Beneficiaries of the Project

The crop recommendation and supervision system targets a large number of end users, from farmers to government agencies, including researchers, academic institutions, technology innovators, NGOs, and agricultural cooperatives.

- ***Smallholder Farmers:*** The primary beneficiaries are smallholder farmers in Arba Minch, who will gain access to data-driven crop recommendations to improve productivity, resource management, and crop yields.
- ***Local Agricultural Cooperatives:*** Cooperatives can leverage the system to coordinate better farming practices among their members, leading to improved collective productivity and resource utilization.
- ***Agricultural Experts and Researchers:*** Experts can use the system to analyze patterns in user data, identify trends, and develop further research or policy recommendations for sustainable farming practices.
- ***Non-Governmental Organizations (NGOs):*** NGOs focused on rural development and food security can integrate the system into their programs to enhance the support they provide to farming communities.
- ***Local Communities:*** Improved agricultural productivity and food security will benefit entire communities in Arba Minch by promoting economic growth, reducing poverty, and enhancing overall well-being.

1.9 Methodology for the Project

The crop recommendation and supervision system in Arba Minch is designed and developed using a structured and systematic approach in order to make the system as accurate, usable, and long-lasting as possible. The methodology consists of the following key phases:

1.9.1 Sources and Collection of Data

Data for the system is gathered from various sources to enhance its accuracy and reliability:

- ***Agricultural Research Institutions:*** Source data from local agricultural research centers, and governmental organizations that publish soil, climate, and crop productivity data specific to the Arba Minch region.
- ***Existing Agricultural Databases:*** Utilize national and international agricultural datasets (e.g., FAO, Ethiopian Ministry of Agriculture) for historical data on crop yields, soil composition, and environmental conditions.

1.9.2 Fact-Finding Techniques

To develop an effective crop recommendation system tailored to the specific needs of farmers in Arba Minch, a combination of fact-finding techniques was employed. These methods ensured the collection of accurate, relevant, and comprehensive data to inform the system's design and functionality.

Interviews

Interviews were conducted with agricultural experts, and extension workers to gather insights into current farming practices, challenges, and expectations.

- Interviews with agricultural experts provided a broader understanding of best practices, common issues, and potential improvements in crop recommendation techniques and also helped us use some of their gathered dataset.

Document Analysis

Relevant documents and reports were analyzed to provide historical and contextual data on agricultural practices in the Arba Minch region.

- Government reports from the Ethiopian Ministry of Agriculture and local agricultural offices were reviewed to gather data on soil quality, crop productivity, and regional climate conditions.
- Academic research papers and agricultural journals were analyzed to understand existing crop recommendation models and how they could be adapted to the local context.
- Reports from NGOs and development agencies working in the region were also reviewed to understand the broader socio-economic factors influencing farming practices and technology adoption.

By combining these fact-finding techniques, Crop recommendation and supervision ensures that the crop recommendation system is grounded in both scientific data and practical, real-world insights, making it a reliable and user-friendly tool for farmers and agricutltural experts in Arba Minch.

1.9.3 System Analysis and Design

Perform a structured analysis and design of the system architecture needed for:

- *Requirements Analysis:* Identifying the user's needs, defining core functionalities, and setting technical specifications.
- *User-Centric Design:* Having an intuitive UI/UX approach, whereby the system is easy to use with a user-friendly interface for farmers.
- *Modeling Techniques:* It will be done by drawing Use Case Diagrams, Data Flow Diagrams (DFD), and Entity-Relationship Diagrams (ERD).

1.9.4 Development Tools and Technologies

List of modern scalable technologies used for efficiency and reliability includes but is not limited to the following:

- *Frontend Development:* The React.js for a user's friendly and responsible interface.
- *Backend Development:* Node.js with Express.js to implement scalable server-side processing.
- *Database Management:* MongoDB to store weather data, crop recommendations, and farmer profiles.
- *Machine Learning (random forest):* Jupyter notebook to train the machine for better crop recommendations.
- *Version Control:* Git and GitHub to track code changes, collaborate with developers, and manage different versions of the system during development.
- *Testing Tool:* Postman to test API endpoints without needing to run the full application, making it easier to ensure back-end functionality works as expected.
- *Design and Prototyping:* Figma collaborative design tool for wireframing and prototyping.
- *Cloud Hosting:* Vercel for the frontend and AWS/Heroku for the backend.

1.9.5 Testing Procedures

Testing will be done at various levels to ensure the reliability and accuracy of the system:

1. Unit Testing*:* Verify the correctness of individual functions and modules in the system, particularly those that process user input and generate crop recommendations.

Procedure

- ❖ Test each module handling soil parameters (temperature, humidity, pH, N, K, P values) to ensure it processes inputs correctly.
- ❖ Test the crop recommendation logic to ensure that it accurately maps input values to appropriate crop recommendations.
- ❖ Verify that the system correctly handles edge cases, such as missing or extreme values for parameters.

2. Integration Testing*:* Ensure that different parts of the system work together smoothly, particularly the interaction between the front-end input forms and the back-end recommendation engine.

Procedure

- ❖ Test the communication between the user interface (where farmers input parameters) and the recommendation system (which processes the inputs).
- ❖ Ensure that input data is correctly passed to the back-end, processed, and results in the correct output (crop suggestions).
- ❖ Test database interactions to ensure that inputs are stored and fetched correctly when generating recommendations.

3. Functional Testing: Test whether the system functions according to the requirements and delivers the correct crop recommendations based on given inputs (temperature, humidity, pH, N, K, P values).

Procedure

- ❖ Perform end-to-end testing of the user journey: entering parameters, receiving crop recommendations, and checking the accuracy of those recommendations.
- ❖ Verify that input validation works correctly (e.g., ensuring that entered values are within acceptable ranges).
- ❖ Test the system’s behavior with various combinations of inputs to ensure it provides reliable and accurate results.
- ❖ Verify that the system adapts to different input scenarios (such as changes in one parameter affecting the recommended crops).

5. System Testing: Ensure that the entire system works correctly as a whole, including input collection, data processing, and recommendation output.

Procedure

- Perform tests on the complete system flow, from inputting soil parameters to receiving crop recommendations.
- Ensure the system is capable of handling different sets of parameters and generating accurate recommendations for each set.
- Test the system's stability and performance under varying levels of user load.

8. User Acceptance Testing (UAT): Verify that the system meets the users' needs, particularly farmers in Arba Minch, by ensuring the crop recommendations are helpful and relevant.

Procedure

- Conduct user testing with farmers from the region to confirm that the system provides valuable crop recommendations based on local conditions.
- Gather feedback on the ease of use, accuracy of recommendations, and overall user satisfaction.
- Make any necessary adjustments based on user feedback to improve the system before deployment.

1.9.6 Implementation

Partial implementation is the most effective strategy for our project. It allows us to introduce the crop recommendation system in a controlled manner, gradually incorporating different regions or groups of farmers in Arba Minch while ensuring that any technical issues or user challenges can be addressed early. This phased approach also enables us to gather feedback and adjust the system before a full rollout, ensuring a smoother transition for farmers with varying levels of technological literacy.

- ***Partial Implementation:*** Partial implementation involves rolling out Crop recommendation and supervision in stages, either by geography, functionality, or user groups. Some users or features of the system are introduced first, while the rest are gradually added.

Partial implementation would work well for our crop recommendation system, especially given that it is targeted at a specific location (Arba Minch) and may involve farmers with varying levels of technological experience. Initially, we could start with a small group of farmers in a specific region or with a subset of the crop recommendations, and then expand the system gradually to other areas or add additional features (such as more detailed recommendations or a blog page).

Advantages

- A controlled approach that allows for troubleshooting and adjustments before full-scale deployment.
- Easier to gather user feedback and make improvements based on real-world use.
- Can be rolled out to areas with more experienced or tech-savvy users first, followed by broader adoption.

Challenges

- The system may take longer to be fully deployed across all target farmers.
- Farmers in different areas might have different experiences if the system is not uniformly implemented.

CHAPTER TWO

Existing System

2.1 Introduction of Existing System

The current agricultural practices in the Arba Minch area are dominated by a traditional mode of farming, with limited integration of modern technology. Farmers mostly depend on local knowledge and seasonal patterns to guide the selection of crop and irrigation usually characterized by inefficiency and mismanagement of resources. The various systems that are now available consist merely of basic current weather forecasting or advisory systems related to agriculture, not integrated or focused to the needs of the region per se, with no real-time actionable insights being provided. Missing is an integrated, user-friendly platform that would put in one easy interface all the weather data, crop recommendations, and irrigation guidance a farmer needs to make data-driven decisions toward optimized productivity and sustainability.

2.2 Players in the Existing System

1. Farmers: Most of them depend on local traditional knowledge, seasonality of time, and mere weather forecasting-majorly through radio or television to decide on the crop to cultivate and irrigate; lacking in real-time and weather-signal information.

2. Agricultural Extension Officers: Traditionally offer farm advisory services based on field visits and printed information. They need a structured, one-stop avenue to pass timely and individualized advice.

3. Government and NGOs: This is usually given through mass media such as radio programs, brochures, and public meetings. This is normally generalized and not specific to any individual farmer.

4. Technology Providers: Various companies have developed agricultural tools and mobile apps for farmers. However, this is hardly combined with weather data and specific conditions around the Arba Minch area.

5. Researchers and Experts: Research and make informed opinions about good farming practice but often do not have any straightforward, easily accessible means to pass on useful advice to real farmers in realistic and timely fashion.

2.3 Major Functions/Activities in the Existing System

Inputs:

- Local weather patterns and seasonal knowledge
- General agricultural advice and guidelines from government and NGOs
- Basic weather forecasts from radio or television
- Information from agricultural extension officers
- Crop selection advice based on past experiences or trial and error

Processes:

- Information dissemination through traditional media-radio, television, print
- Communication between farmers and extension officers through field visits and phone calls
- General agricultural education through workshops and community meetings.
- No personalized, weather-based advisory services whatsoever.

Outputs:

- General weather forecasting related to farming
- Crop selection based on traditional methods or historic data
- Limited use of improved farming practices due to a lack of real-time, location-specific advice
- resources are applied based on generalized information rather than actual facts and data.
- Communication and collaboration mostly take place within small groups or locally within small circles or through word of mouth.

2.4 Business Rules

The agricultural sector in the Arba Minch region requires good management and dissemination of information on time for better productivity and sustainability. Current systems and practices function in the context of certain business rules that establish a basis on how decisions in farming, including irrigation management and crop selection, are made. Most of these rules depend a lot on traditional methods with minimum technological integrations.

BR1: Generally, irrigation scheduling depends upon observations by the individual farmer about soils and weather that can be subjected to inefficiencies and may easily lead to misuse or waste of water.

BR2: Usually, this recommendation is offered face-to-face between the agriculture professional and farmer or in seminars; not every farmer has better access, neither the frequency will increase.

BR3: Extension services pass on advisories in agriculture, weather forecasts, and crop advisories through traditional channels of print material and personal visits, which do not reach every farmer in time.

BR4: Farmers take decisions in the absence of an integrated real-time advisory system based on a mixture of inputs from basic weather reports, local observations, and manual assessment, which can be inconsistent and possibly inaccurate.

BR5: Telecommunication services like SMS, although widely available even in rural areas, the agricultural information delivery using SMS services has been largely underutilized and hence unable to reach out effectively to the farmers.

2.5 Reports Generated in the Existing System

Traditional farming in the prevailing agricultural scenario of the Arba Minch region depends on fragmented data collection and informal knowledge sharing. The reports generated in this system are mostly based on manual observations, expert consultation, and seasonal trends rather than on real-time data-driven analytics.

1. Weather Observation Report: Farmers depend on personal weather observations and shared experiences within the community. This report will contain seasonal rainfall patterns, temperature fluctuations, and estimated drought risks based on past trends rather than real-time meteorological data.

2. Crop Performance Report: This report, based on informal discussions and field observations, underlines the yield of different crops in different seasons. It lacks scientific analysis and does not have real-time data on soil and climate.

3. Irrigation Schedule Log: Irrigation activities by farmers are based on ocular estimates of the soil's condition and personal experience. The irrigation frequency, sources of water used, and estimated crop water requirements are summed up in this report, usually resulting in anomalies in water management.

4. Agricultural Workshop & Advisory Report: The extension officers and NGOs organize periodical workshops for farmers to upgrade their farming skills. This report describes the number of workshop participants, topics covered, and expert advice; however, it has limited scope since there is no follow-up on the same and not all farmers are reached.

5. Pest & Disease Occurrence Report: Through community discussions, farmers report on outbreaks of pests and diseases, even to the level of agricultural officers. This record captures common occurrences, affected crops, and indigenous solutions applied, though this inaction is well delayed due to the absence of a centralized monitoring system.

2.6 Bottlenecks of the Existing System

1. Reliance on Traditional Methods: Farmers still majorly rely on word-of-mouth, past experiences, and observational techniques in making crucial decisions in farming. This makes traditional methods inefficient and antiquated.

2. Lack of Real-Time Data: Real-time weather or crop data is not available to farmers from the available agricultural advisory system. The inability to provide timely information impacts the farmers' inability to change strategies at short notice due to changes in environmental conditions.

3. Limited Access to Expert Advice: Extension officers and experts are not always accessible, and their advice is normally provided through occasional workshops or field visits, which cannot be scaled up.

4. Inefficient Water and Resource Use: In the absence of any integrated irrigation scheduling system, the farmers either overuse or underuse the available water resources, leading to a waste of resources and poor growth of crops.

5. Fragmented Information Dissemination: Farmers are usually advised on agriculture by several uncoordinated sources, such as radio, newspapers, local meetings, and government programs. It is, therefore, quite difficult to filter and act upon relevant information.

6. Slow Response to Pest and Disease Outbreaks: Without any centralized tracking system, farmers are forced to respond to pest infestations and diseases through manual reporting, which is often received quite late. This limits interventions in good time and increases crop loss.

2.7 Practices to be preserved

- Indigenous Knowledge: Intercropping and organic fertilization are some of the traditional farming methods that should supplement modern techniques.
- Community Knowledge Sharing: Local get-togethers and farmer meetings are still important for lessons from experience.
- Seasonal Crop Selection: Farmers' intuition on crop cycles needs to be informed by weather information.
- Sustainability: technology has to supplement rather than supplant them.
- Water Conservation: Traditional irrigation and rainwater harvesting integrated with smart water management.

2.8 Proposed Solution for the New System (As an Alternative)

In the wake of the issues faced by farmers in the Arba Minch region, a Crop Recommendation and Supervision System would be developed to give the poor farmer real-time, evidence-based recommendations for better decision-making. This system, unlike traditional approaches that rely on manual inputting and poor forecasting capabilities, will use the MERN stack with machine learning-Random Forest-for pretty accurate and timely insight into crop selection and irrigation planning without the need for hardware sensors.

It shall integrate crop recommendations with irrigation schedules through an easy-to-use interface. It will be user-friendly, where even the most basic unskilled farmers will be well informed on appropriate farming decisions. With AI analytics, continuous learning from data drives personalized recommendations to maximize crop yield, resource conservation, and sustainability.

2.9 Requirements of the Proposed System

2.9.1 Functional Requirements

Functional requirements are the central functionalities the system should provide to make it effective, easy to use, and accessible.

- *Create Account:* The system should provide a way of creating an account for farmers and agricultural experts.
- *Login*: The user has to log in securely with a username and password.
- *Crop Recommendations:* The system should provide data-driven recommendations on crops to plant based on factors such as soil type, crop history, and regional climate patterns.
- *Irrigation Scheduling:* The system should be allowed to develop crop type-based irrigation schedules, soil type, among other relevant schedules.
- *Blog Post Management for Admin***:** The admin should be able to create, edit, and delete blog posts to share agricultural tips, best practices, and advisory content with users.
- *Real-time Data Processing:* The system shall analyze continuously updated data through machine learning algorithms to give farmers timely and efficient recommendations.
- *User Response:* The system shall be able to receive responses from the user regarding the recommendation/advice given for continuous improvement.

2.9.2 Non-Functional Requirements

Non-Functional requirement explains and describes the user visible aspects of the system. Constraints on the services or functions offered by the system are constraints of timing, the development process; standards, etc. are things we have to focus on developing new systems to achieve its functionality. Non-functional requirements are requirements which specify criteria that can be used to judge the operation of a system. This is contrasted with functional requirements that specify behavior or functions.

High Performance and Responsiveness

❖ *Fast loading Times:* Users expect instant access to information and features. Pages and Content should load quickly, even on low-bandwidth connections, for a seamless and Frustration-free experience.

❖ *Scalability:* The system must be able to scale up in a broader manner for future times regarding the increasing intensity for the need of our system.

❖ *Device Optimization:* Consider the majority of users' access habits and ensure the system offers a smooth and user-friendly experience on digital devices.

Intuitive and User-Friendly Interface

❖ *Accessibility:* the system is made to be as easy to use as possible in order to incorporate users with different level of English proficiency.

❖ *Consistency:* User interface elements should be consistent throughout the system for intuitive navigation and ease of use.

Robust Security Measures and Data Privacy Protection

❖ *Data Encryption:* Implement secure data encryption for user information, both in transit and at rest, to prevent unauthorized access and data breaches.

❖ *Clear Privacy Policy:* Have a clear and transparent privacy policy outlining how user data is collected, used, and protected. Users should be able to easily access and understand their privacy rights.

Secure Backup and Recovery Mechanisms

❖ *Data Backups:* Regular backups of all system data must be performed to ensure information is not lost in case of technical failures or cyberattacks.

- *Disaster Recovery Plan:* Implement a comprehensive disaster recovery plan to quickly restore functionality and data in case of unforeseen events.

- *Regular Testing:* Regularly test your backup and recovery procedures to ensure they are effective and up-to-date.

CHAPTER THREE

System Analysis

3.1 Introduction

In this chapter, we explore the System Analysis phase, which involves a comprehensive examination of client requirements, system functionalities, and limitations. Systems analysis is a process of collecting factual data, understand the processes involved, identifying problems and recommending feasible suggestions for improving the system functioning.

The objective System Analysis is to ensure the effective planning and utilization of the proposed solution. This chapter outlines user roles, and interactions through various UML diagrams such as ***use case diagrams, sequence diagrams, activity diagrams, and class diagrams***. Additionally, it presents a ***user interface prototype*** to demonstrate the system's usability and accessibility.

3.2 System Requirement Specifications (SRS)

The System Requirement Specification (SRS) serves as a blueprint for system developers, outlining what the Crop Recommendation and Supervision System should do, how it should behave, and the constraints it must operate within. An SRS typically includes use cases, system interactions, performance criteria, security requirements, and design constraints.

For this project, the SRS defines the technical and functional requirements needed to develop a system that leverages machine learning-based crop recommendation, soil data analytics, and supervision tools to enhance agricultural decision-making. It ensures that the system meets the agricultural experts by providing data-driven crop recommendations, soil monitoring, and insights for better crop management.

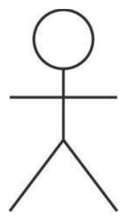
3.2.1 Use case Diagram

A use case diagram is a visual representation of the interactions between users (actors) and a system. It helps illustrate the functional requirements of the system, showing how different users will interact with it to achieve specific goals.

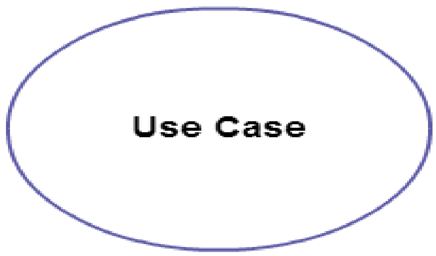
Use case diagrams help in understanding how agricultural experts and system administrators will interact with the Crop Recommendation and Supervision System and what functionalities the system will provide.

The following are key components of a use case diagram:

Actors: These represent individuals or external systems that interact with the system. Actors can be people, organizations, or external systems that interact with the application or system. They are external entities that generate or consume data. And represented with:



Use case: describes a sequence of actions that provides something of measurable value to an actor and is drawn as a horizontal ellipse. And represented with:



System boundary: indicates the scope of the system project. Anything within the box represent functionalities in side in scope. And represented a rectangular box.

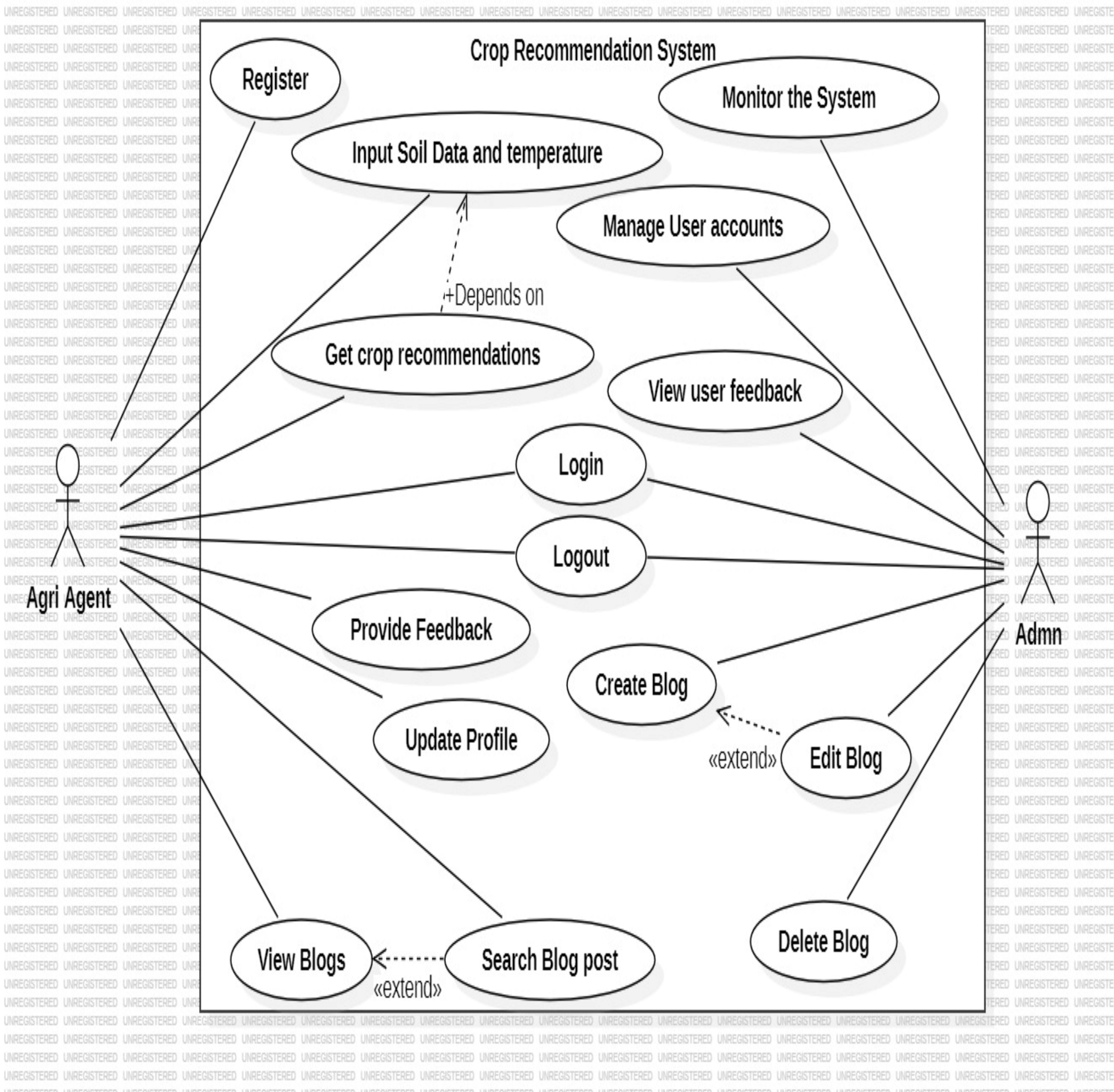


Figure 1: use case diagram

Actor Identification

These actors interact with the system's platform to play certain roles, which contribute to the overall functionality of the system.

Farmer: The main user of the system will create an account, log in, and receive information-based crop recommendations. He/She can also provide soil conditions manually for refinement of recommendations and best practices. Apart from this, farmers can view advisory content and participate in discussion forums to improve their knowledge.

The ***Administrator*** manages the system by creating, editing, deleting, enabling, and disabling user accounts. He assigns roles and permissions, monitors user activities, and the performance of the system, hence ensuring smooth operations on the platform. The administrator also posts notifications, updates, and agricultural advice, handles technical issues, and maintains the system.

3.2.2 Use case documentation

Table 5:use case description for register

Use case id	01
Use case name	Register
Actors	Agri Agent
Description	The User registers in the system by providing personal details such as name, username email, password and phone number.
Goal	To create a user profile in the system.
Precondition	The must have access to the system
The basic flow of action	1. The Agri Agent navigates to the registration page. 2. He/She enters required details such as name, email, phone number, and password. 3. The system validates the entered data (e.g., checks if the username is unique). 4. If the data is valid, the system creates an account and stores the details in the database. 5. The system displays a confirmation message: "Registration successful!"
Post condition	The Agri Agent is successfully registered and can log in.

Alternative action	*Invalid Username/Email*: If the Username or Email is already in use, the system prompts the user to enter a different Username or email. *Weak Password*: If the password does not meet security requirements, the system suggests a stronger password.

Table 6:use case description for login

Use case id	02
Use case name	Login
Actors	Agri agent and Admin
Description	This use case allows registered users to log in to the system.
Goal	To authenticate users and grant access to the system
Precondition	The user must be registered. The system must be online.
The basic flow of action	1. The user navigates to the login page. 2. The user enters their username/email and password. 3. The system verifies the credentials against stored data. 4. If credentials are valid, the system grants access and redirects the user to the dashboard. 5. A welcome message is displayed
Post condition	The user is successfully logged in and can access system features.
Alternative action	*Incorrect Password*: If the password is incorrect, the system displays an error message and allows retries. *Unregistered Username/Email*: If the username or email is not found, the system suggests registering first. *Forgot Password:* The user can reset the password via an email verification process.

Table 7: use case description for Input Soil data and Temperature

Use case id	03
Use case name	Input Soil data and Temperature
Actors	Agri Agent
Description	This use case allows the Agri Agent to input soil data and temperature for analysis.
Goal	To collect soil data and temperature for generating crop recommendations.
Precondition	The Agri Agent must be logged in.
The basic flow of action	1. The Agri Agent clicks Recommendation page. 2. The system prompts the user to enter soil parameters (e.g., Nitrogen, Phosphorus, Potassium, pH level, temperature). 3. The Agri Agent enters the data and submits the form. 4. The system validates the input data. 5. If validation is successful, the data is stored in the database.
Post condition	The soil data is successfully recorded and ready for processing.
Alternative action	If validation fails, the system prompts the user to correct error.

Table 8: use case description for Get Crop Recommendations

Use case id	04
Use case name	Get Crop Recommendations
Actors	Agri Agent

Description	This use case enables the system to provide crop recommendations based on soil data.
Goal	To generate accurate crop recommendations using supervised learning
Precondition	Soil data must be available in the system.
The basic flow of action	1. The Agri Agent selects the "Get Crop Recommendations" option. 2. The system retrieves the stored soil data. 3. The system applies a trained supervised learning model to analyze the data. 4. The system processes the data and generates a list of recommended crops. 5. The system displays the recommended crops to the Agri Agent.
Post condition	The user receives a list of suitable crops for the given soil data.
Alternative action	If no soil data is found, the system tells the user to input data first. If the machine learning model fails, the system displays an error message.

Table 9: use case description for Provide Feedback

Use case id	05
Use case name	Provide Feedback
Actors	Agri Agent
Description	This use case allows Agri Agents to provide feedback about the crop recommendations or the system.
Goal	To gather user feedback for system improvement.

Precondition	The Agri Agent must be logged in.
The basic flow of action	1. The Agri Agent selects the "Feedback" option. 2. The system displays a feedback form. 3. He/she enters their feedback and submits the form. 4. The system stores the feedback in the database. 5. The system displays a confirmation message.
Post condition	The feedback is successfully recorded.
Alternative action	If the feedback form is incomplete, the system prompts the user to fill in all required fields.

Table 10: use case description for View Blogs

Use case id	06
Use case name	View Blogs
Actors	Agri Agent
Description	This use case allows Agri Agents to read and watch videos blogs related to agricultural practices.
Goal	To provide agricultural knowledge through blog posts.
Precondition	The Agri Agent must be logged in.
The basic flow of action	1. The Agri Agent clicks to the blog section. 2. The system retrieves and displays available blog posts. 3. The Agri Agent selects a blog post to read and watch videos.

Post condition	The Agri Agent successfully views a blog post.
Alternative action	If no blogs are available, the system displays a message indicating no content is present.

Table 11: use case description for Manage User Accounts

Use case id	07
Use case name	Manage User Accounts
Actors	Admin
Description	This use case allows the Admin to manage Agri Agent accounts
Goal	To ensure smooth user management.
Precondition	The Admin must be logged in.
The basic flow of action	1. The Admin navigates to the "User Management" section. 2. The system displays a list of registered users. 3. The Admin can view, edit, or delete user accounts. 4. Changes made and updates the database.
Post condition	The user account information is successfully managed.
Alternative action	If an error occurs, the system displays an error message.

Table 12: use case description for Create Blog

Use case id	08
Use case name	Create Blog
Actors	Admin
Description	An Admin can create blog posts which will be read and watched by the Agri Agents
Goal	To allow knowledge sharing.
Precondition	The Admin is logged in and the contents of the blog must be present
The basic flow of action	1. An Admin selects the create blog option. 2. The system presents a blog entry form. 3. Admin enters a title and content. 4. The system validates and stores the blog
Post condition	The blog is created and Agri Agents Learn from blogs
Alternative action	If the title is missing, an error appears.

Table 13: use case description for Manage Edit Blog

Use case id	09
Use case name	Edit Blog
Actors	Admin

Description	The Admin modifies an existing blog post.
Goal	To update blog content.
Precondition	A blog post must exist and Admin is logged in
The basic flow of action	1. The Admin selects a blog post to edit. 2. The system displays the post in an editable format. 3. The Admin modifies the content. 4. The system saves and updates the blog post.
Post condition	The blog post is updated.
Alternative action	If the post is invalid, the system displays an error.

Table 14: use case description for Delete Blog

Use case id	10
Use case name	Delete Blog
Actors	Admin
Description	Admin can delete blog posts which are no longer necessary in the blog
Goal	To manage blog content.
Precondition	The admin must be logged in.
The basic flow of action	1. The admin selects a blog and clicks the delete button 2. The system asks for confirmation. 3. The admin confirms deletion. 4. The system removes the blog.

Post condition	The blog is deleted
Alternative action	If the blog doesn't exist, an error appears

Table 15: use case description for Logout

Use case id	11
Use case name	Logout
Actors	Agri Agent and Admin
Description	Allows users to securely exit their accounts.
Goal	To end a user session securely.
Precondition	The user must be logged in.
The basic flow of action	1. The user clicks the logout button. 2. The system terminates the session. 3. The system redirects the user to the login page.
Post condition	The user is logged out.
Alternative action	If an error occurs, the system displays a logout failure message and requests retry.

Table 16: use case description for Monitor the System

Use case id	12
Use case name	Monitor the System
Actors	Admin
Description	The Admin monitors system performance and usage.
Goal	To ensure the system is functioning correctly.
Precondition	The Admin must be logged in.
The basic flow of action	1. The Admin accesses the monitoring dashboard. 2. The system displays system metrics and logs in graphical and chart models 3. The Admin reviews and analyzes the data from these graphs and chars
Post condition	The Admin successfully monitors the system.
Alternative action	If metrics are unavailable, the system notifies the Admin.

3.2.3 Sequence diagram

A sequence diagram is an essential tool in the design and development of the Crop Recommendation and Supervision System, as it visually represents the interactions between system components and actors over time.

This type of diagram focuses on the flow of messages and processes, illustrating how agricultural experts, administrators collaborate to achieve specific functionalities, such as generating crop recommendations analyzing environmental factors, and supervising agricultural activities.

Sequence diagram includes:

- Actors who initiate the use case
- Object which accept flow of action
- Arrow: Starting and ending of action
- Iteration (Loop): Checked until required data is matched
- Activation: the time of an object needs to complete task
- Life time: objects presence overtime
- Destroy: termination point

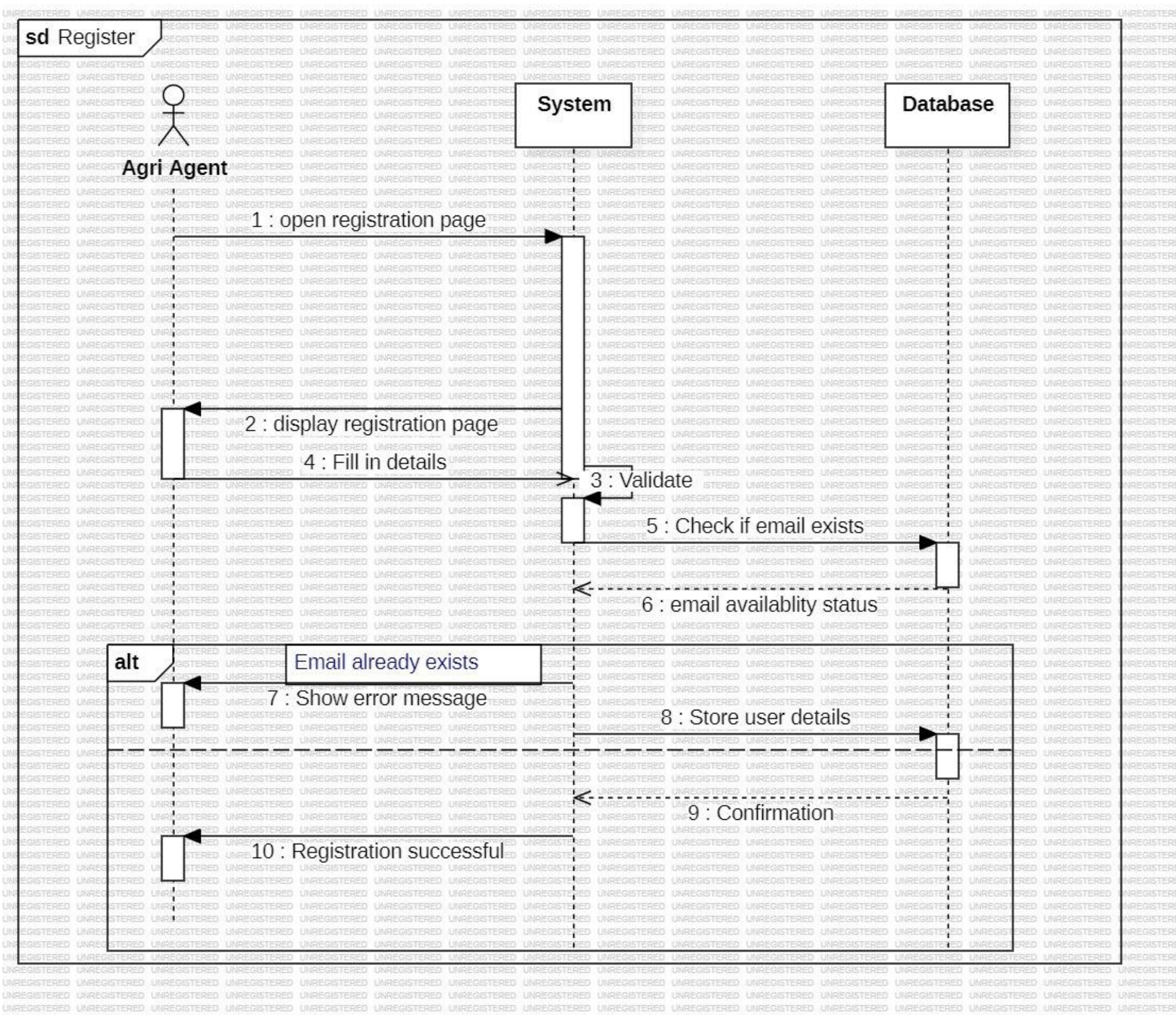


Figure 2: Sequence diagram for user registration

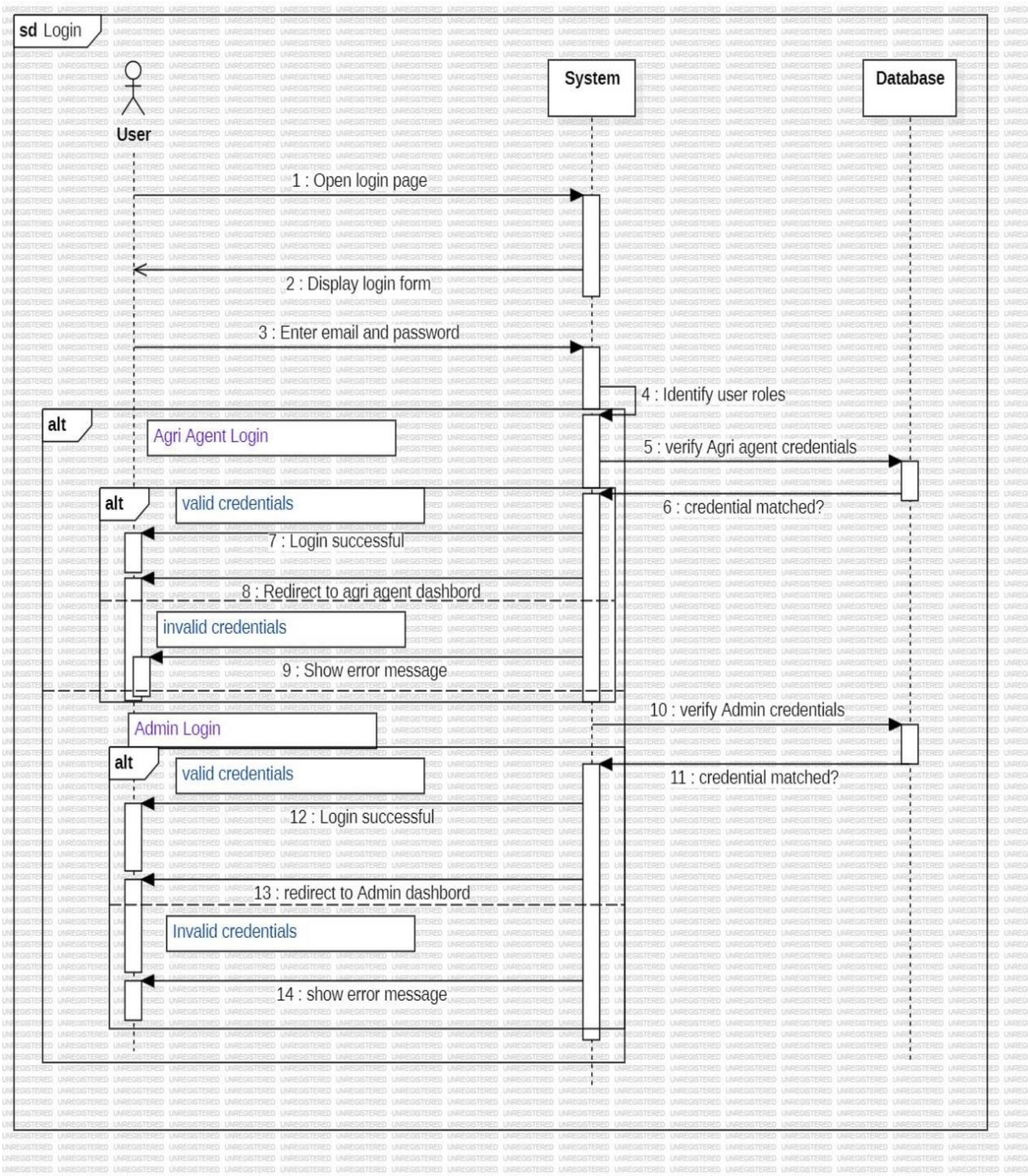


Figure 3: *Sequence diagram for login*

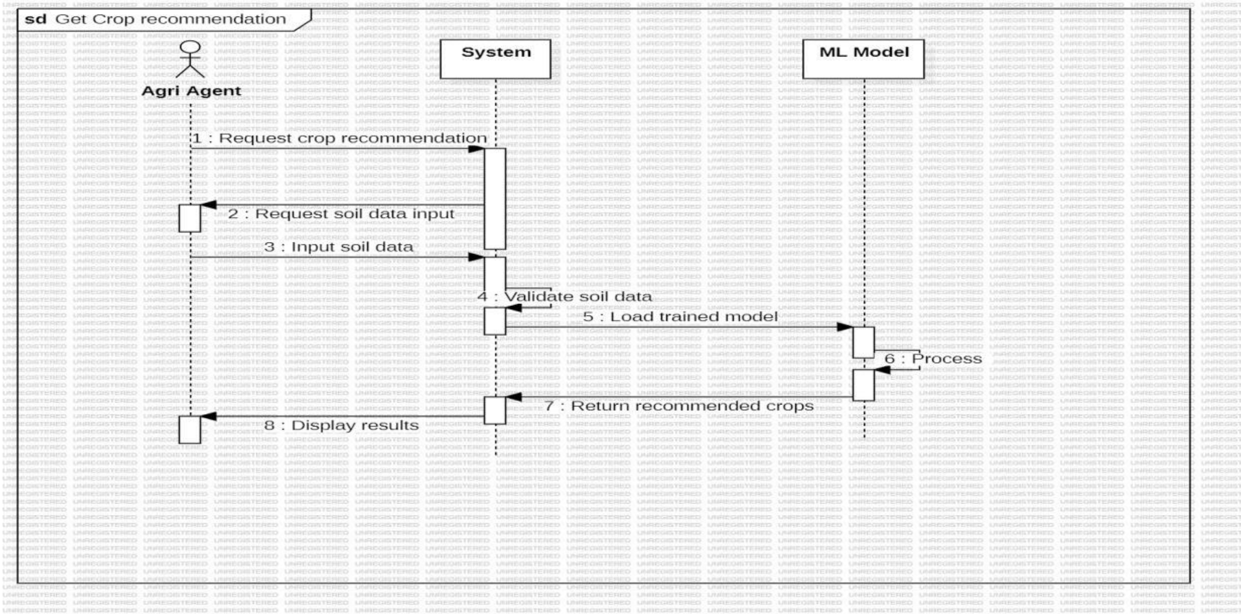


Figure 4: Sequence diagram for crop recommendation

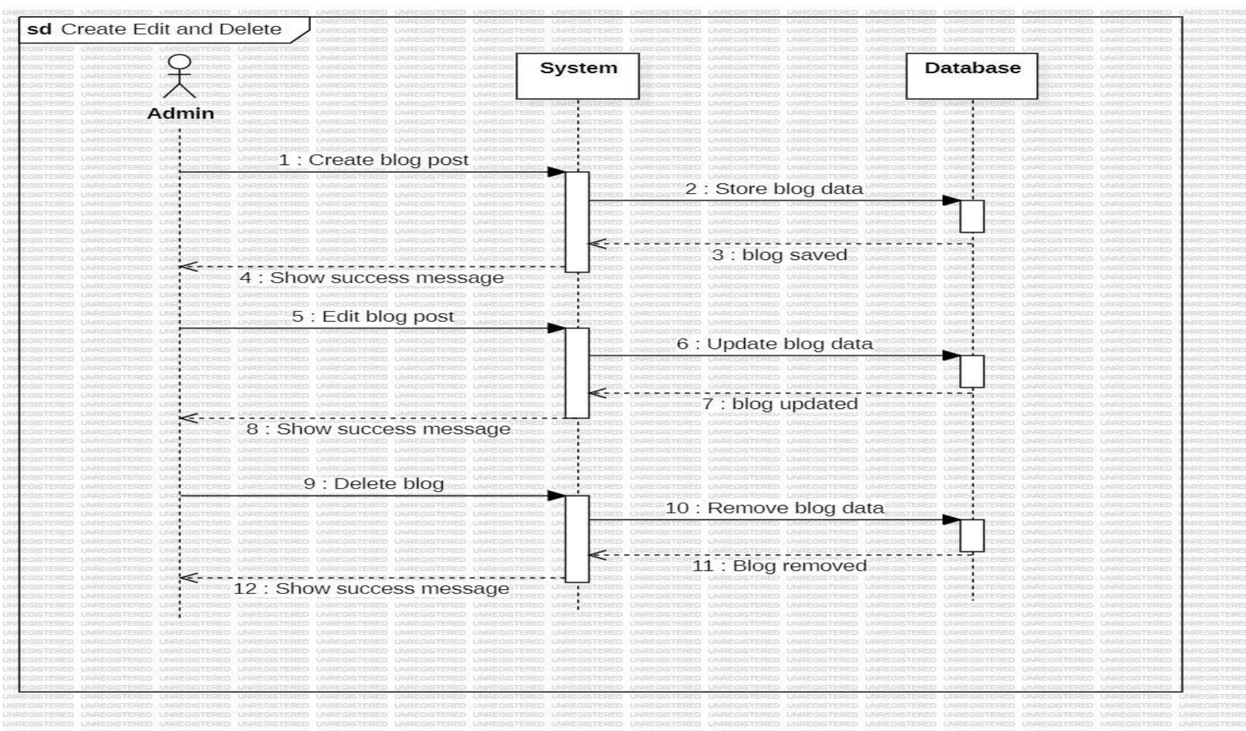


Figure 5: Sequence diagram for create, edit and delete blog

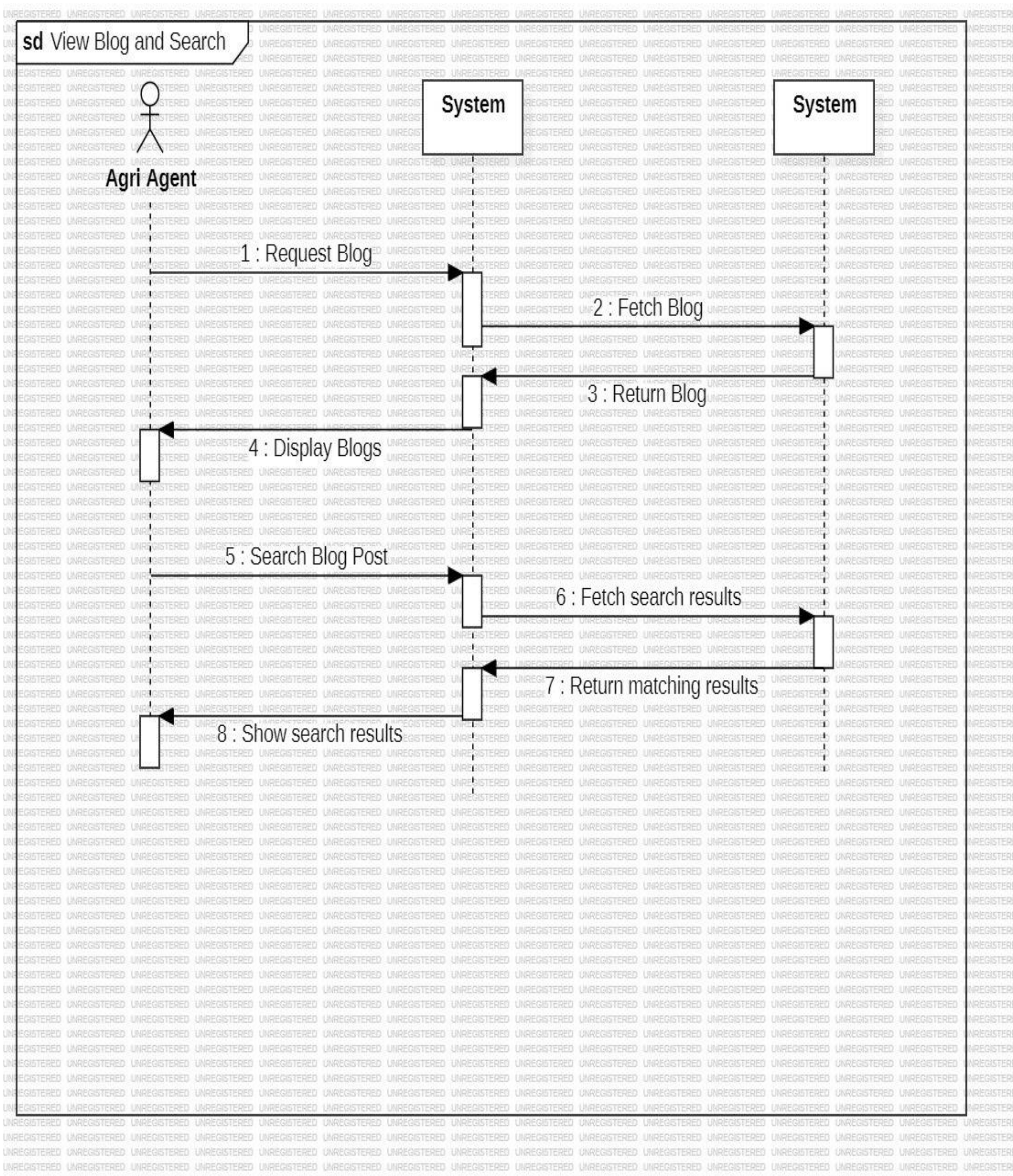


Figure 6: Sequence diagram for view blog

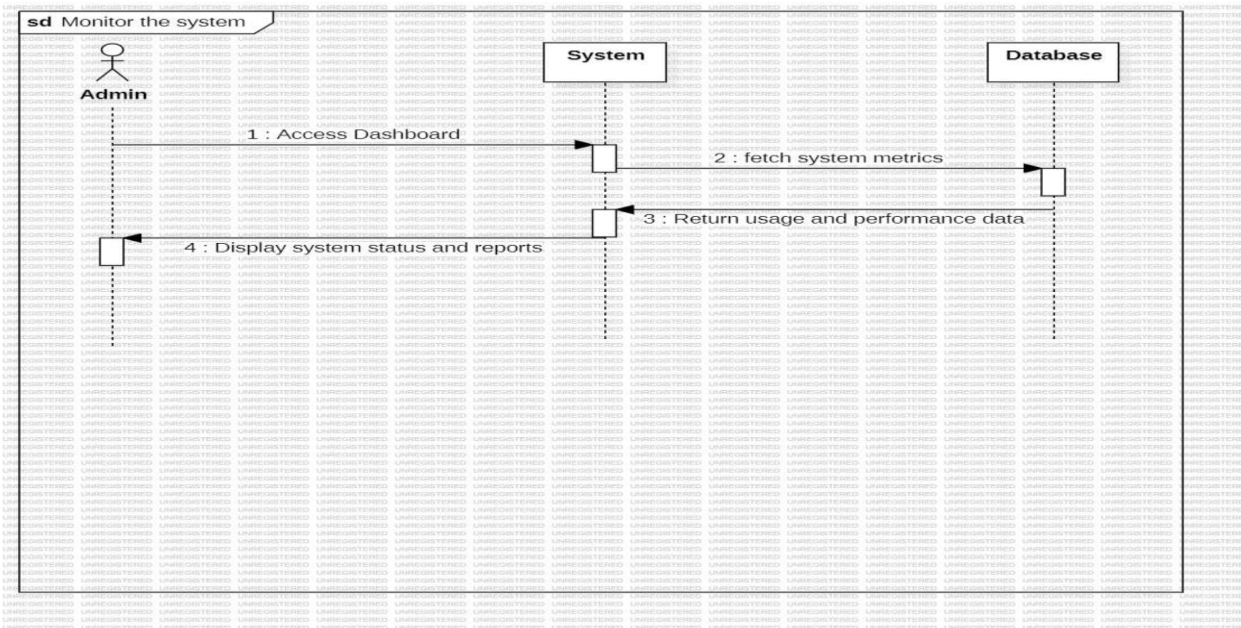


Figure 7: Sequence diagram for monitoring the system

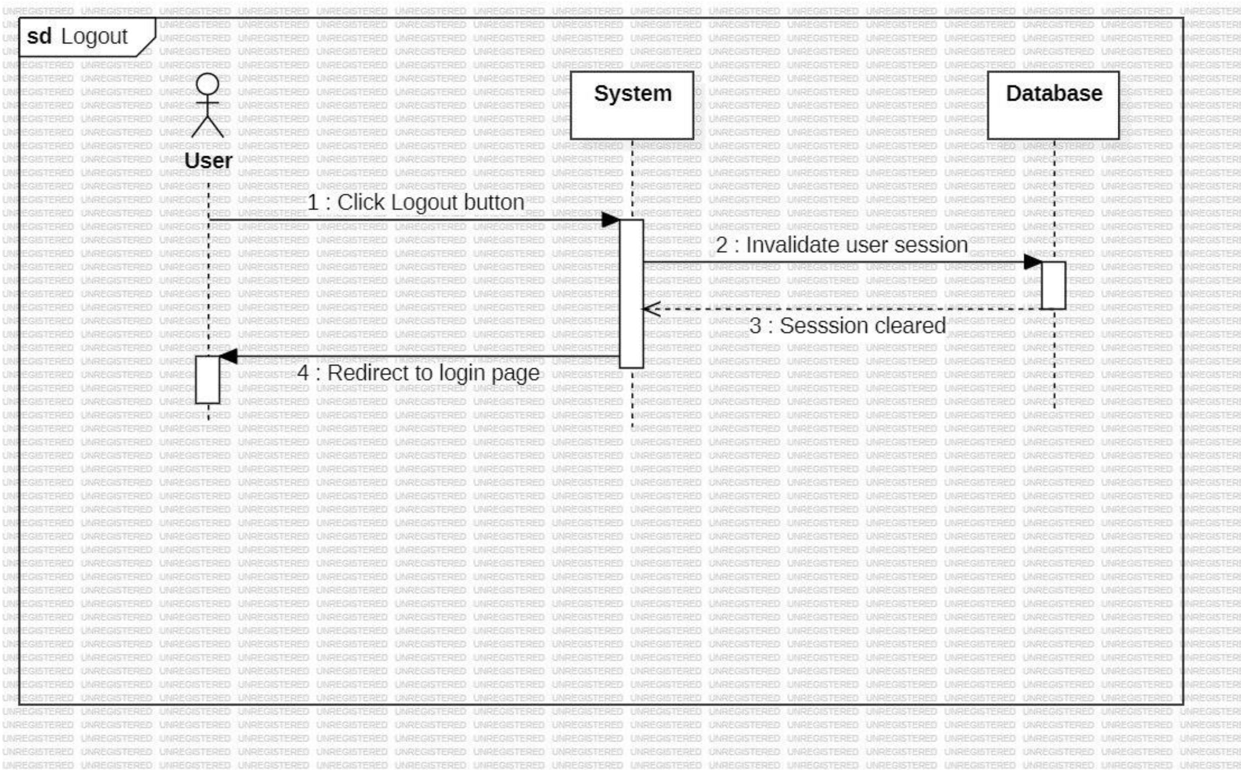


Figure 8: Sequence diagram for logout

3.2.4 Activity Diagram

Activity diagram helps in visualizing the workflow and processes within the system. The diagram captures the sequence of activities, decision points, and interactions among different entities, agricultural experts, administrators, and external systems. This ensures a clear understanding of how various processes are executed within the system.

Activity diagram visually presents a series of action or flow of control in a system.

❖ ***Initial Node****:* Shown as a small solid black circle. When an activity starts executing, a control token is placed on each initial node in the activity. The token can then trigger the execution of an action via an outgoing control flow.

❖ ***Final Node***: Like as a bulls-eye (double circle). When a control or object token reaches an activity final node during the execution of an activity, the execution terminates.

❖ ***Merge node****:* Has multiple incoming edges and a single outgoing edge. A merge node is a control node that brings together multiple alternate flows. It is not used to synchronize concurrent flows but to accept one among several alternate flows.

❖ ***Decision node****:* Control node that accepts tokens on one or two incoming edges and selects one outgoing edge from one or more outgoing flows. Decision nodes were introduced in UML to support conditionals in activities

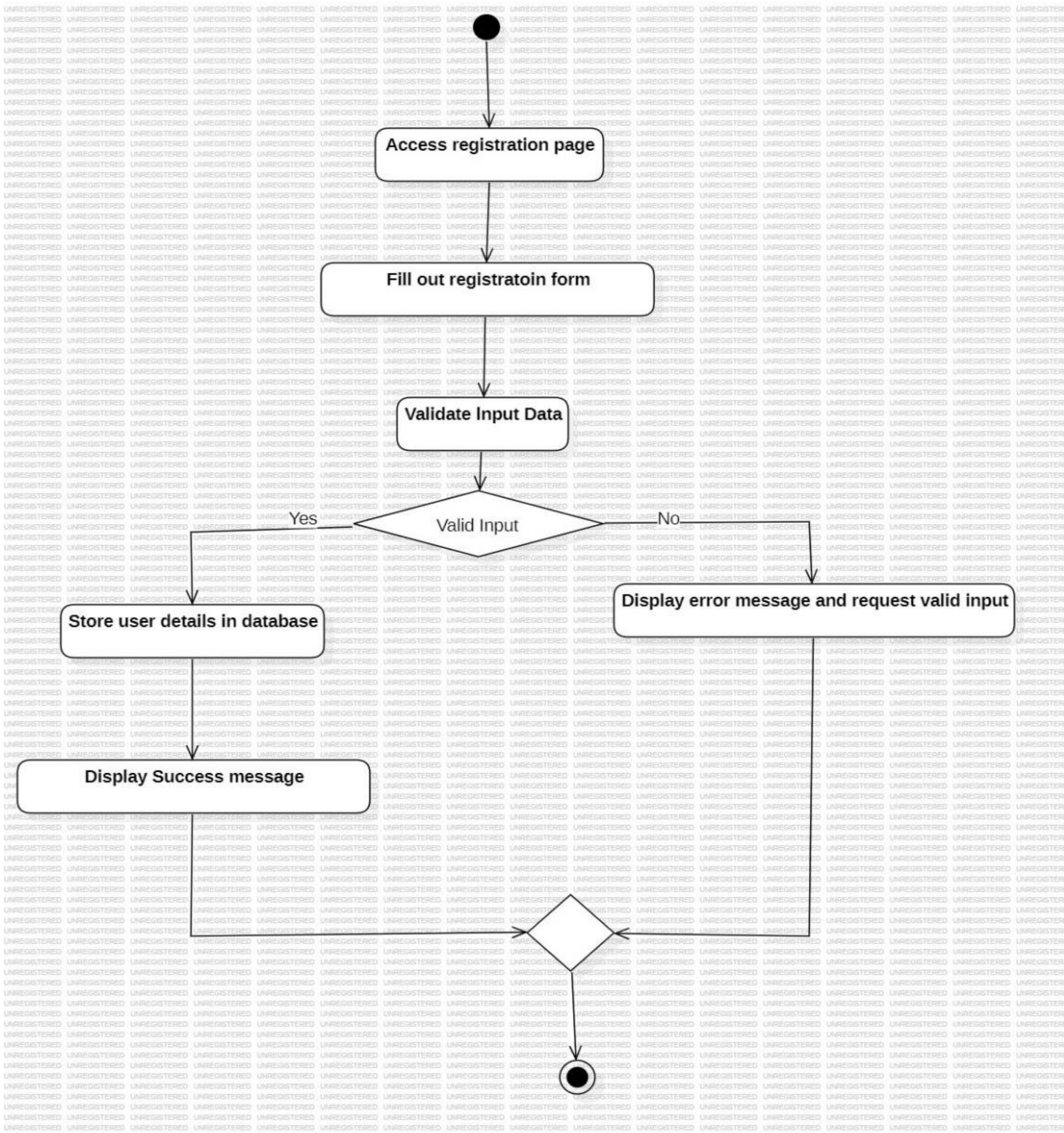


Figure 9: Activity diagram for registration

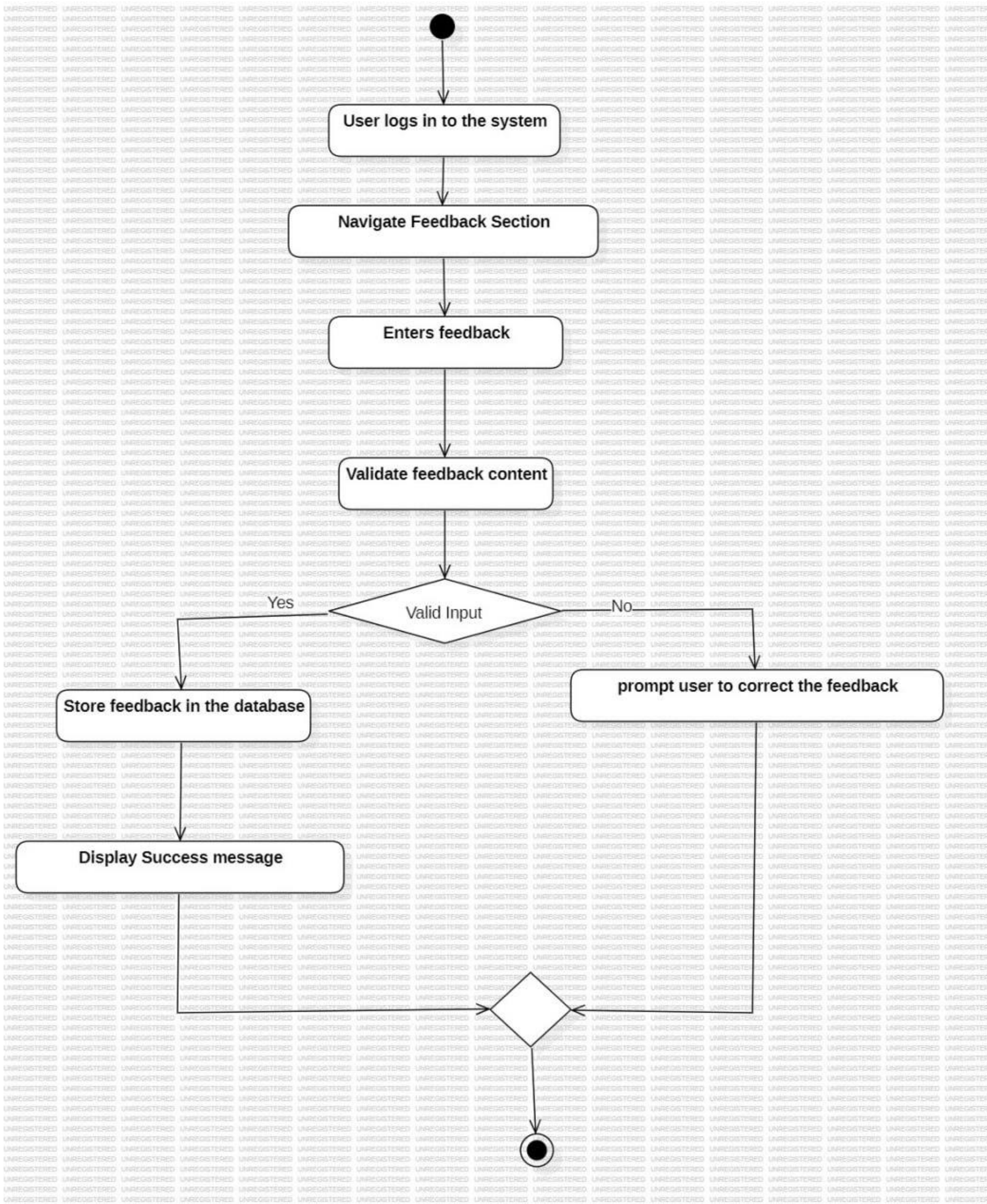


Figure 10: Activity diagram for feedback

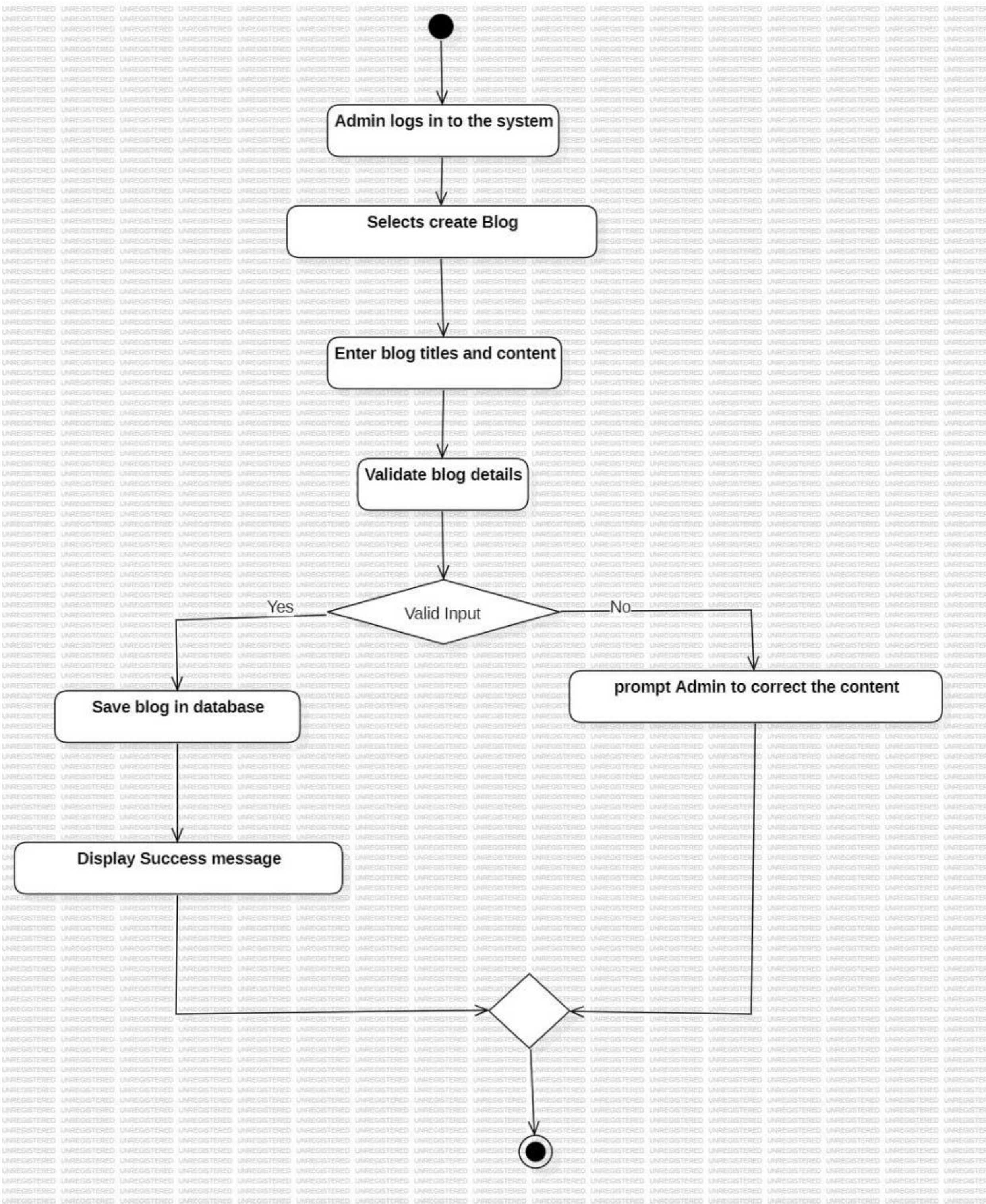


Figure 11: Activity diagram for create blogs

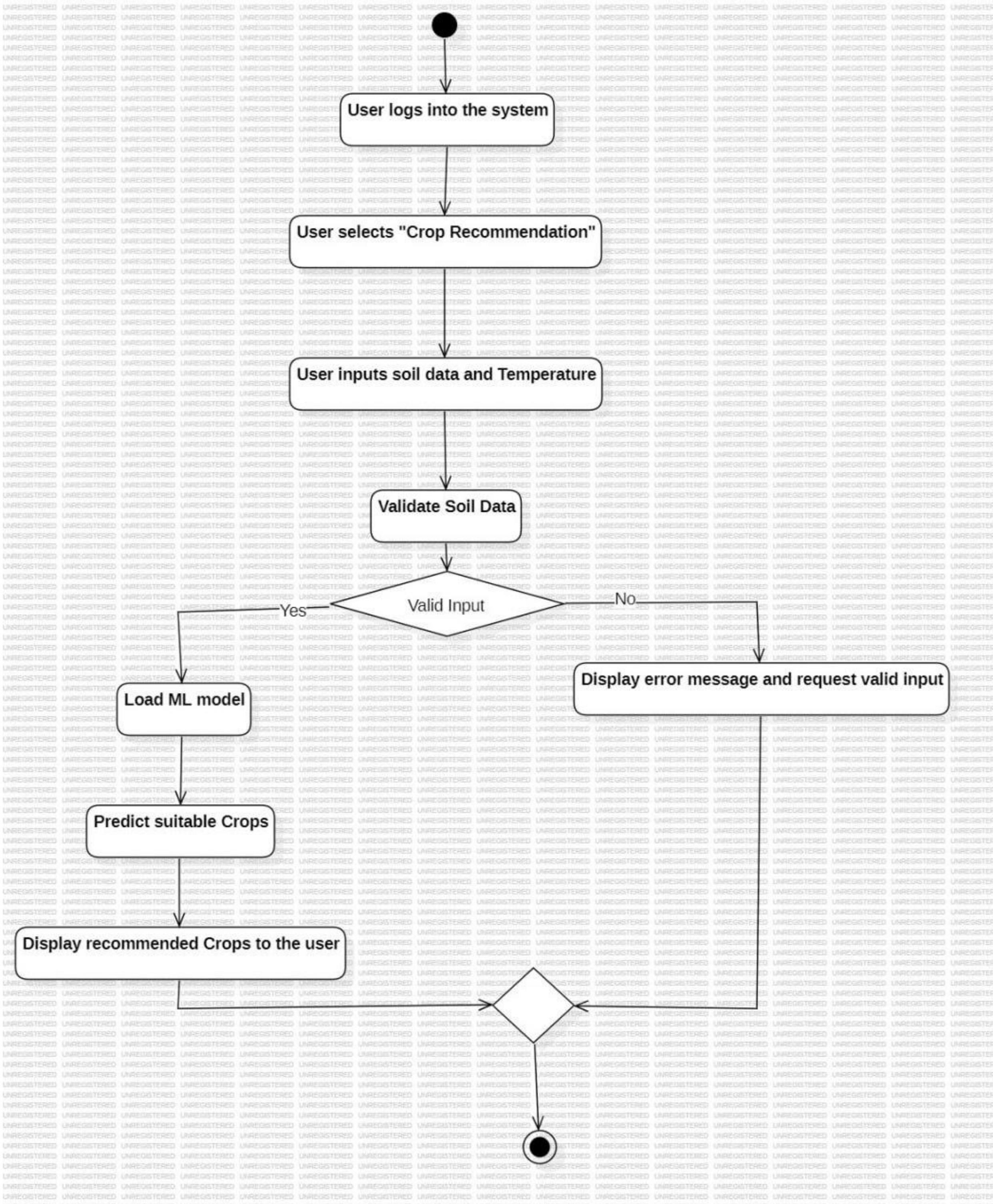


Figure 12: Activity diagram for crop recommendation

3.2.5 Analysis level class diagram

The analysis-level class diagram is a essential in the design and development process of the Crop Recommendation and Supervision System. It provides a high-level view of the system structure, identifying the main entities and their relationships. At this stage, the class diagram focuses on defining essential classes, attributes, and associations without delving into the specific implementation details.

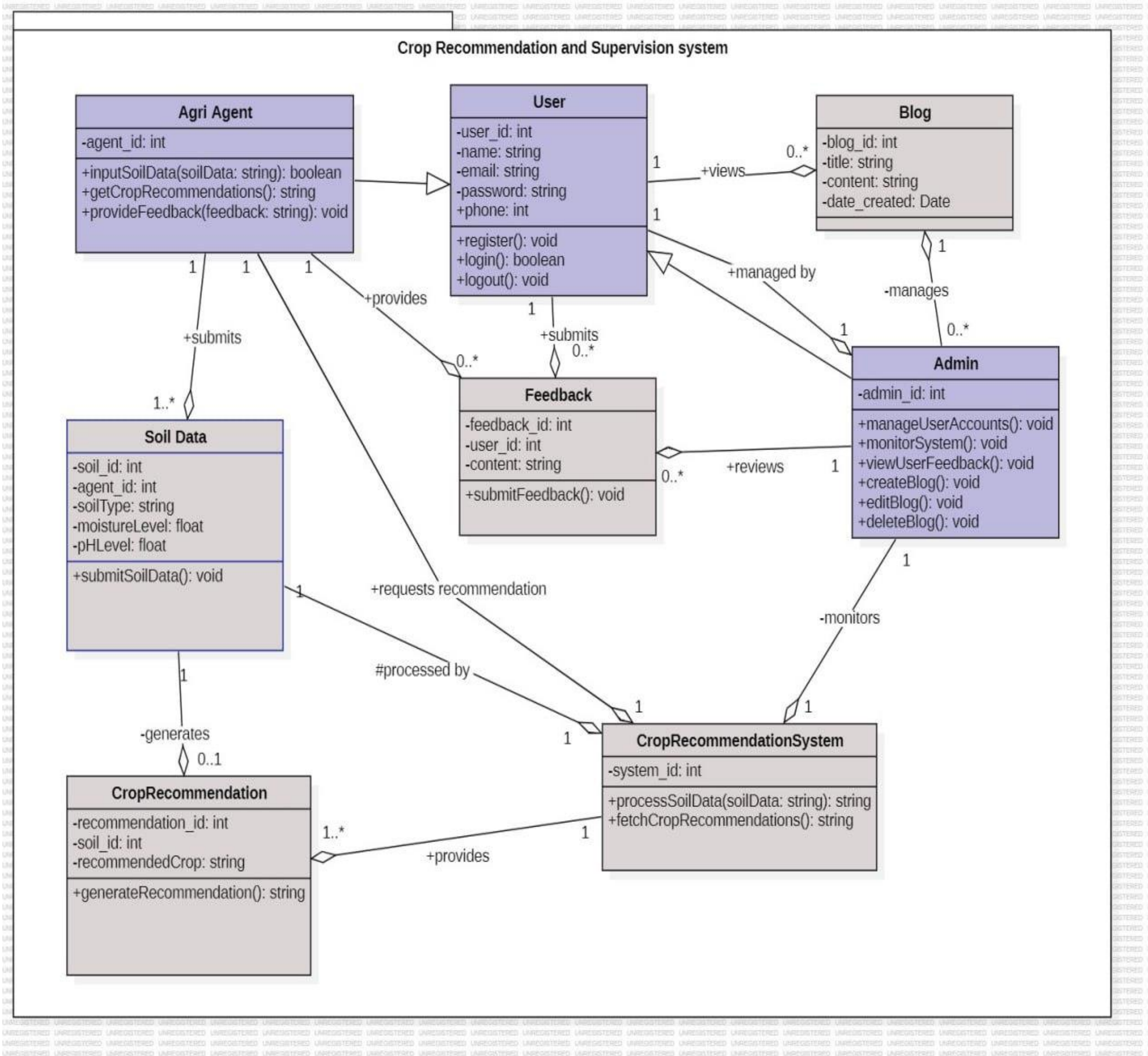


Figure 13: Class diagram

3.2.6 User Interface Prototyping

UI prototyping is a crucial step in the development of the Crop Recommendation and Supervision System, ensuring the creation of an intuitive and user-friendly interface that meets the needs of farmers and agricultural experts. This process involves designing interactive mockups that visually and functionally demonstrate how users will interact with the system.

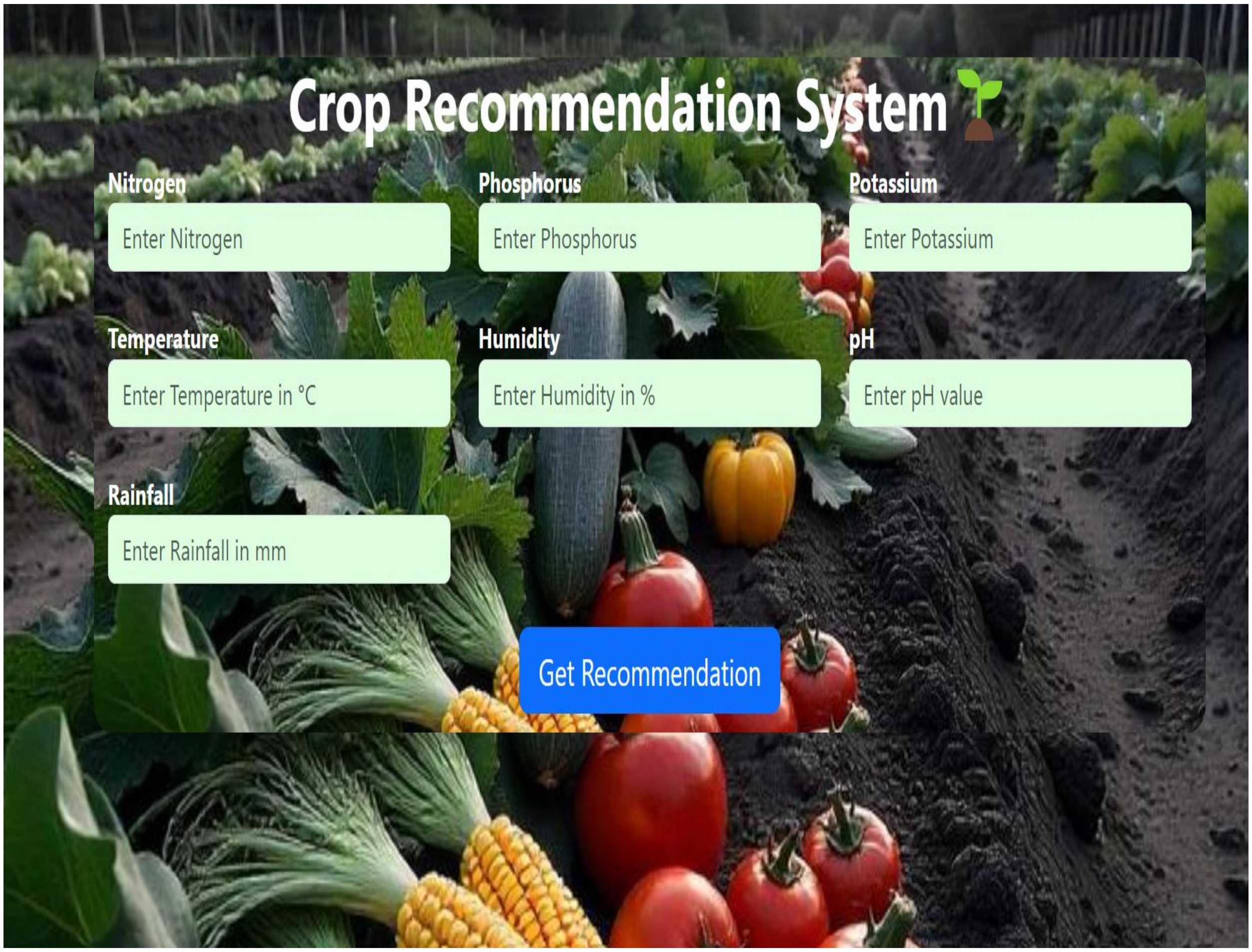


Figure 14: UI sample

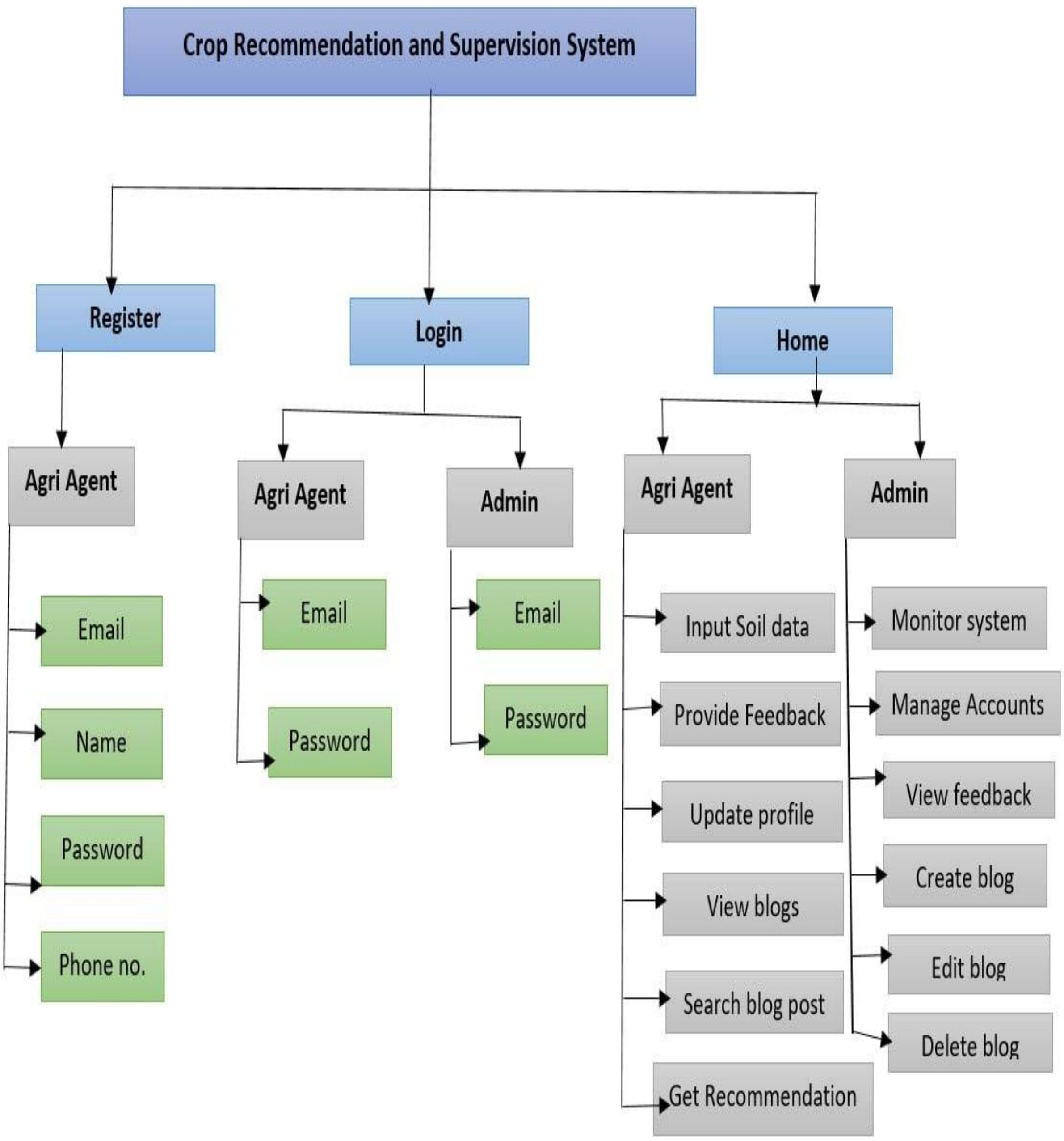


Figure 15: UI prototype