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Defended publicly on / /2025 in Tiaret in front the jury composed of:

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Glossaries

— **Ai :** Artificial Intelligence .

— **UI :** User Interface.

— **UX :** User experience

— **IOT :** Internet of things.

— **JSON :** JavaScript Object Notation.

— **E :** Event.

— **C :** Condition

— **A :** Action

— **MVC :** Model View Controller

— **API :** Application Programming Interface

— **NPK :** A set of three essential soil nutrients for plant growth: Nitrogen (N), Phosphorus (P), and Potassium (K).

— **UML :** Unified Modeling Language

— **ECA :** Event-Condition-Action

— **LLM :** Large Language Model

Abstract

Precision agriculture is crucial for assisting farmers in addressing increasing food demands, optimizing scarce resources, and adapting to climatic challenges. This study results in intelligent application that amalgamates data from various sources — such as field parcels, meteorological information, geolocation, soil nutrients (NPK), and satellite imagery — and employs four analytical types: descriptive (to discern historical trends), diagnostic (to investigate factors affecting yields), predictive (utilizing machine learning to anticipate future yields), and prospective (to model scenarios that assist farmers in selecting appropriate strategies). The model also accounts for particular agricultural constraints, including resource availability, seasonality, financial limitations, and farmer preferences regarding crop selection and sustainable practices. The Data-Driven Approach Automation (DDAA) system utilizes machine learning and deep learning to automate tasks by replicating human actions. An essential attribute is an interactive advisor driven by a Large Language Model (LLM) that engages with farmers, providing tailored guidance in accordance with their objectives, such as optimizing yield or conserving water. The application offers precise forecasts, practical insights, and a user-friendly interface that is multilingual and accessible. This work integrates multi-source data analysis with AI-driven guidance to promote intelligent, sustainable agriculture and enhance the accessibility of advanced tools for farmers.

ملخص

تُعد الزراعة الدقيقة أمرًا بالغ الأهمية لمساعدة المزارعين على تلبية الطلب المتزايد على الغذاء، وتحسين الموارد الشحيحة، والتكيف مع التحديات المناخية. يُنشئ هذا المشروع تطبيقًا ذكيًا يجمع البيانات من مصادر مُتنوعة - مثل قطع الأراضي الزراعية، والمعلومات الجوية، وتحديد المواقع الجغرافية، ومغذيات التربة(NPK) ، وصور الأقمار الصناعية - ويستخدم أربعة أنواع من التحليل: الوصفي (لتمييز الاتجاهات التاريخية)، والتشخيصي (لدراسة العوامل المؤثرة على الغلة و حتى الأمراض)، والتنبؤي (باستخدام التعلم الآلي لتوقع الغلة المستقبلية)، والمستقبلي (لنمذجة سيناريوهات تُساعد المزارعين على اختيار الاستراتيجيات المناسبة). كما يُراعي النموذج القيود الزراعية المُحددة، بما في ذلك توافر الموارد، والتغيرات الموسمية، والقيود المالية، وتفضيلات المزارعين فيما يتعلق باختيار المحاصيل والممارسات المستدامة. يستخدم نظام أتمتة النهج القائم على البيانات (DDAA) تقنيات التعلم الآلي والتعلم العميق لأتمتة المهام من خلال محاكاة الإجراءات البشرية. ومن السمات الأساسية وجود مُستشار تفاعلي مُدار بواسطة نموذج لغوي واسع (LLM) يتفاعل مع المزارعين، مُقدمًا إرشادات مُصممة خصيصًا وفقًا لأهدافهم، مثل تحسين الغلة أو الحفاظ على المياه. يقدم التطبيق تنبؤات دقيقة، ورؤى عملية، وواجهة سهلة الاستخدام ومتعددة اللغات وسهلة الوصول. يدمج هذا العمل تحليل البيانات من مصادر متعددة مع التوجيه المدعوم بالذكاء الاصطناعي لتعزيز الزراعة الذكية والمستدامة، وتحسين إمكانية وصول المزارعين إلى الأدوات المتقدمة.

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General Introduction

General Introduction

1.1 Context and Motivation

There are issues in farming that have never been seen before.like Weather changes, rising temperatures, soil erosion, and a lack of water and arable land are some of the things that put food quality food security and at risk around the world. Also, as the population grows, so does the need for food. This puts pressure on farming systems to be more productive and last longer. A lot of the time, farmers, especially those who live in developing areas,or hate the technologies , can't get the real-time data, advanced decision-making tools, and personalized advice that would help them handle these issues better.

It is becoming more and more important for farmers to use digital tools. This is called "smart farming" or "precision agriculture." Using data and AI, farmers can keep a closer eye on their crops, get the most out of the things they put into them, guess how much they'll produce, and be ready for risks. When farming and artificial intelligence (AI) work together, it could start a new era of farming that is based on data, flexible, and good for the environment.

1.2 Role of Artificial Intelligence in Agriculture

Artificial Intelligence, especially Machine Learning (ML) and Deep Learning (DL), has shown a lot of promise in changing farming. Some uses include predicting agricultural yields, finding diseases, analyzing soil, and improving irrigation. More recently, Large Language Models (LLMs) like ChatGPT have made it possible for farmers and advisory systems to talk to one other in natural language. These models can interpret questions in plain English, find the right information, and provide personalized advice, making them like virtual agricultural consultants.

AI may also be used with data from many sources, including as satellite images, soil sensors, historical climate data, and observations given by farmers, to provide a complete picture of crop conditions, farm performance, and potential threats. These tools may provide farmers a lot of ability to make choices based on facts and in a timely manner.

1.3 Project Overview

This thesis suggests creating and designing an intelligent agriculture assistance system called GHALATY. The system's goal is to bring together:

- Data from several sources, such field sensor readings, satellite photos, weather reports, and soil conditions,
- A model that can anticipate production and tell you how healthy a plant is,2
- A Large Language Model (LLM) that works as a virtual assistant in real time,
- And a Data Dashboard and AI Application (DDAA) that lets farmers see insights and make decisions based on them.

GHALATY is a hybrid, modular system that combines conventional data analysis with conversational AI to provide farmers advice that is relevant to their situation, in real time, and predictive analytics, as well as interactive visual aids to help them farm better.

1.4 Problem Statement

Even though there are vast agricultural databases and new technologies, farmers sometimes have trouble understanding the data or using it to make smart decisions. Traditional consulting services are sluggish, one-size-fits-all, and hard for smallholder farmers to get to. Also, the choices farmers make depend on the circumstances on their farm, the climate in their area, the sort of crop they grow, and the resources they have.

How can we provide a system that gives farmers precise, real-time, individualized guidance based on data from several sources? When we think about farmers' chosen language (such Arabic), connection issues, and the requirement for advice that are specific to their area, this situation becomes much harder

1.5 Research Question :

"How can farmers use multi-source agricultural data with Artificial Intelligence (AI), especially Large Language Models (LLMs), to help them make decisions that are real-time, personalized, and based on data?"

1.6 Objectives of the Study

The major goals of this study are to:

Build and use an integrated system **(GHALATY)** that uses both predictive models and conversational AI.

Use data from several sources, such sensors, satellites, and the environment, to estimate how healthy and productive crops will be.

Add a domain-adapted LLM that can talk to farmers in their own language, such Arabic dialects.

Make a dashboard and mobile app that are easy to use for seeing data and talking to the AI helper.

Check the system's performance, ease of use, and real-world effect on making decisions.

1.7 Methodology

To achieve this objective, we will use Scrum methodology, a widely recognized agile approach known for its flexibility and efficiency. Scrum was designed to increase speed of development, align individual and organization’s mottos, define a culture focusing on performance, support shareholder value creation, to have good communication of performance at all levels, and improve individual development and quality of life [12]. Thus, its numerous advantages justify our choice of this approach, as it promotes better communication within the team and especially allows for early detection and resolution of problems during the development stage.

1.8 Thesis Structure

There are three primary chapters in this thesis:

Chapter 1 : Agriculture 4.0 and data driven and multi source

Chapter 2 : goes into depth on how the **GHALATY** system was analyzed and designed, including things like requirements, architecture, UML diagrams, and data preparation.

Chapter 3 : talks about putting the plan into action, testing it out, and talking about the outcomes. It ends with a conclusion and ideas for how to make things better in the future.

Chapter 1

The Rise of Agriculture 4.0

Chapter 1: The Rise of Agriculture 4.0

1.1 The Evolution of Agriculture:

Over thousands of years and across the ages, agriculture has undergone significant changes, moving from labor-intensive methods to the highly technologically advanced systems we use on a daily basis. Agriculture began during the Neolithic period, when early inhabitants of the Fertile Crescent grew crops such as wheat, barley, and emmer wheat using primitive, time-consuming, and labor-intensive techniques [1].

Food production increased significantly during the Green Revolution of the 20th century, marked by the advent of mechanization and artificial fertilizers that helped advance agriculture in general and the discovery of high-yielding crop varieties [2].

Precision agriculture, which uses Global Positioning System (GPS) technology for activities such as field mapping and variable rate applications, emerged in the late 1990s. This breakthrough made the concept of Agriculture 4.0, which integrates digital technology to improve agricultural operations, possible [3].

1.2 Agriculture 1.0 To 4.0 Overview (Focusing on 4.0):

Era	Description	Technologies	Key Impact
Agriculture 1.0	Manual labor & traditional methods	Basic tools, animal traction	Subsistence farming
Agriculture 2.0	Industrial agriculture	Tractors, fertilizers, breeding	Increased productivity
Agriculture 3.0	Precision agriculture	GPS, GIS, remote sensing	Resource optimization
Agriculture 4.0	Digital and smart farming	IoT, AI, robotics, big data	Sustainable automation

Table 1: Agriculture 1.0 To 4.0(Source: Author's own design)

1.2.0 Time line :

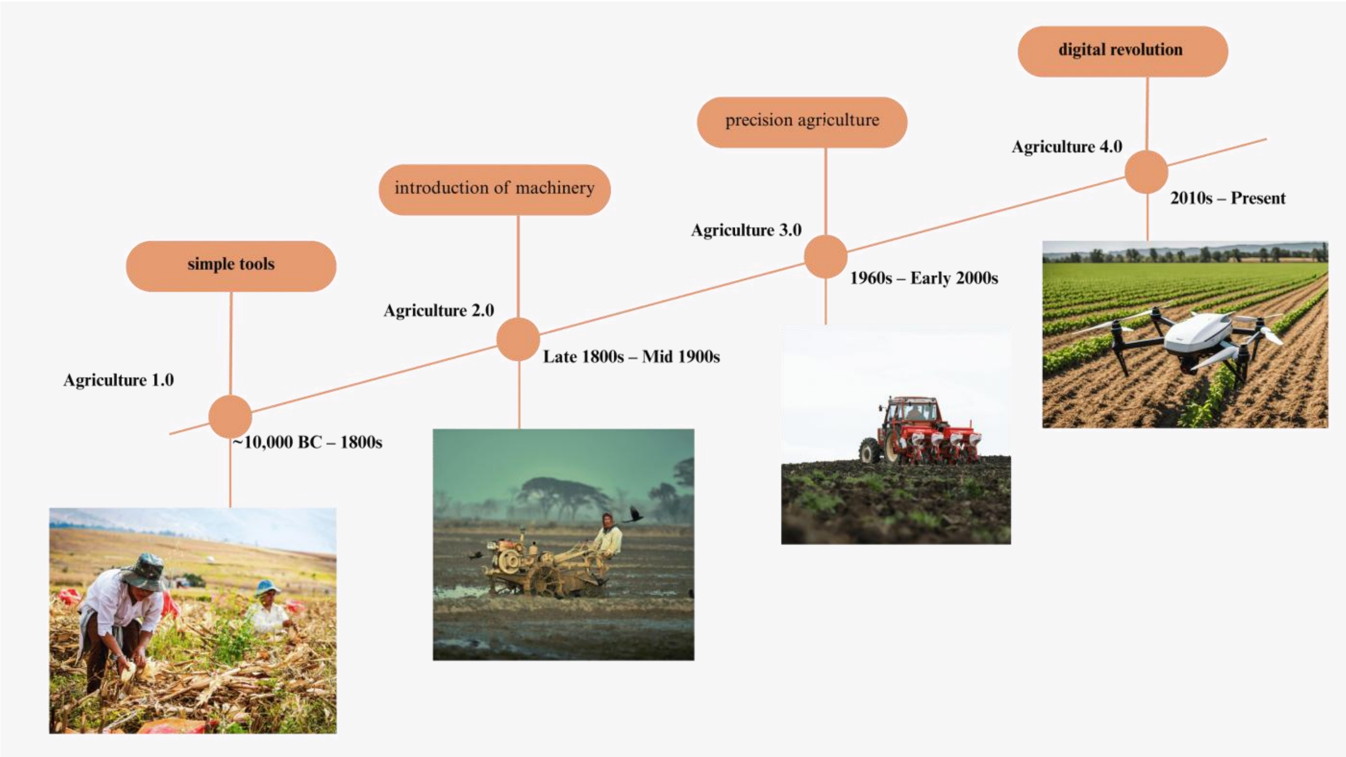

Figure 1: Time line Agriculture (Source: Author's own design)

1.2.2 Agriculture 2.0

Saw the introduction of machinery, such as tractors and harvesters, which replaced manual labor and increased productivity. This era also witnessed the development of chemical fertilizers and pesticides, which improved crop yields but had negative environmental impacts. Many of those changes were consequence of the re-adaptation of mechanical and chemical industries, converted to civil uses after having been producing for the army in World War II. Also breeding started to boost, both from public universities and public institutes, and private companies [5].

1.2.3 Agriculture 3.0

Utilizing technology to maximize agricultural methods, precision agriculture is another name for this approach. Geographic Information Systems (GIS), remote sensing, and GPS technologies were used into agricultural operations to gather information on weather patterns, crop health, and soil conditions. In order to minimize waste and environmental harm, this data was then used to produce accurate maps and apply inputs, such as pesticides, fertilizers, and irrigation water, just where and when required [3]. During this time, the general people became aware of the negative effects that the widespread use of pesticides and fertilizers was having on the environment.

1.2.4 Agriculture 4.0

Agriculture 4.0 represents the ongoing digital revolution in farming. It is characterized by the convergence of technologies such as the Internet of Things (IoT), artificial intelligence (AI), robotics, and big data analytics. In this era, farms are becoming increasingly automated, with robots performing tasks like planting, de-weeding, and harvesting. IoT sensors monitor various aspects of farm operations, from soil moisture to livestock health. AI algorithms analyze vast amounts of data to optimize decision-making and predict future outcomes [6]. Precise application of resources strongly reduces waste and environmental impact. A big contribution is brought also from Breeding, developing varieties needing less input to produce a good yield, and more resilient to environmental stress [7].

1.2.4.1 Key Technologies Driving Agriculture 4.0

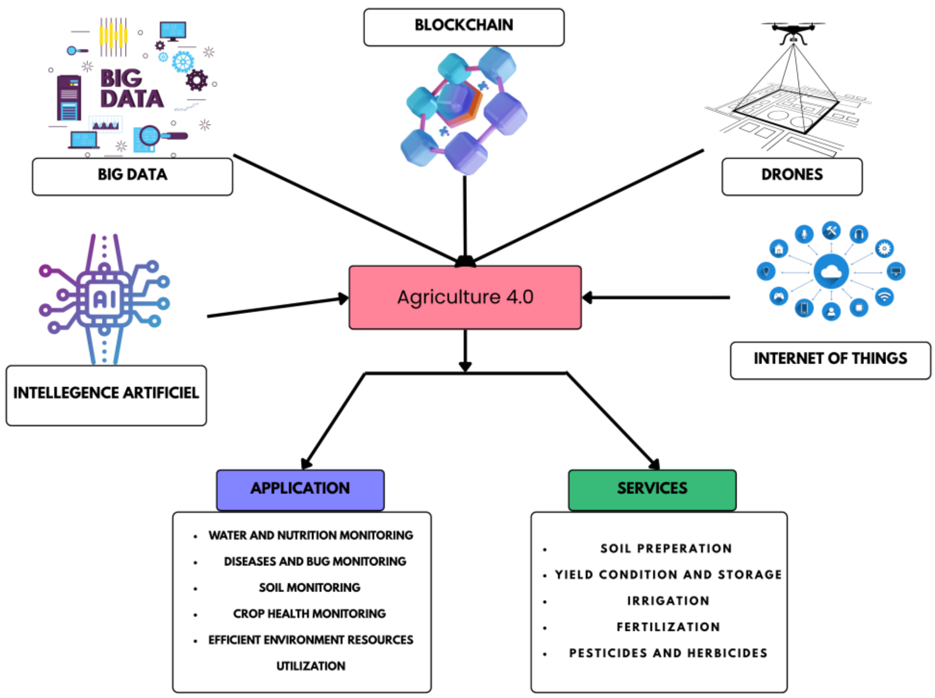

Figure 2: Key Technologies Driving Agriculture 4.0(Source: Author's own design)

- **Internet of Things (IoT):** IoT devices connect farm equipment, sensors, and other devices to collect and transmit data.

- **Artificial Intelligence (AI):** AI algorithms analyze data to identify patterns, make predictions, and automate tasks.
- **Robotics:** Robots perform tasks such as planting, weeding, and harvesting, increasing efficiency and reducing labor costs.
- **Drones:** Drones are used for tasks such as crop monitoring, spraying, and delivering supplies.
- **Big Data Analytics:** Big data analytics helps farmers make informed decisions based on vast amounts of data.
- **Blockchain:** Blockchain technology can be used to track the origin and quality of food products [8].

1.2.4.2 Benefits of Agriculture 4.0

Several studies have highlighted the benefits of Agriculture 4.0 in transforming traditional farming into a more efficient, data-driven, and sustainable practice . These include:

- **Increased productivity:** Automation and optimization lead to higher yields.
- **Reduced environmental impact:** Precision agriculture minimizes the use of inputs, reducing pollution.
- **Improved food safety:** Technology can help track food from farm to table, ensuring safety and quality.
- **Enhanced sustainability:** Agriculture 4.0 can help address challenges such as climate change and food security [6], [8].

1.2.5 Challenges and Future Directions

While Agriculture 4.0 offers many benefits, it also presents challenges, such as the high cost of technology, the need for skilled labor, and concerns about data privacy [9]. As the industry continues to evolve, future developments may include:

- **Autonomous farming:** Fully autonomous farms operated by AI and robotics.
- **Vertical farming:** Growing crops in stacked layers in urban environments.
- **Gene editing:** Using CRISPR and other technologies to create genetically modified crops with desirable traits [10].

In conclusion, from what we've learned, the evolution of agriculture from manual labor to advanced technological practices has been remarkable. Agriculture 4.0 represents the latest in agricultural technology, offering a system that makes food more sustainable, efficient, and productive. With continued technological advancements, the future of agriculture appears bright, offering opportunities to increase productivity and reduce environmental impact. This is something we'll discuss later.

1.3 Agriculture 4.0 include

Several studies have highlighted the benefits of Agriculture 4.0 in transforming traditional agriculture into a more efficient, data-driven, and sustainable practice. These include:

Precision Agriculture: Using data analytics to make informed decisions about crop management.

Automation: Using robots and autonomous machines to perform agricultural tasks.

Connectivity: Using IoT devices for real-time monitoring and control.

Sustainability: Reducing environmental impact through efficient use of resources [6], [11].

By leveraging these technologies, Agriculture 4.0 seeks to address challenges such as climate change, population growth, and resource scarcity.

1.4 The Role of the Internet of Things in Modern Agriculture

The Internet of Things (IoT) has become an integral part of modern agriculture, enabling real-time data collection and analysis. IoT devices, such as soil moisture sensors, weather stations, and livestock trackers, provide farmers with important information for data-driven decision-making. [12].

1.4.1 IoT applications in agriculture include:

Crop monitoring: Sensors measure soil conditions, temperature, and humidity to optimize irrigation and fertilization.

Livestock management: Wearable devices track animal health, behavior, and environmental information, improving welfare and productivity.

Supply chain optimization: The Internet of Things facilitates step-by-step traceability and quality control from the farm (primary product) to the consumer.

There are many uses, but we will only discuss those that serve the memorandum's purpose. in finale Integrating IoT technologies improves efficiency, reduces waste, and supports sustainable farming practices [12], [13].

1.5 Data-Driven Approach Automation (DDAA)

Data-Driven Agricultural Applications (DDAA) use data analytics and artificial intelligence to enhance decision-making in agricultural practices. The DDAA system analyzes data from many sources to provide insights on crop health, production predictions, and resource management [14].

1.5.1 Key components of the DDAA system include:

- **Predictive analytics:** Predicting crop yields and disease outbreaks.
- **Decision support systems:** Providing recommendations on planting, irrigation, and fertilization schedules.
- **Market analysis:** Evaluating market trends to guide pricing and distribution strategies.

Adopting a DDAA system enables farmers to make informed decisions, enhancing productivity and profitability [14].

1.8 The Importance of Multi-Source Data Integration

Integrating data from multiple sources is critical for comprehensive agricultural analysis. Combining information from IoT devices, satellite imagery, and historical records enables a comprehensive understanding of farming systems [15].

1.9 The benefits of multi-source data integration include:

Integrating data from multiple sources is crucial for comprehensive agricultural analysis. Combining information from IoT devices, satellite imagery, and historical records allows for a holistic understanding of farming systems.

1.9.1 Benefits of multi-source data integration include:

Enhanced Accuracy: Cross-referencing data improves the reliability of predictions.

Comprehensive Insights: A unified data set provides a complete picture of farm operations.

Informed Decision-Making: Integrated data supports strategic planning and risk management.

1.10 Challenges in Implementing Agriculture 4.0

Challenges	Description
Infrastructure Limitations	Lack of reliable internet connectivity in rural areas hinders technology adoption.
High Costs	The expense of acquiring and maintaining advanced technologies can be prohibitive for small-scale farmers.

Technical Expertise	Farmers may require training to effectively utilize new tools and systems.
Data Privacy Concerns	Ensuring the security of sensitive agricultural data is paramount.

Table 2: Challenges in Implementing Agriculture 4.0(Source: Author's own design)

1.11 the Role of LLMs in Agriculture 4.0

We examined Agriculture 4.0's technical foundation, now we will emphasizing the incorporation of sophisticated data systems and intelligent agents. We examine the ways in which contemporary structures facilitate communication, prediction, data collecting, and storage. We specifically draw attention to the expanding function of Large Language Models (LLMs) in supporting decision-making, real-time advising, and farmer contact.

1.11.1 Definition of Large Language Models (LLMs)

Large Language Models (LLMs) are deep learning models trained on massive datasets of text to understand, generate, and interact using human language. Models like **GPT-4**, **BERT**, and **T5** belong to this class. They are built on the **Transformer architecture**, which uses self-attention mechanisms to process input sequences efficiently and contextually [16].

In agricultural contexts, LLMs can act as intelligent assistants capable of:

- Answering farmers' queries
- Translating technical data into understandable language
- Interpreting sensor results
- Generating automated reports
- Interacting in local dialects or specific farming terminologies

"LLMs function not only as knowledge retrievers but also as adaptive communicators, bridging the digital divide in precision agriculture" [17].

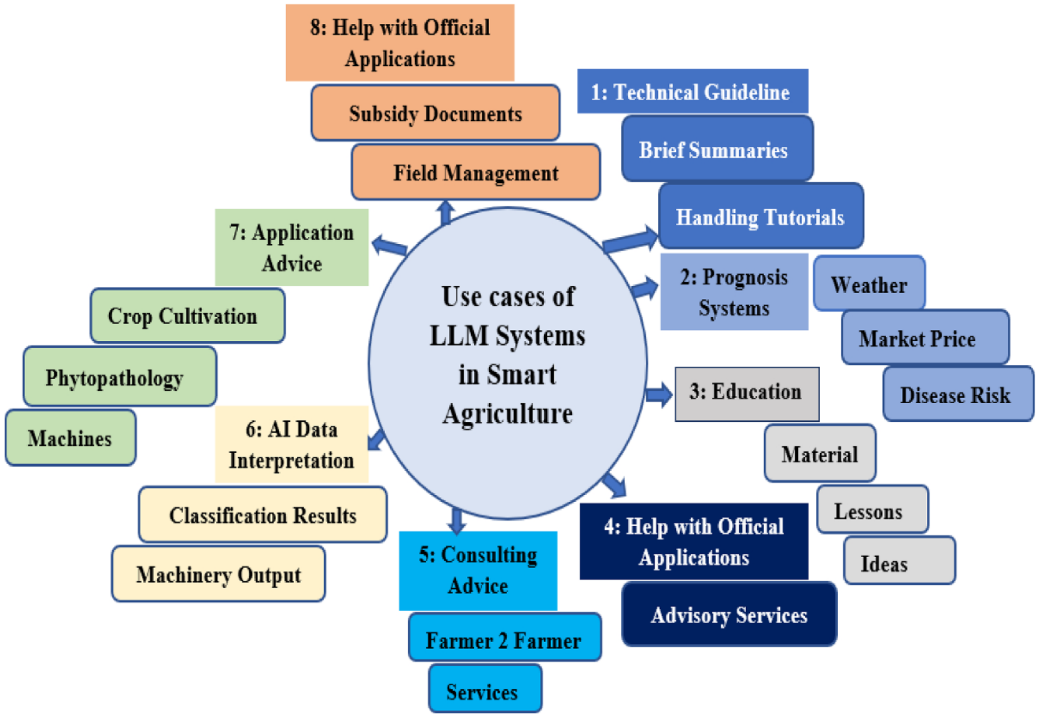

Figure 3: The role of large language models in agriculture (Source: Tawseef Ayoub Shaikh and al., 2024) [18].

1.11.2 Applications of LLMs in Advice and Communication:

In this section, we discuss the integration of LLMs into agricultural systems for advisory and communication purposes. Several real-world applications exist or are emerging:

Use Case	**Description**	**LLM Benefit**
Chatbots (LLM) for Farmers	Virtual assistants accessible via application	Provide 24/7 responses in local languages
Pest & Disease Diagnosis	LLMs interpret symptoms or photos via multi-modal inputs	Aid in accurate diagnosis and treatments
Policy and Market Advice	Summarizing news, weather, and farm reports	Help farmers make informed decisions

Voice-to-Text Interaction	Speech-based queries	Enhance accessibility for illiterate users
Report Generation	Daily or seasonal farm summaries	Automate documentation using IoT data

Table 3: Applications of LLMs

For instance, the **GhALATY application** was integrate an LLM module that allows farmers to ask natural language questions like:
"What's the best time to irrigate based on this week's forecast?"
The LLM can query internal data, apply logic, and reply contextually.

1.11.3 LLMs vs Traditional Chatbots in Agriculture :

Feature	**LLM-Based Chatbots**	**Traditional Chatbots**
Training Data	Billions of tokens	Manually programmed responses
Flexibility	Can handle complex questions	Limited to predefined flows
Language Support	Multilingual, even dialects	Often language-limited
Updates	Fine-tuned with new data easily	Requires manual reprogramming

Table 4: LLMs vs Traditional Chatbots

1.11.4 Future Integration with Satellite Data and IoT:

Future developments aim to couple LLMs with satellite imagery, weather forecasts, and sensor data to provide multimodal decision support. An LLM might process:

- Satellite NDVI data
- Soil moisture sensor readings
- Disease reports

...and then generate a summary like:

"Your northern field shows a 20% decrease in vegetation index. Consider checking for irrigation issues or pest infection."

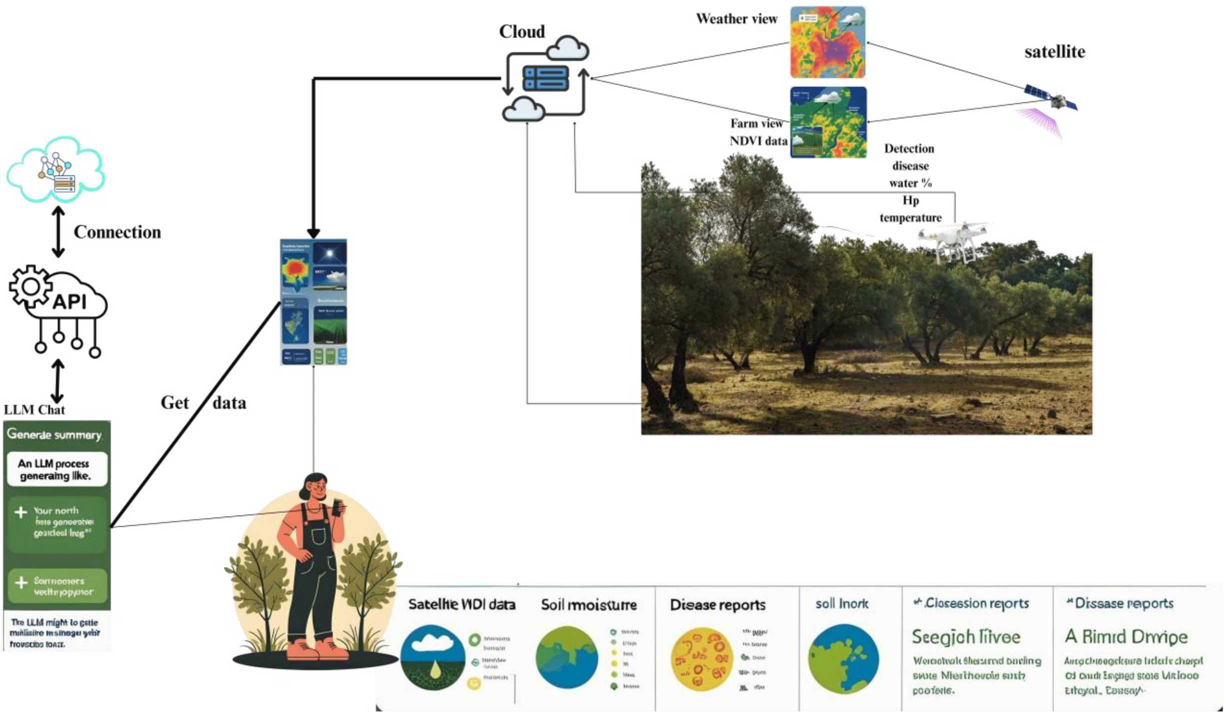

Figure 5 : Smart Agriculture System (Source: Author's own design)

1.11.5 Challenges and Considerations:

Despite the promise of LLMs in agriculture, several challenges persist:

- **Data Privacy:** Sensitive farm data must be protected.

- **Bias**: LLMs trained on general data might misinterpret niche agronomic content.
- **Connectivity**: Many rural areas lack stable internet access.
- **Language Barriers**: Support for local dialects must be fine-tuned.

Conclusion:

Agriculture 4.0 represents a radical change from conventional methods to data-driven, intelligent agricultural systems that can handle today's pressing global issues. Its promise to improve crop resilience, lessen environmental impact, and guarantee food security is obvious, despite current obstacles including cost and technical complexity. Furthermore, new opportunities for real-time data interpretation, individualized advising systems, and intelligent decision-making are made possible by the integration of developing technologies, especially the expanding importance of Large Language Models (LLMs). The collaboration of LLMs, IoT devices, and AI-powered dashboards will be crucial in forming a more sustainable and scalable future for smart farming as the agricultural industry develops.

Chapter 2

Part 1: Analysis, Design, and Architecture of GHALATY

Chapter 2 -Part 1: Analysis, Design, and Architecture of GHALATY

2.1 Introduction

In this chapter, we analyze the conceptual foundation and system architecture of GHALATY—our integrated platform for **"development of a prediction model for precision agriculture based on the integration of multi-source data using four types of analysis."** We begin with a real-world motivating example, then outline domain considerations, propose our solution, and conclude with architectural and user-centered design insights.

2.2 Motivating Example

We explore a realistic scenario to ground our architecture in real-world needs.

2.2.1 Scenarios

We consider a smallholder olive farmer in Ksar-chellala ,Tiaret, Algeria, challenged by unpredictable weather, soil nutrient depletion, and lack of expert guidance. In such contexts, farmers rely on tradition rather than data-driven insights. GHALATY offers them intuitive, actionable advice via smartphone—whether it's when to irrigate, fertilize, or rotate crops.

2.2.2 Domain Analysis

In this section, we examine data sources (IoT sensors, satellite imagery, climate APIs, farmer inputs), user roles, and analytical needs specific to olive farming. We also review existing agricultural tools and identify gaps in cost, context-awareness, and offline usability.

2.2.3 Avenues for Improvement

Most current systems are either expensive, lack contextual guidance, or fail to personalize recommendations. GHALATY bridges these gaps by integrating real-time data, AI-powered prediction, multilingual support, and an LLM advisor.

2.2.4 Motivation and Research Question

Our guiding question is:

How can we design a predictive, context-aware platform that integrates multi-source data and provides descriptive, diagnostic, predictive, and prescriptive insights to smallholder farmers?

2.3 Our Proposal: LLM Advisor Integrated System

2.3.1 Internet of Things (IoT) Integration

We integrate:

- **Soil sensors** for NPK, moisture, and pH
- **Environmental sensors** for microclimate data
- **Drones** for aerial NDVI imagery
- **Camera traps** monitoring crop health
- **Google earch engine** satellite images

These feed into a real-time decision pipeline.

2.3.2 Storage Layer

We use **SQLite** for structured data (e.g., user profiles and farm details and chats)

Currently, the prototype is in progress, but as the final model is released, we are working on using **Firebase** and cloud storage.

2.3.3 User Interface

The mobile application (built in Flutter) includes a chatbot, dashboards, and guided data input—designed for low-literacy farmers, with language options (Arabic and English).

2.4 Theoretical Foundation

2.4.1 Core Elements

Core components: Sensor network, Data pipeline, Prediction model, LLM advisor, and Mobile App interface.

2.4.2 System Behavior

We define system behavior UML Sequence Diagram representing key triggers:

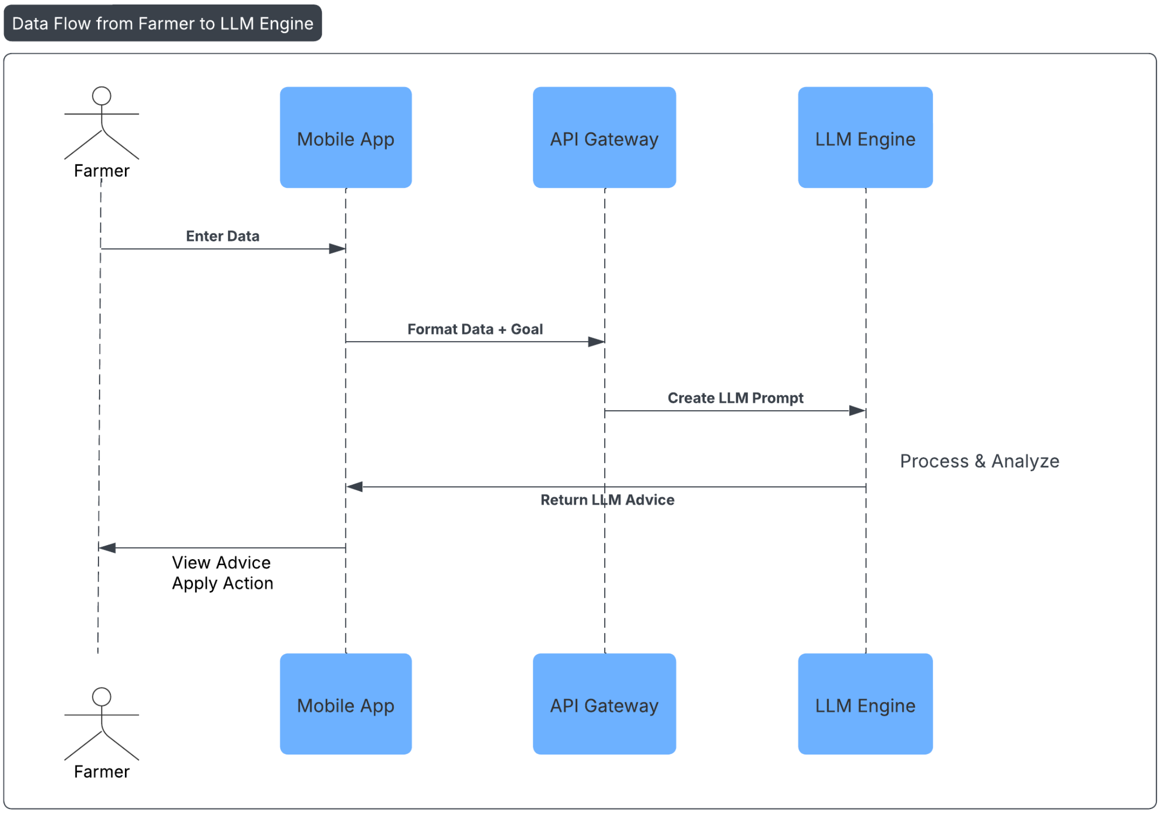

Figure 6 – UML Sequence Diagram of the LLM Interaction Process (Source: Author's own design)

This diagram details the dynamic message exchange between the user (farmer), mobile interface (Flutter app) and the Large Language Model (LLM). It starts from user input and ends with the delivery of actionable advice.

2.4.3 Fault and Exception Handling

Mechanisms include sensor anomaly detection, fallback to satellite data, and safe defaults for missing inputs.

2.4.4 Behavioral Patterns

We implement observer and MVC (Model–View–Controller) design patterns to ensure scalability and maintainability.

2.5 Problem Formalization

2.5.1 Objective (Goal)

To develop an intelligent assistant for precision agriculture that analyzes multi-source data (drone images, IoT, weather, soil) and responds to farmer goals or problems using a Large Language Model (LLM).

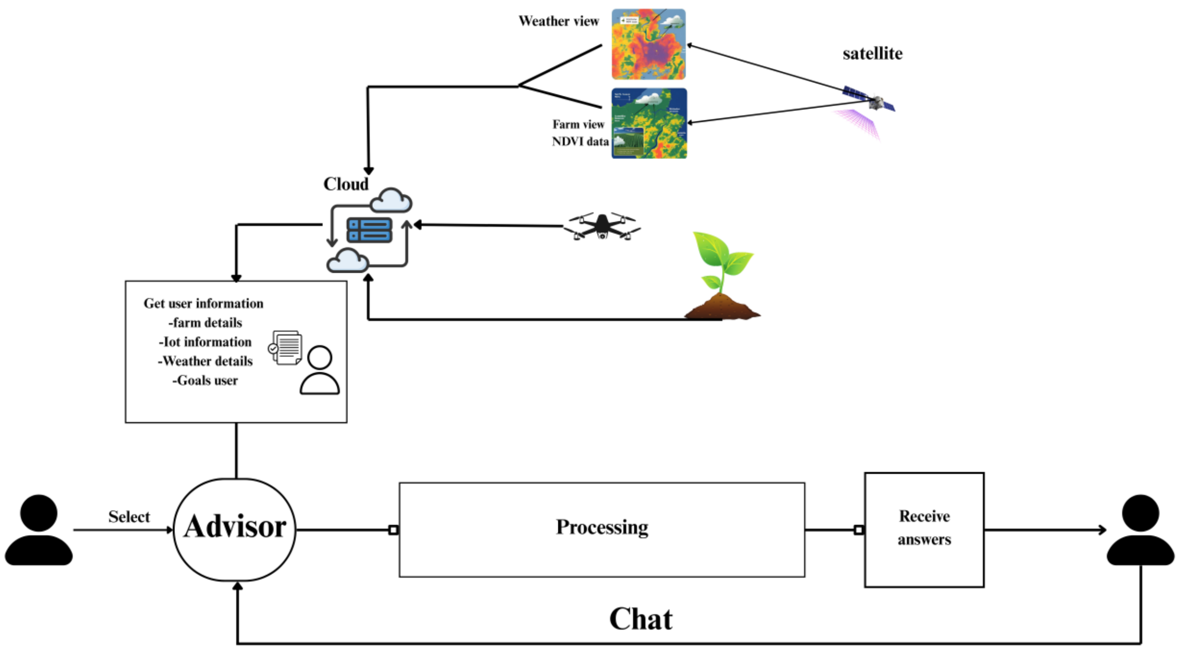

Figure 7: Intelligent assistant for precision agriculture (Source: Author's own design)

2.5.2 Mathematical Formalization

Let's define:

- Let F be the set of all farmers $\{f_1, f_2, \ldots, f_n\}$
- Let $D = \{d_s, d_i, d_w, d_u\}$ be the **multi-source data** collected:
  - d_s: Soil data (NPK, pH, moisture, etc.)
  - d_i: Drone image features (plant color, size, health score)
  - d_w: Weather data (temperature, rainfall, humidity)
  - d_u: User/farmer input (selected goals/problems)
- Let $G = \{g_1, g_2, \ldots, g_m\}$ be a set of **goals/problems** selectable by farmers (e.g., *"Yellowing leaves"*, *"Low yield"*).
- Let $LLM : (D, g_i) \to R$, where R is the set of natural-language **responses** generated by the LLM.

```
Input:
    - Farmer f_i selects goal g_i from options list
    - Multi-source data D = {soil_data, drone_images, weather_data, user_input}

Process:
    1. system collects and preprocesses relevant data for f_i:
        a. fetch soil logs and sensor data
        b. analyze drone image features (leaf color, patterns)
        c. retrieve weather history and forecasts
    2. format prompt dynamically for LLM:
        prompt = """
        Farmer issue: [g_i]
        Soil NPK levels: [N, P, K]
        Weather conditions: [T, R, H]
        Drone observation: [leaf_color, anomalies]
        Suggest reason, fix, and long-term advice.
        """
    3. send prompt to LLM
    4. receive response R
    5. display R in natural language to the farmer

Output:
    - LLM Response R: Advice, diagnosis, solution steps
```

Figure 6 – Pseudocode for Problem-Based LLM Interaction Using Multi-Source Agricultural Data

This figure represents how Ghalaty dynamically builds a natural-language prompt using farmer inputs and farm-specific data to generate tailored responses using a Large Language Model.

2.5.3 Example Instantiation

A farmer f_i selects the issue "*My plant leaves are yellow*" (goal g_3):

- $d_s = \{N = 30, P = 10, K = 40, pH = 5.2\}$
- $d_i = \{\text{leaf\_color} = \text{yellow}, \text{plant\_height} = 25cm\}$
- $d_w = \{\text{rainfall} = 15mm, \text{temp} = 35^{\circ}C\}$

```
Farmer issue: Yellowing plant leaves (Sellected from list)
DATA{
    Soil NPK levels: N=30, P=10, K=40, pH=5.2
    Drone: Yellow discoloration detected
    Weather: High temperature, low rainfall
    }

LLM might respond:

“The yellowing may be due to nitrogen deficiency and high so
il acidity. We recommend applying a balanced NPK fertilizer
and adjusting the pH with lime. Also, consider shading
plants during heat waves.”
```

Figure 7 – Pseudocode for LLM Interaction Using Multi-Source Agricultural Data with farmer

2.5.4 Goal of the System

Given:

- A selected goal/problem g_i by the farmer
- Associated farm data D

Produce:

- A natural-language response $R \in \mathcal{R}$ from the LLM

Objective:

$$\text{Find } R = LLM(D, g_i) \text{ that maximizes farmer comprehension and actionable outcomes.}$$

2.6 Conceptual Organization of Our System

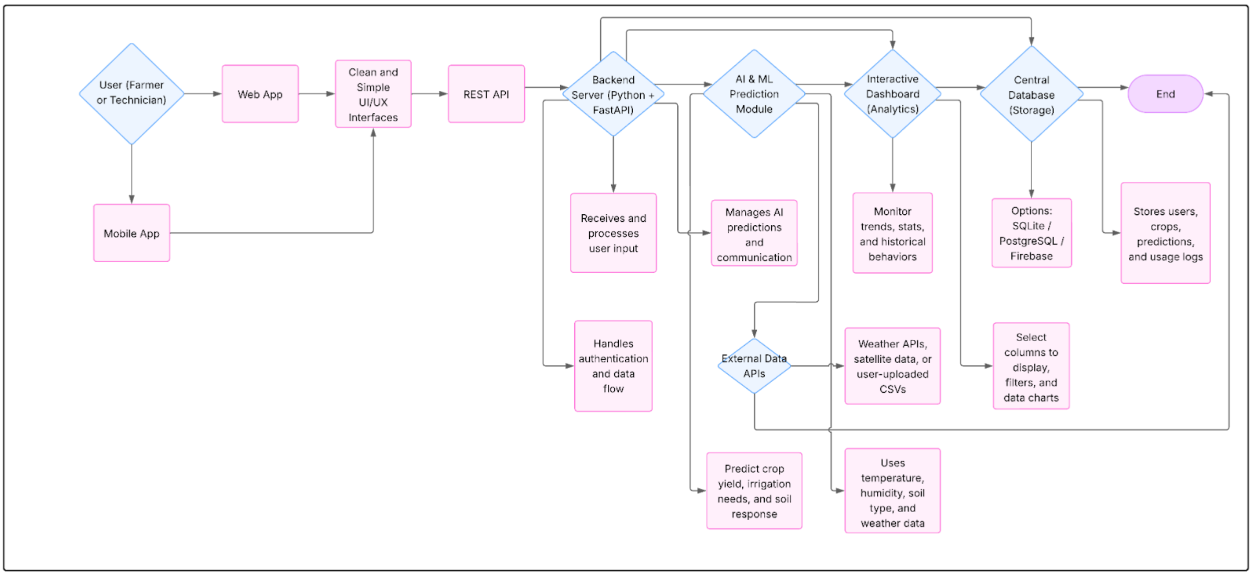

Figure 8: High-Level System Architecture of GHALATY

2.6 User-Centered Design

2.6.1 Design Process

We conducted interviews, created personas, and developed clickable prototypes tested with local farmers. This iterative process ensured functional clarity, localization, and mobile-first simplicity.

2.8 Use Cases & Analysis Mapping

Compared to existing solutions, **GHALATY** excels in integrated data usage, multilingual AI advisory and coverage of all four analysis types:

Feature	Conventional Tools	GHALATY
Data Integration	**Partial**	**Multi-source (IoT, satellite, user)**
Advisory Capability	**Minimal**	**Rich LLM-based with explanation**
Multilingual Support	**No**	**Yes (local dialects)**
Analytical Depth	**Predictive-focused**	**Full four-tier analysis**

Table 5 – Comparative Positioning of GHALATY

2.8.1 Use Case Diagrams

An UCD is an Unified Modeling Language (UML) diagram that graphically represents the functional requirements of a system by illustrating the interactions between users (actors) and the system itself. It describes the different ways in which users can use the system to accomplish specific tasks [19]. In this section, we will present the different use case diagrams related to each of the functional requirements presented above

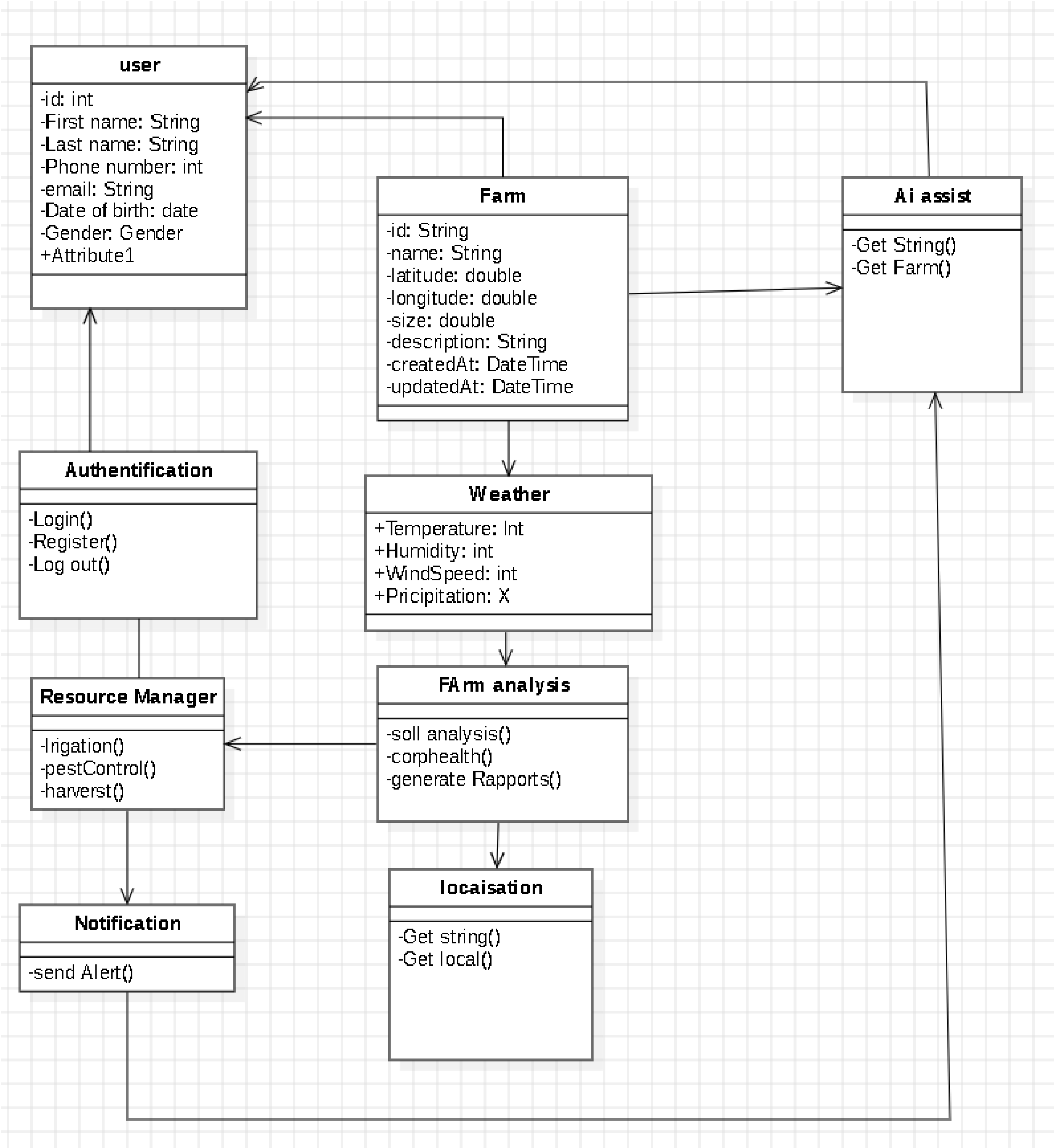

Figure 9 - Class Diagram Ghalaty

2.9 Conclusion of Part 1

We have established a robust conceptual and architectural model for GHALATY. We explored motivations, domain context and user-centered components. This foundation aligns seamlessly with our goal of delivering a predictive model under the four-analysis framework. In Part 2, we will demonstrate how this translates into real-world, tool-supported implementation.

Chapter 2 – Part 2: Proof of Concept & Tooling

Chapter 2 – Part 2: Proof of Concept & Tooling

2.1 Introduction

In this part, we detail the practical implementation of the GHALATY prototype, focusing on software/hardware integration, technical deployment, and system components. We will analyze how each component enables the four types of analysis—descriptive, diagnostic, predictive, and prospective—essential to supporting the project's core objective of predictive, data-driven precision agriculture.

2.2 Software and Hardware Components

2.2.1 Software Components

We implemented a microservices architecture using Fast API for its excellent asynchronous performance and ease of development [21]. Databases include SQLite for structured data storage IoT logs and chat histories [22]. For the mobile app, we used Flutter, ensuring smooth, cross-platform experience.

Component	Description	Technology Used	Justification
Mobile Application	Interface for farmer interaction, data entry, and receiving AI suggestions.	Flutter	Flutter allows cross-platform development with a single codebase, ideal for rural mobile users.
LLM Engine	Provides intelligent advisory by interpreting user queries in natural language.	DeepSeek via API	Enables context-aware, multilingual conversational support without custom model training.
Database	Stores user profiles, history, input logs, and system configuration.	SQLite	Lightweight, file-based relational database ideal for mobile and edge use cases.
External Data Sources	Includes weather APIs, NPK data, satellite imagery feeds.	OpenWeather, IoT	Enhances prediction precision through environmental context integration.

Table 6 – Software Components of **GHALATY**.

This table provides a detailed overview of the core software components that form the **GHALATY** platform. Each component is selected with consideration for low-resource deployment, scalability, and integration with an AI-driven architecture. The use of **SQLite**, in particular, reflects the need for lightweight, offline-capable storage on mobile or low-infrastructure systems typical in agricultural settings.

2.2.2 Hardware Components

The system also integrates environmental sensors (NPK, humidity, temperature) and optional drone support for aerial image capture. These elements support the collection of real-time, on-field data, which is crucial for precision agriculture.

Component	Purpose	Description
ESP32 Controllers	Edge-level data collection	Collect sensor readings (e.g., soil moisture, temperature) and transmit via Wi-Fi/Bluetooth.
NPK & DHT22 Sensors	Soil and environmental measurement	NPK sensor captures soil nutrient levels; DHT22 measures temperature and humidity.
Raspberry Pi 4	Edge computing and preprocessing	Acts as a gateway to process sensor data locally before sending to backend via HTTP or MQTT.
GPS Module	Geolocation tagging	Attaches precise location metadata to data for use in geospatial prediction and mapping.
Drone (optional)	Aerial crop condition mapping	Captures high-resolution multispectral or RGB imagery for crop health analysis.

T able 7 – Hardware Components Used in GHALATY.

This table presents the main physical components employed in the GHALATY architecture to collect, process, and transmit environmental and agronomic data. The combination of embedded sensors and edge computing supports real-time, location-aware AI-driven recommendations in the field.

2.3 Technical Implementation

2.3.1 SQLite Database Configuration

SQLite is an in-process library that implements a self-contained, serverless, zero-configuration, transactional SQL database engine. The code for SQLite is in the public domain and is thus free for use for any purpose, commercial or private. SQLite is the most widely deployed database in the world with more applications than we can count, including several high-profile projects. [23]

2.3.2 Integration of AI Components

The GHALATY platform integrates this key AI services:

- LLM Advisor: A large language model (DeepSeek) Configured for agricultural vocabulary and online dialects, deployed through an API.

The predictive model pipeline includes feature extraction from satellite imagery (NDVI, EVI), sensor readings, and time-series weather data and selected inputs from user with a saved goal.

2.3.3 Technical and Technological Choices

In this section we will see the technologies used to ensure collaboration as well as the tools and development environments.

2.3.3.1 Collaboration and Design Technologies

These technologies have allowed us to collaborate effectively remotely while being supervised by our supervisor. They are among others :

2.3.3.1.1 Google Meet

A videoconferencing service developed by Google. It allows in particular to launch meetings or to join which was useful for us to debrief on the progress of the project.

2.3.3.1.2 Git/GitHub

It is a project version management platform allowing to follow its evolution and to know all the deployed versions. Its advantages are the collaboration on the same project of several collaborators and the management of changes as well as its integration into several development environments.

2.3.3.1.3 Figma

It is a collaborative web application for interface design, with additional offline features enabled by desktop applications for macOs and Windows. The feature set of Figma focuses on user interface and user experience design, with an emphasis on real-time collaboration [25], utilizing a variety of vector graphics editors and prototyping tools.

2.3.3.1.4 Draw.io

Draw.io is a robust technology stack designed for constructing diagramming applications. A key strength of draw.io lies in its comprehensive support for UML (Unified Modeling Language), a standardized method for visually representing software systems[26]. It offers the following features:

• Effortless UML Diagramming: With a drag-and-drop interface and pre-made UML shapes, draw.io enables quick and easy diagram creation.

• Versatile UML Support: Draw.io supports a variety of UML diagrams, including class diagrams and use case diagrams, among others.

• Real-Time Collaboration: An added advantage of draw.io is its real-time collaboration feature, allowing multiple users to work on the same UML diagram simultaneously.

2.3.3.2.1Mobile development tools

Those are tools used specifically to implement the system at the mobile level. They are among others:

2.3.3.2.2 Android Studio

According to Wikipedia, ”Android Studio is the official Integrated Development Environment (IDE) for Google’s Android operating system, built on JetBrains’ IntelliJ IDEA software and designed specifically for Android development”. We chose it to allow the development of the mobile application under Android. It uses languages like

• Kotlin or Java for the backend;

• Extensible Markup Language (XML) or Kotlin for the front-end

2.4 UI/UX of the Assistant Tool

2.4.1 Mobile App Design Process

The UI/UX design followed Google's Material Design principles, featuring clear navigation, simple forms, and multilingual support (Algerian Arabic, French, English). UI elements are optimized for low-literate users, featuring icons and voice input options [24].

2.4.1.1 Sketching

Sketching is the initial phase of the design process where we translate our ideas into rough visuals. This stage involves :

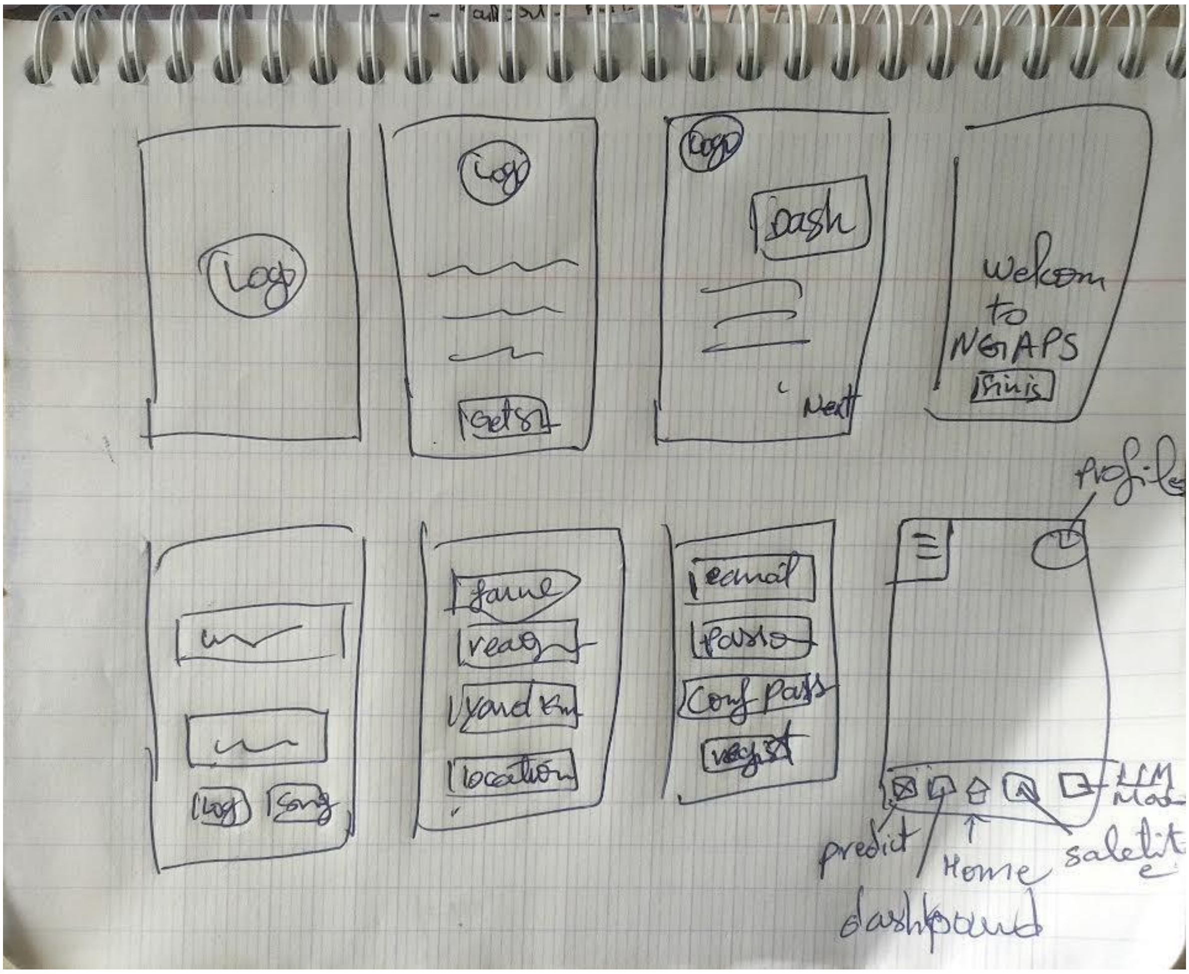

Figure 9- Sketching

—**Brainstorming sessions :** Generating concepts and defining user needs.

— **Rough sketches :** Creating hand-drawn representations of key interfaces and user flows to explore different layout options.

— **Feedback gathering :** Sharing sketches with stakeholders to refine ideas based on initial feedback.

2.4.1.2 Storyboards

Storyboards help visualize the app’s functionality through a sequence of screens, providing a narrative of user interactions :

— User scenarios : Creating scenarios that depict how users will interact with the app in real-world situations.

— Screen sequences : Designing sequences that illustrate key interactions and transitions between screens.

— Experience mapping : Mapping out the emotional journey of users to ensure the app delivers a positive and engaging experience.

2.4.2 Mobile app demonstration

To showcase the effectiveness of our design process, we provide a demonstration of key interfaces within the mobile app. This demonstration highlights the app's capabilities and user experience.

Figure 10– Open application

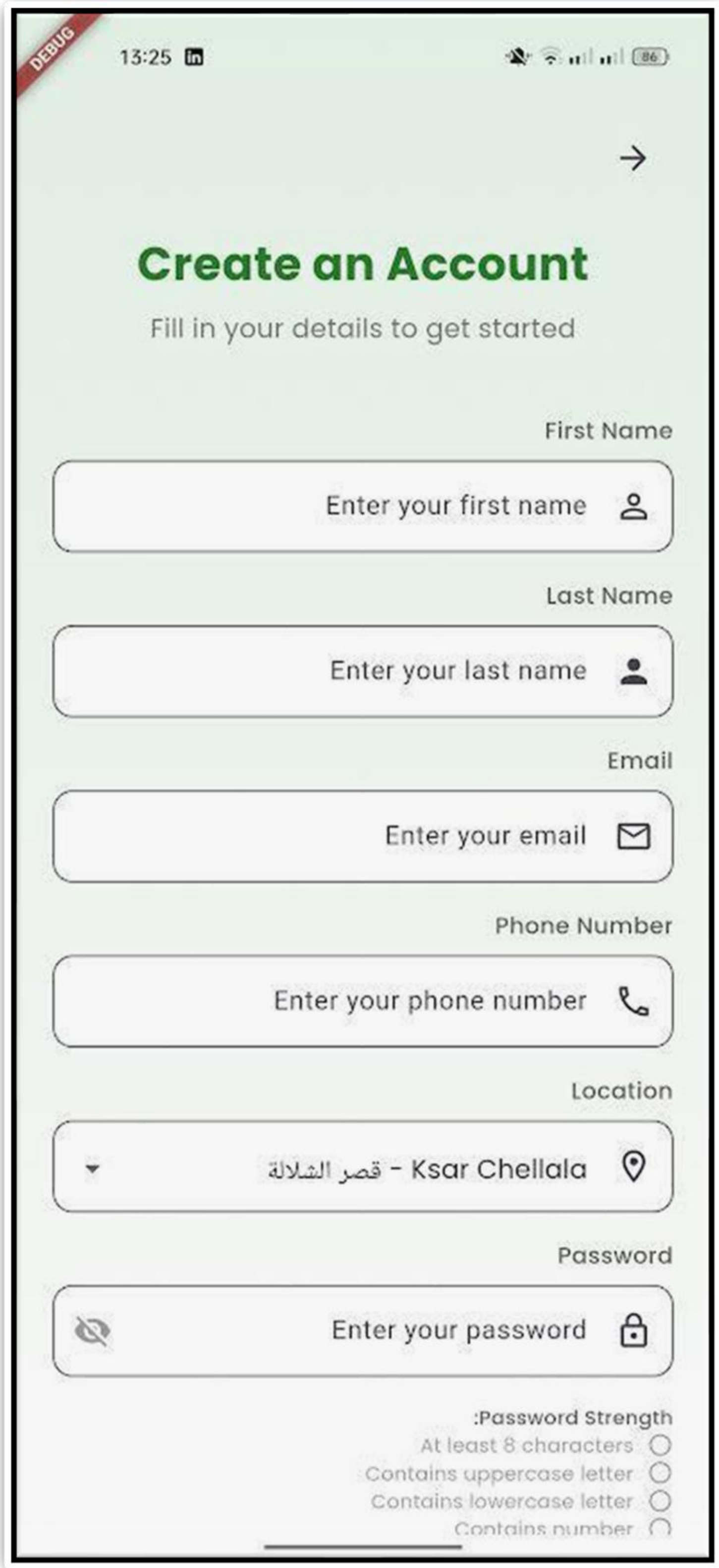

Figure 11 – Create account

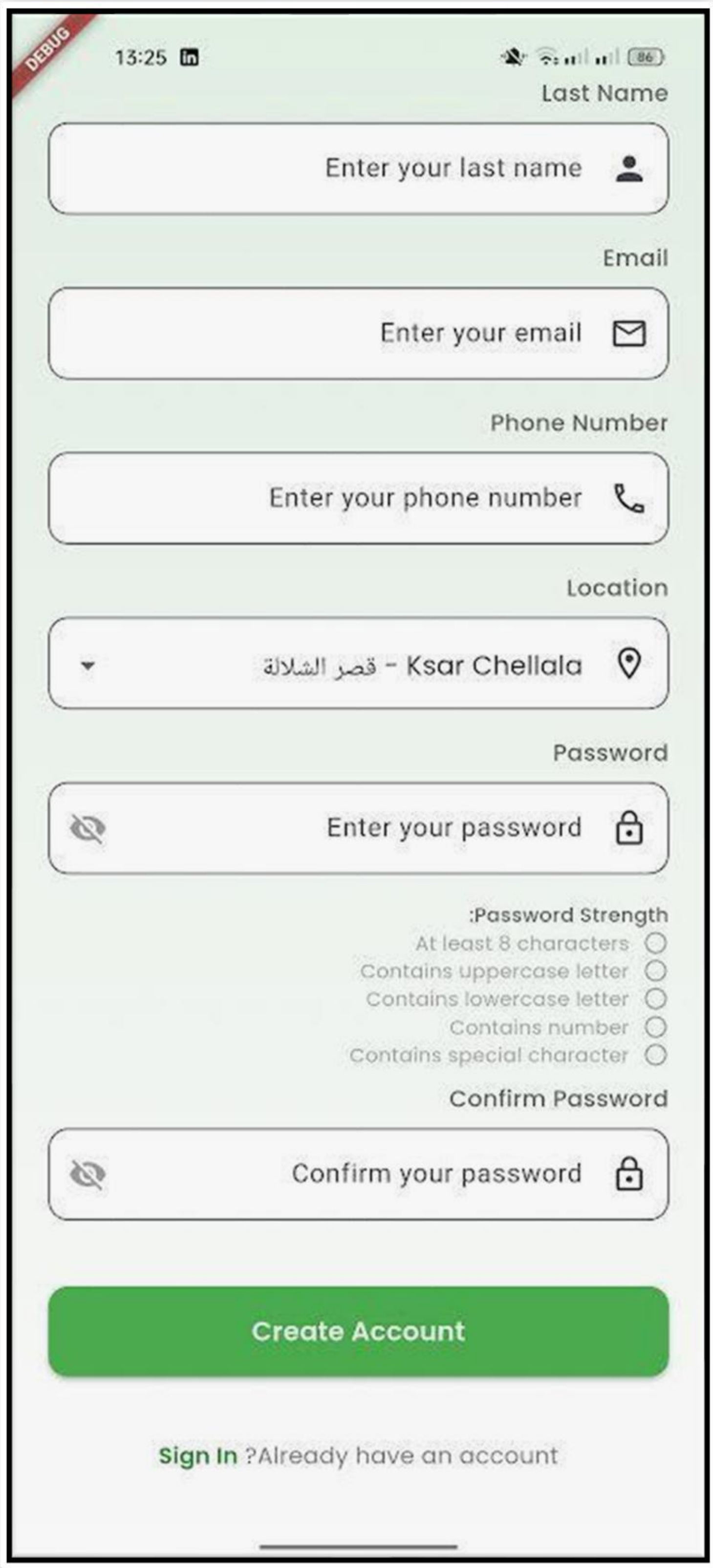

Figure 12– create account slide 2

Figure 13 – Login

Figure 14 – loading data

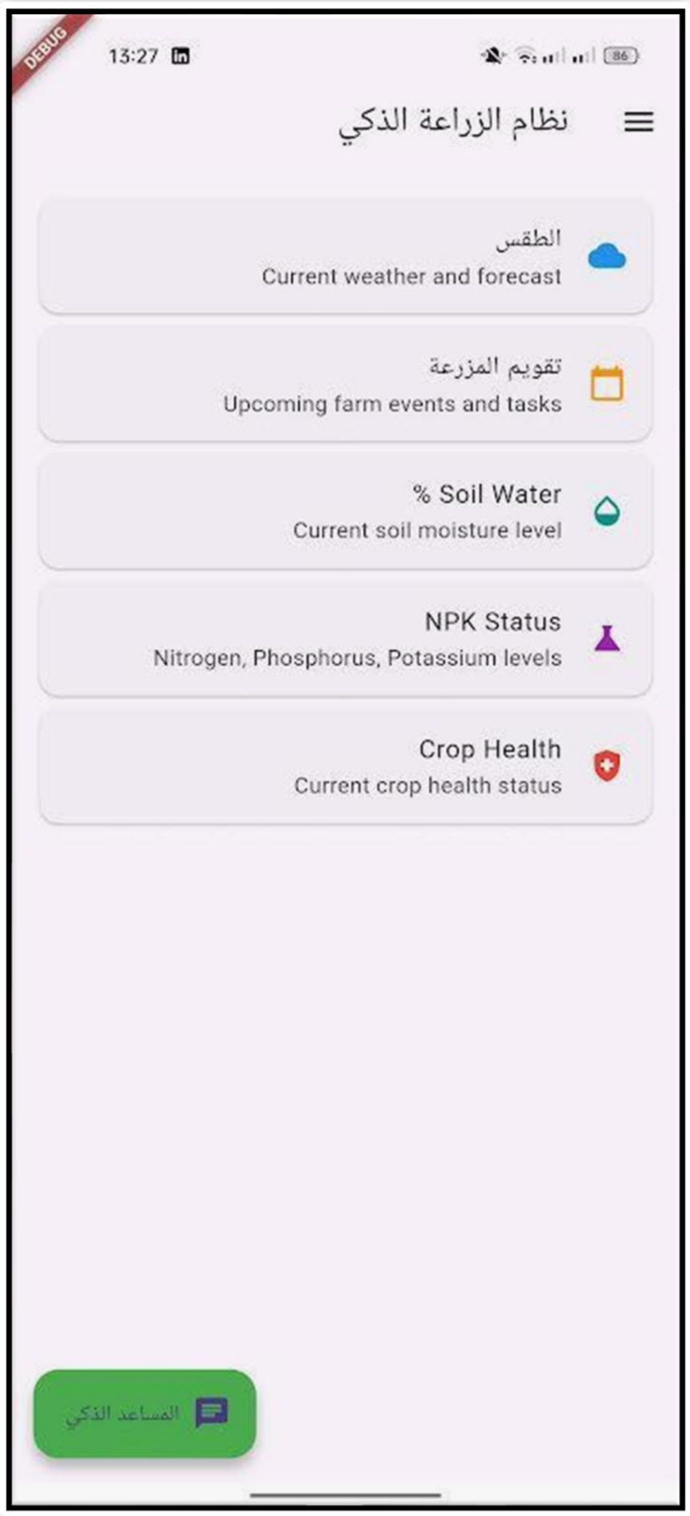

Figure 15 – Home screen

Figure 16 – Menu arabic version

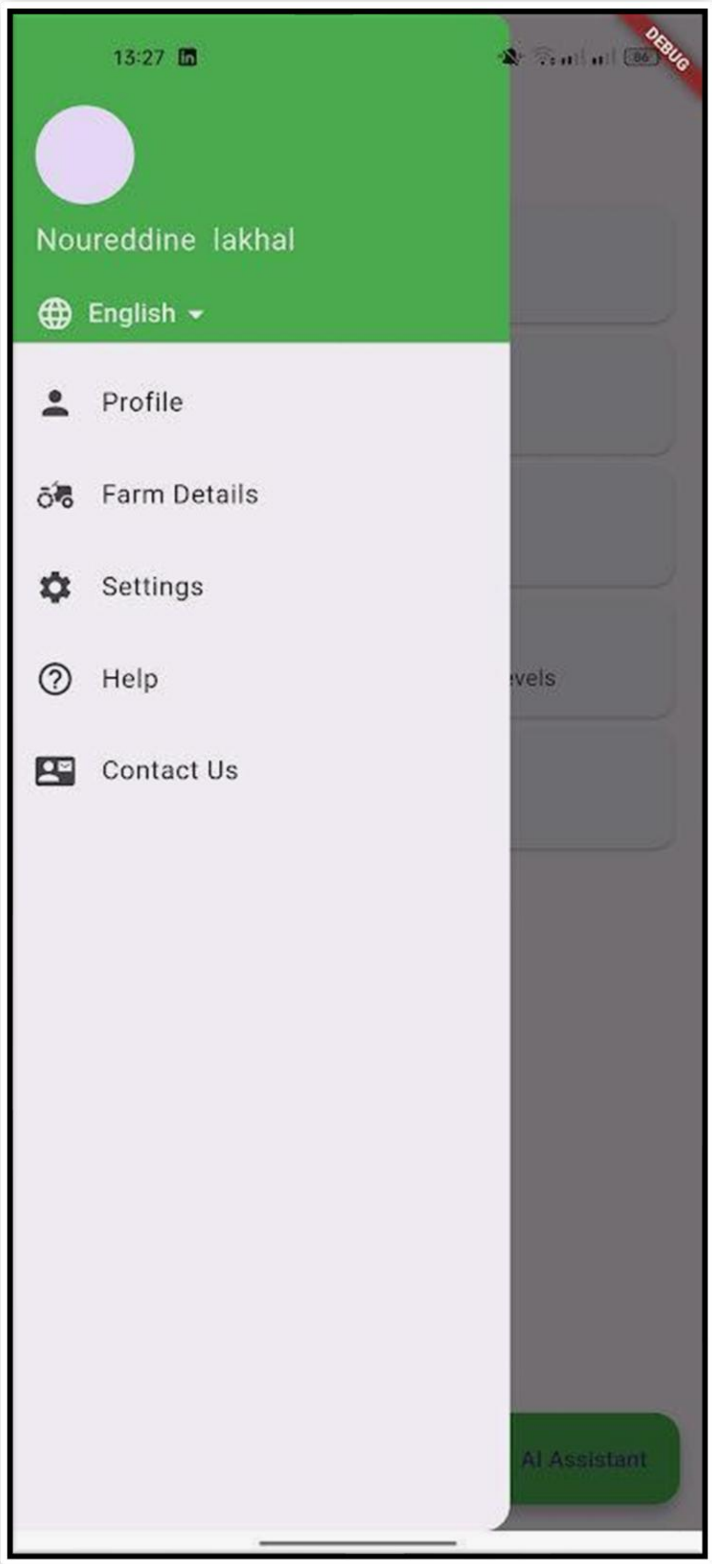

Figure 17 – Menu English version

Figure 18 – Ai advisor

- **Advisor Results**

We built an intelligent farm advisor interface that allows users to select multiple agricultural criteria for analysis. In this section, we focus on providing farmers with a comprehensive set of parameters they can choose from, including weather conditions, soil quality, water usage, productivity metrics, and pest management options. The interface supports multi-select functionality for more tailored advice, with options ranging from productivity enhancement to sustainable farming practices. We used a clean Arabic interface to ensure accessibility for local farmers.

Figure 19 – Received Ai advisor

- **Received Ai advisor**

In this results screen, we demonstrate how the system provides detailed weather impact analysis on crop production. We built an intelligent parsing system that breaks down complex meteorological data into actionable insights. The analysis covers three key weather factors: temperature ranges and their effect on photosynthesis, precipitation patterns and their impact on root systems, and humidity levels that influence pest proliferation. We used bullet-point formatting to make the technical agricultural information easily digestible for farmers.

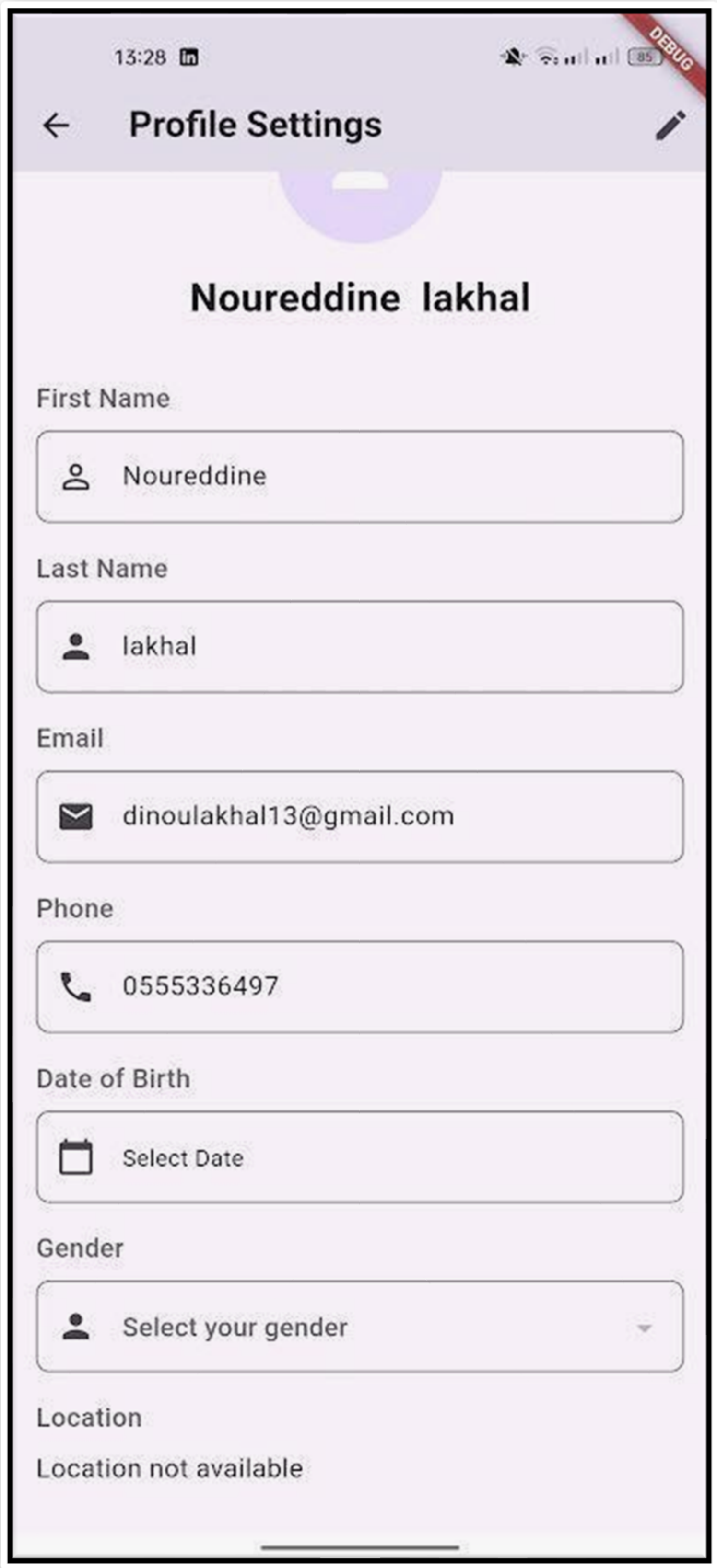

Figure 20 – Profile setting

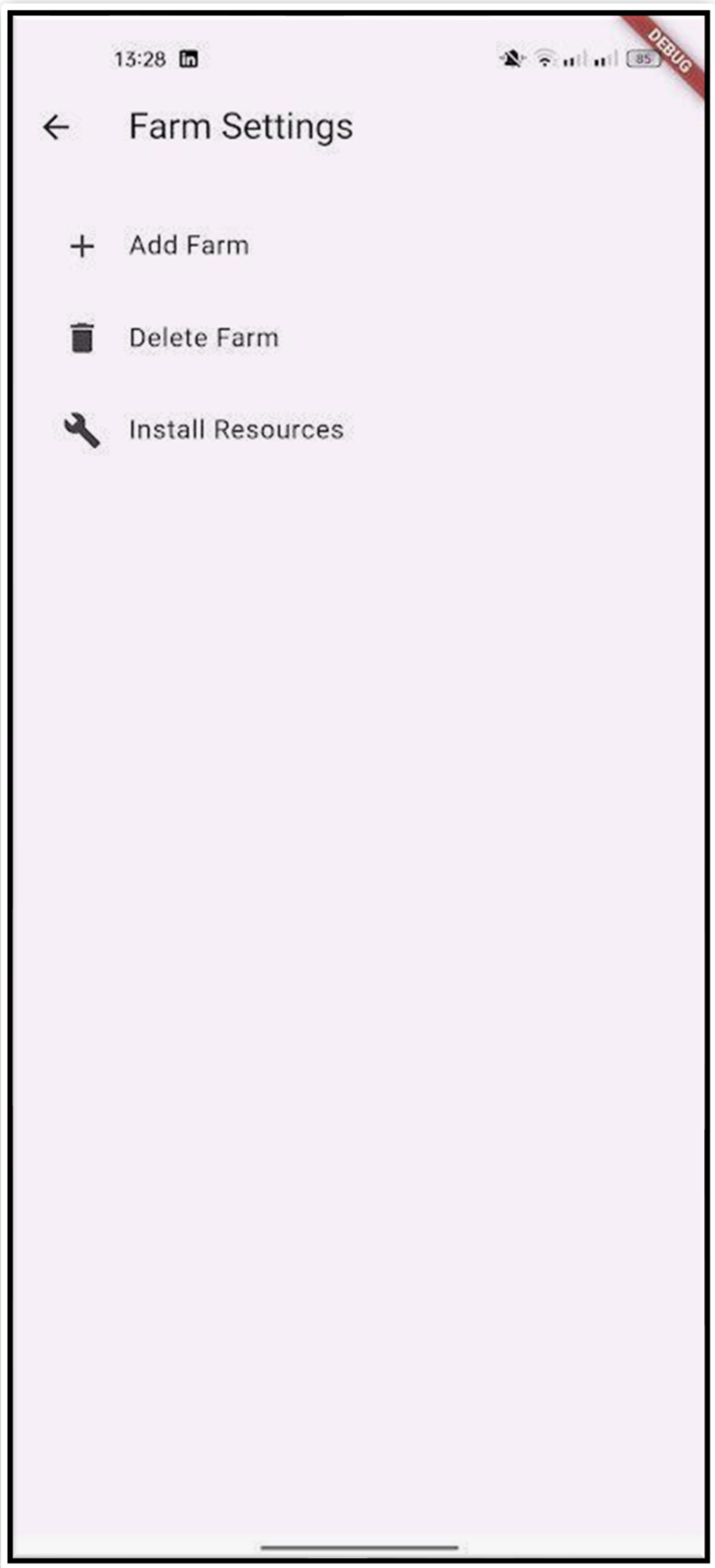

Figure 21 – Farm setting

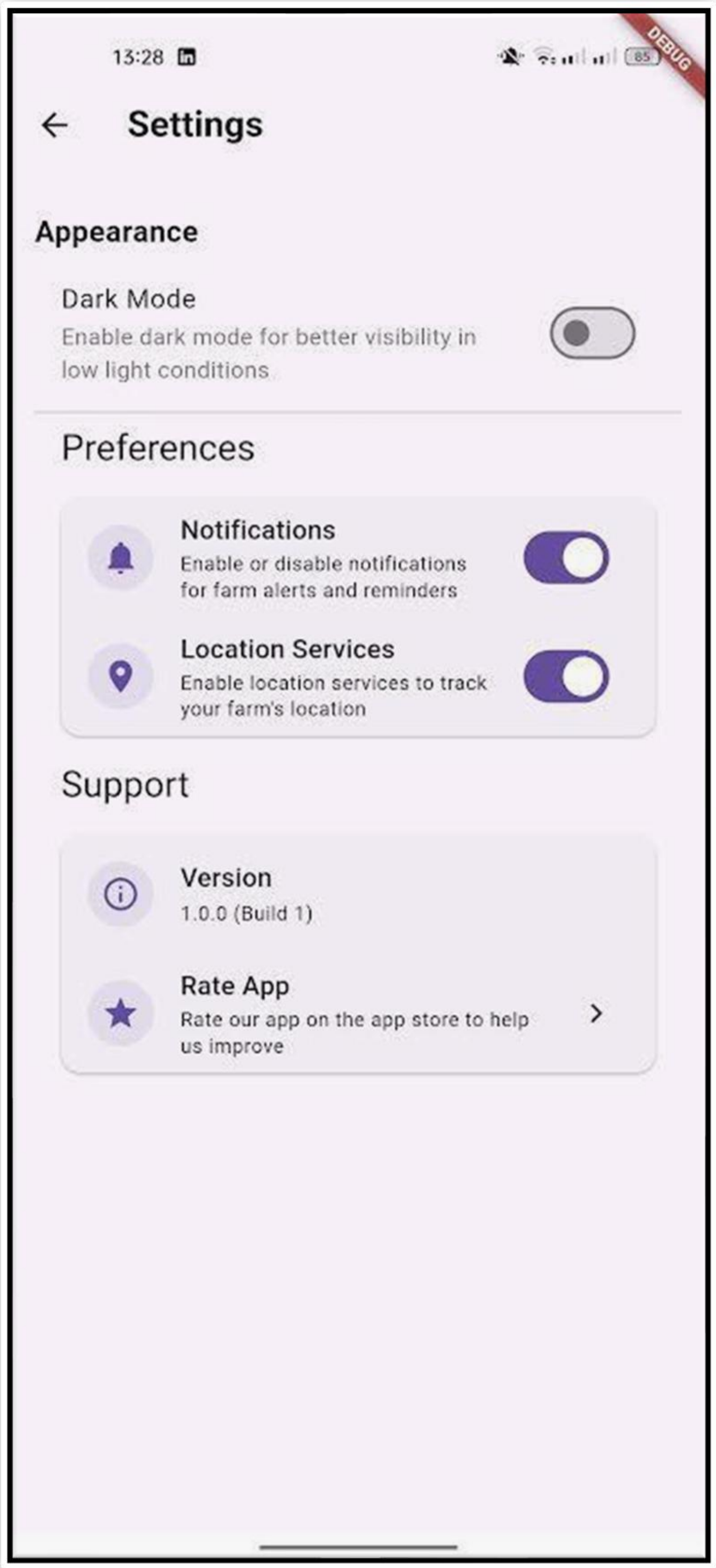

Figure 22 – Generale setting

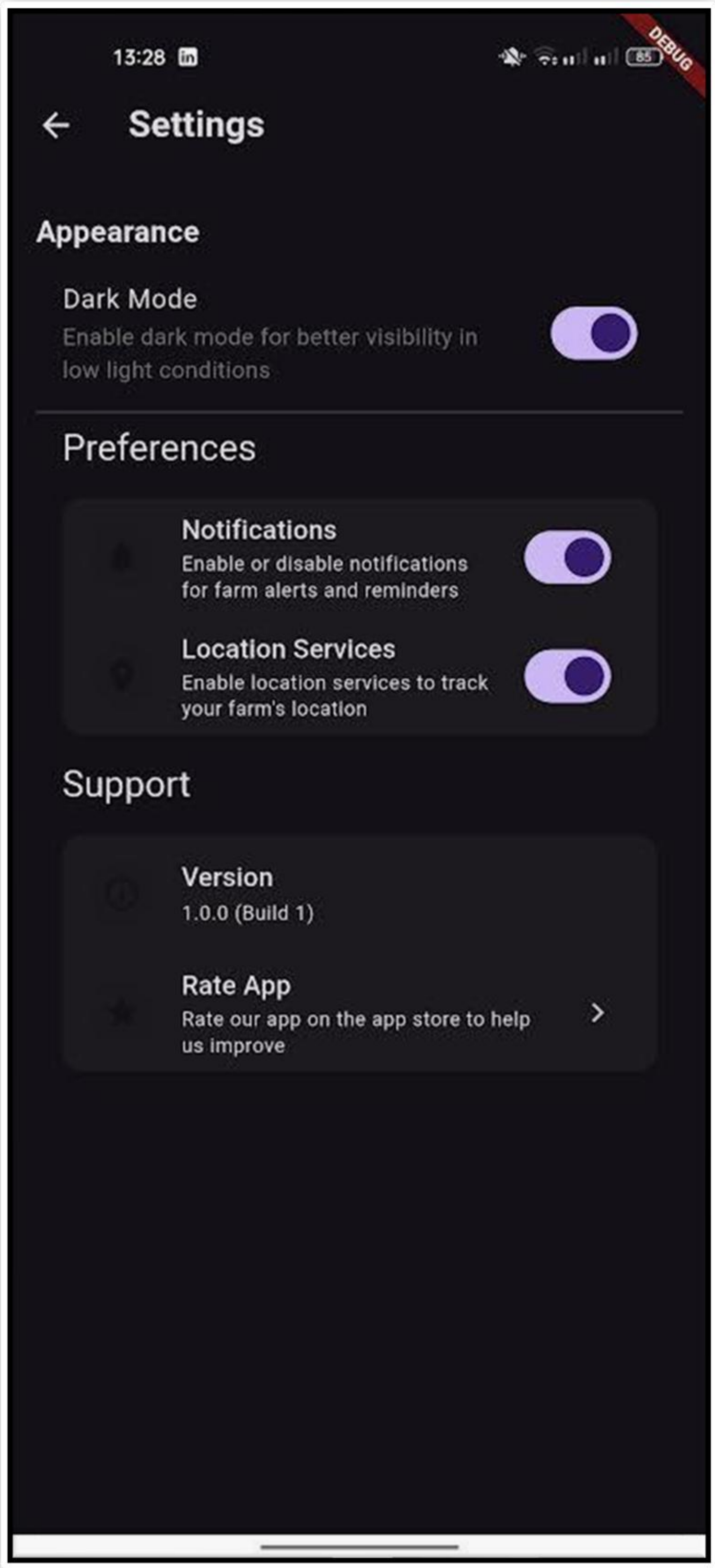

Figure 23 – Dark mode

Figure 24 – Help and support

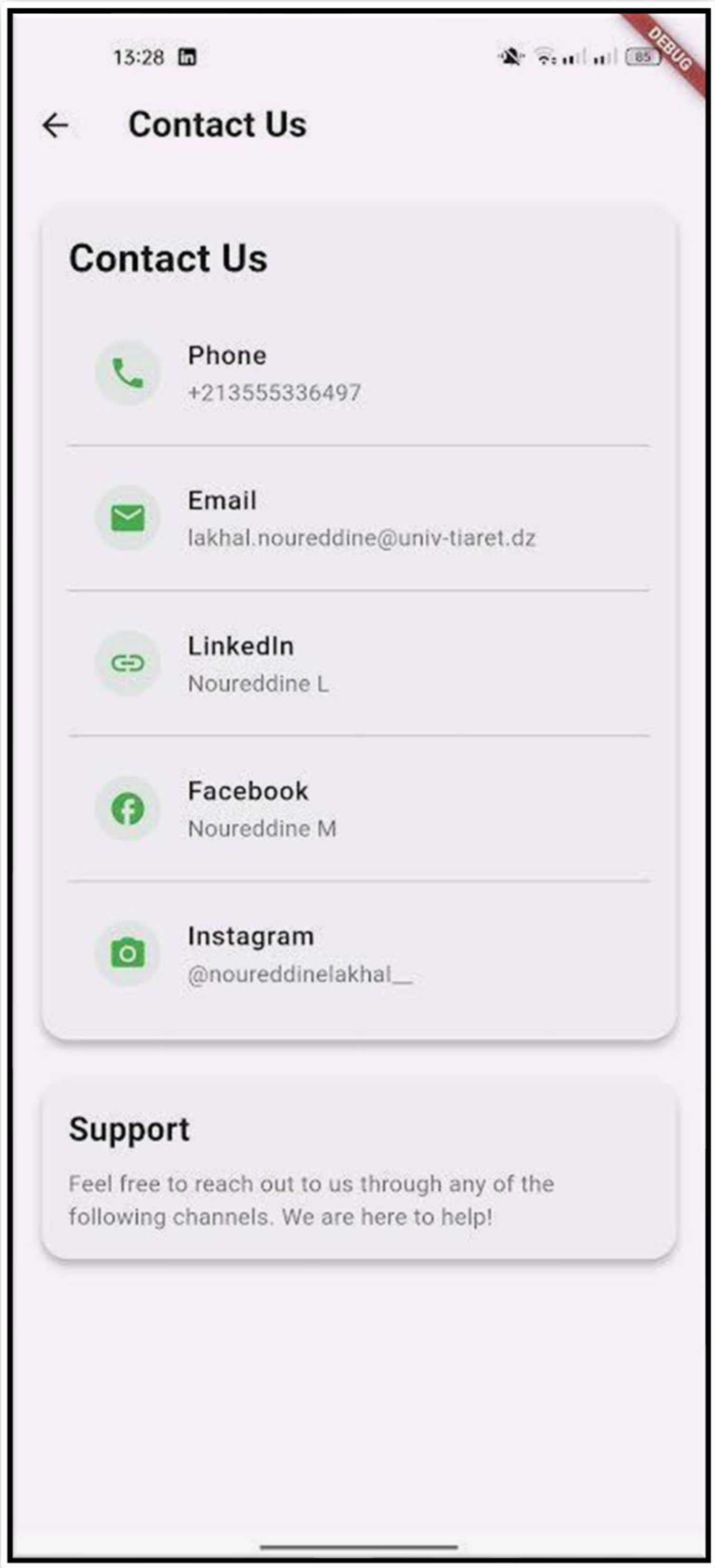

Figure 25 – Contact us

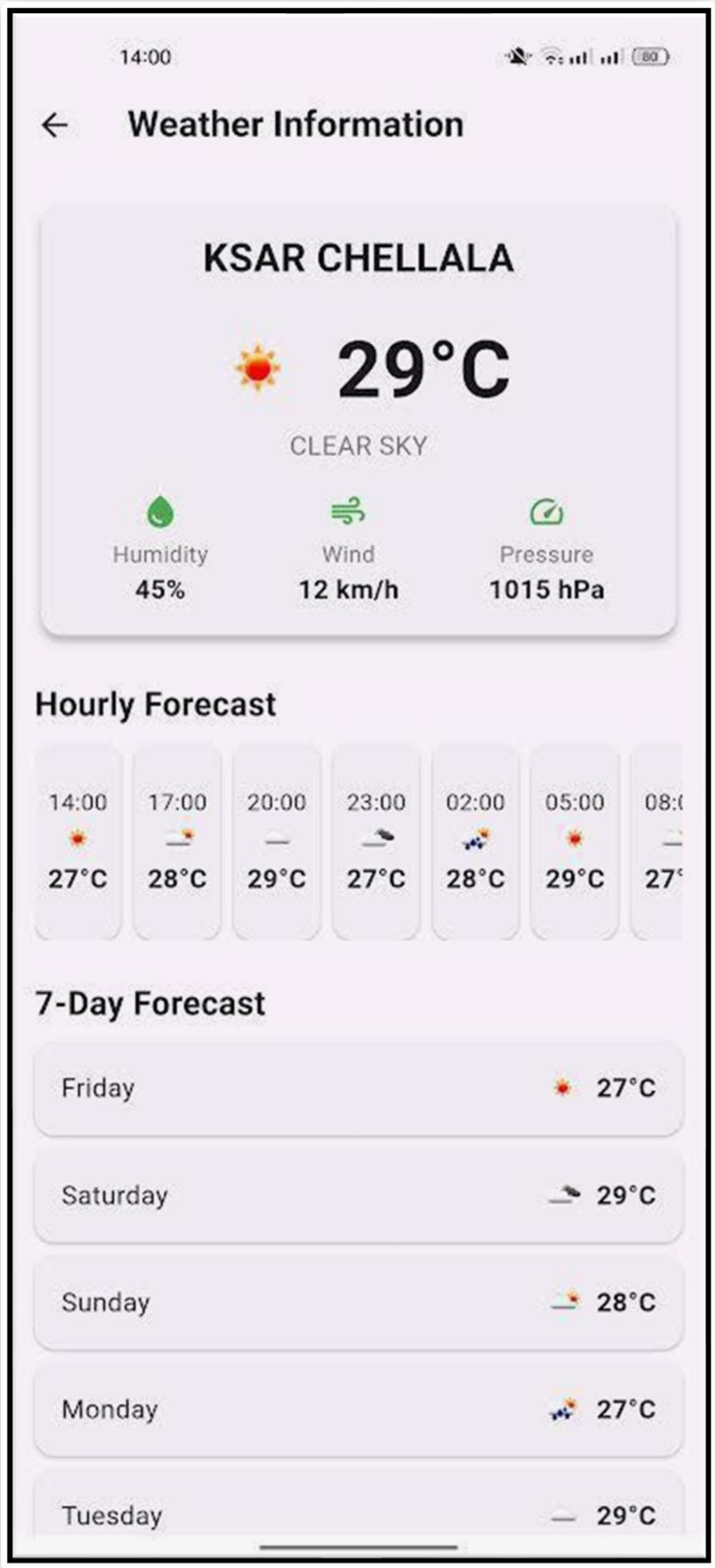

Figure 26 – weather screen

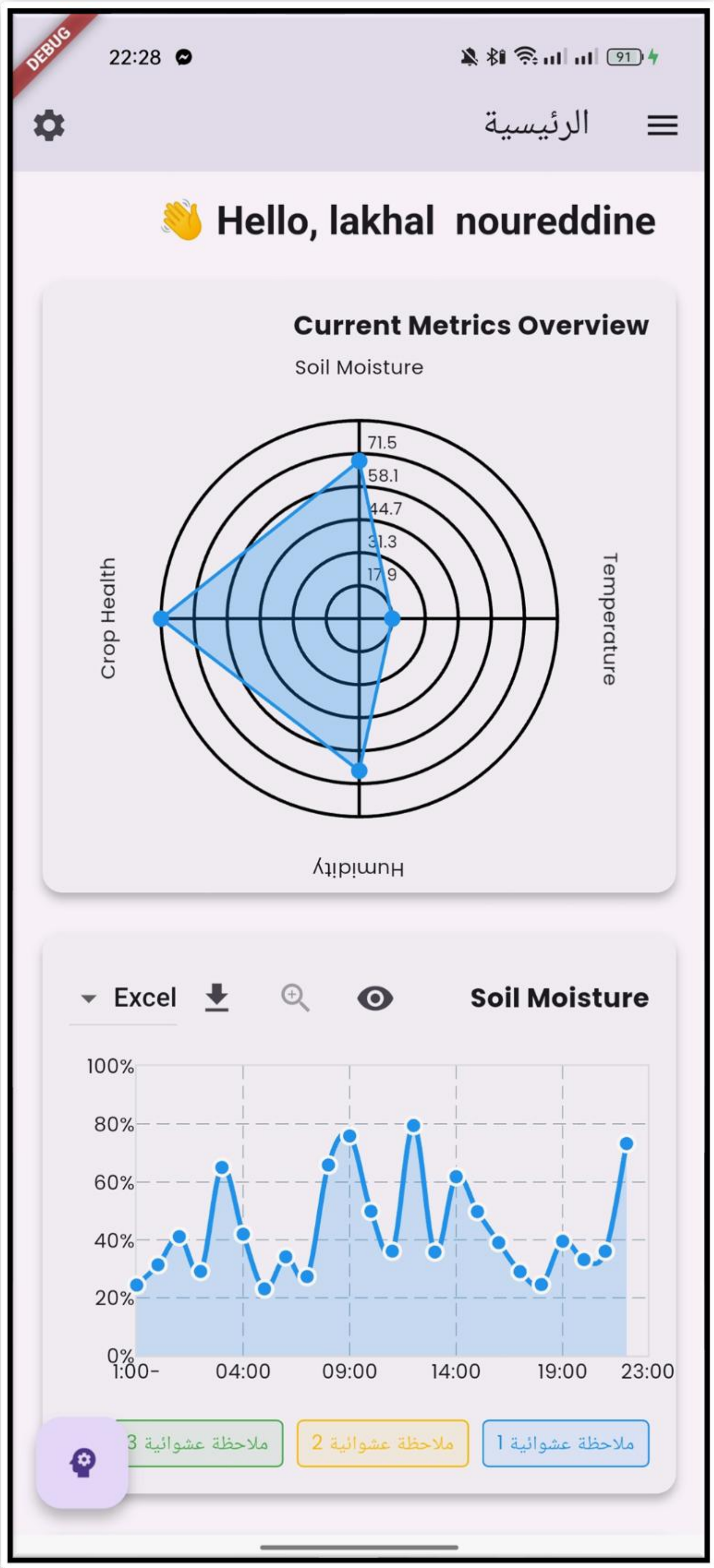

Figure 27 – farm analyse (dashboard - 1)

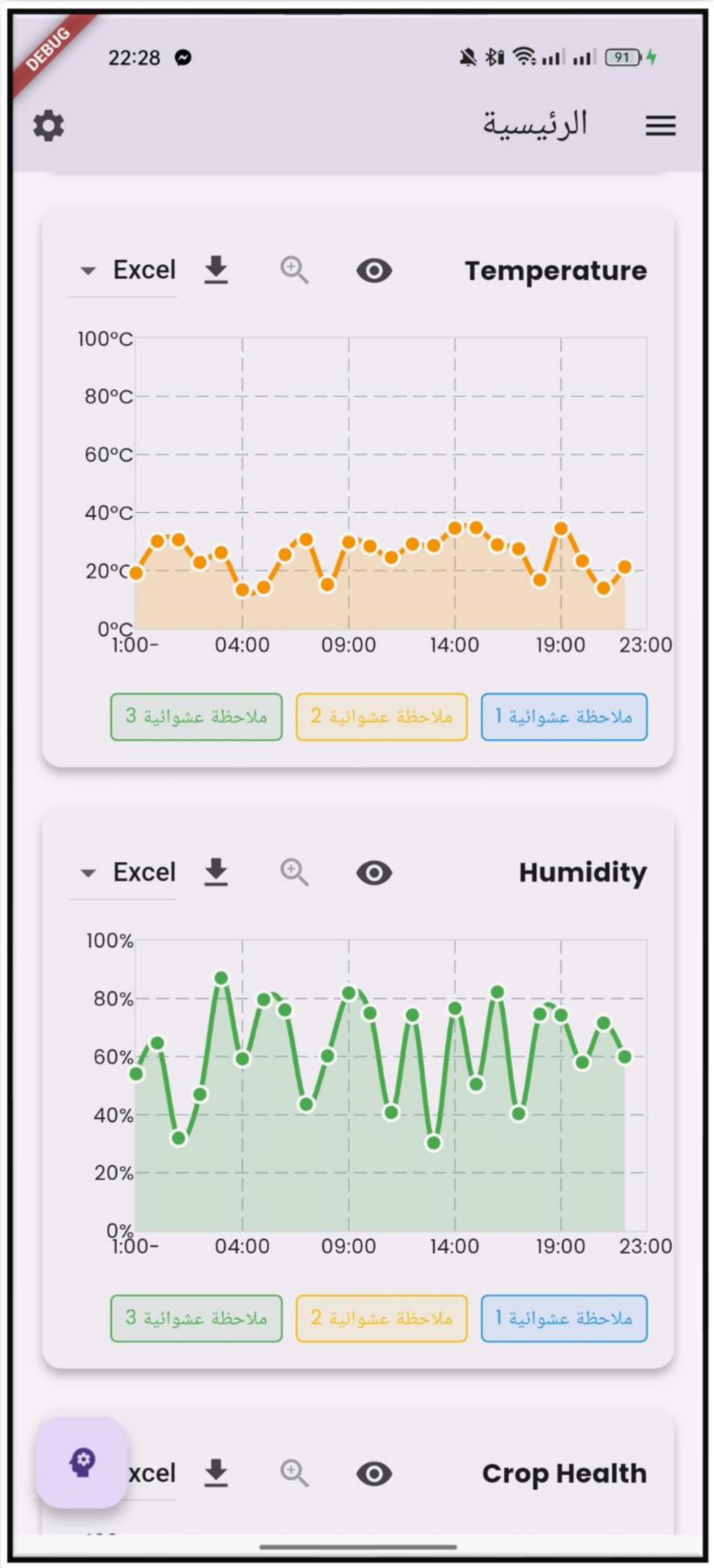

Figure 28 – farm analyse (dashboard - 2)

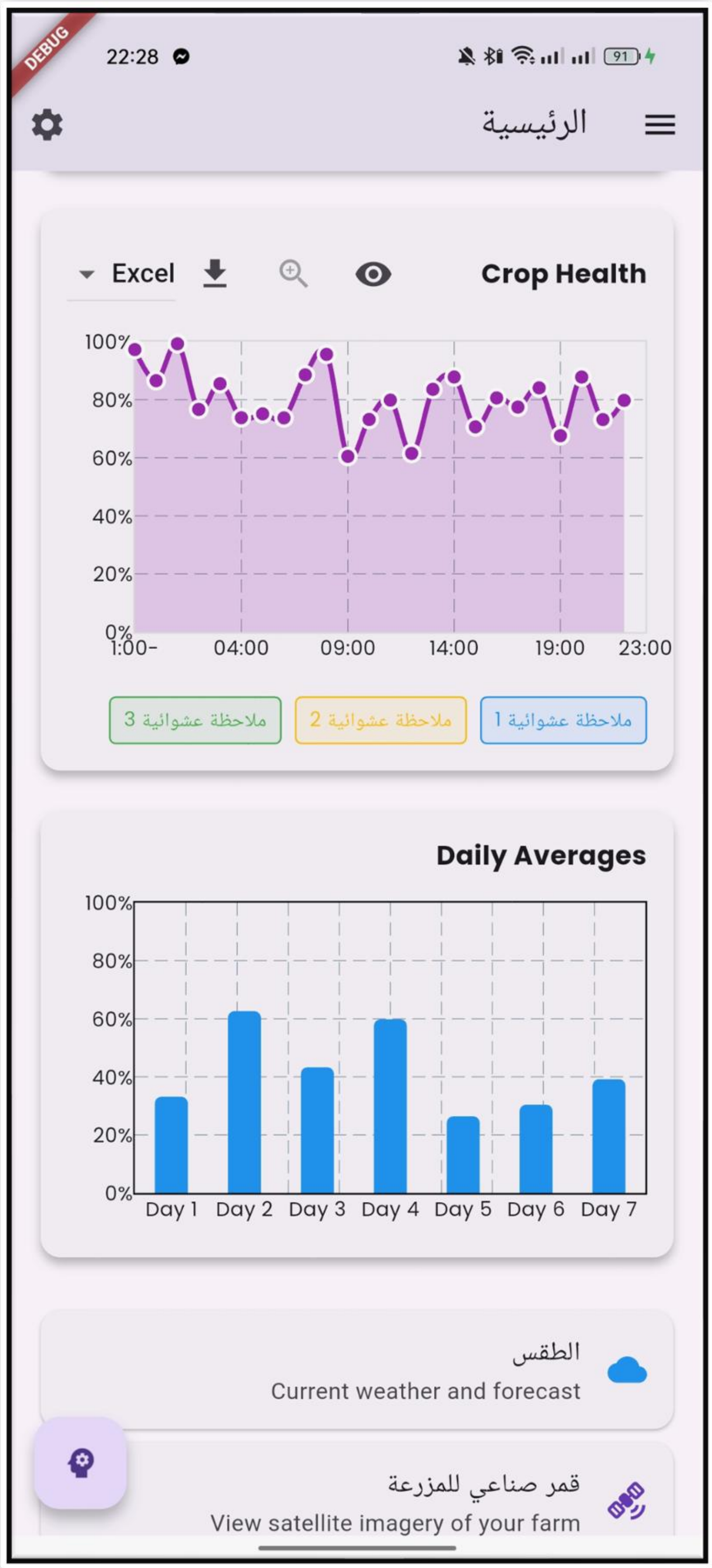

Figure 29 – farm analyse (dashboard - 3)

- **Dashboards Overview**

We built a **real-time agricultural monitoring system** that provides farmers with actionable insights through intuitive dashboards. In these sections, we focus on **visualizing critical farm metrics**, including **soil moisture, temperature, humidity, and crop health**, using a combination of **graphs, percentages, and time-based trends** to ensure clarity and quick decision-making.

- **Key Features & Design Choices**

1. **Dynamic Data Visualization**
    - We used **percentage-based bar graphs** to display fluctuations in temperature, humidity, and soil moisture over **24-hour periods** (1:00–23:00).
    - **Daily averages** (Day 1–Day 7) help farmers track trends across a week, allowing for long-term adjustments in irrigation or pest control.
2. **User-Centric Layout**
    - The dashboard greets the user personally (**"Hello, Lakhal Noureddine"**) and organizes data into **clearly labeled sections** (e.g., "Current Metrics Overview," "Excel Temperature," "Crop Health").
    - **Color-coded thresholds** (e.g., 100°C–0°C) make it easy to identify critical ranges that could affect crop viability.
3. **Actionable Insights & Annotations**
    - We included **"Random Notes"** (e.g., "ملاحظة عشوائية 3") as placeholders for **system-generated alerts** (e.g., soil dryness warnings) or **farmer observations**.
    - **Satellite imagery integration** ("قمر صناعي للمزرعة") allows users to cross-reference sensor data with visual farm conditions.
4. **Real-Time Weather & Forecasts**

    - A dedicated **weather panel** provides current conditions and forecasts, helping farmers plan around rain, heatwaves, or humidity spikes.

Why This Approach?

- **Mobile-first design**: The vertical scrolling and compact graphs ensure readability on smartphones, crucial for farmers in the field.
- **Offline resilience**: Since SQLite stores data locally, the dashboard remains functional even without internet access, syncing later when connectivity resumes.
- **Minimalist but informative**: We avoided clutter while ensuring all key metrics (soil, weather, crop health) are visible at a glance.

Figure 30 – farm view satelite

2.6 Positioning of Our Work

GHALATY stands out in the precision agriculture landscape for its fully integrated approach: combining IoT data, LLM-powered advice, user-friendly mobile design, and four-tier analysis—all while being optimized for smallholder farmers in rural areas.

2.7 Conclusion of Part 2

This section outlined the architectural and technical realization of GHALATY, showcasing how each tool, device, and model contributes to the system's scalable and effective application in precision agriculture. We demonstrated real-time data integration, robust AI model deployment, and intuitive user interaction. The implementation supports all four types of analysis and is fine-tuned for practical use in smallholder farming contexts.

Chapter 3: General Conclusion and Perspectives

Chapter 3: General Conclusion and Perspectives

3.1 General Conclusion

In this research, we developed GHALATY, an intelligent and modular platform for precision agriculture, centered around the integration of multi-source data and powered by a Large Language Model (LLM). Our main objective was to provide context-aware, real-time assistance to farmers through the automation of four analytical pillars: descriptive, diagnostic, predictive, and prospective analysis.

Throughout the project, we explored the critical role of data fusion from heterogeneous sources such as soil sensors, drones, GPS, and weather APIs, and how these contribute to forming a coherent, unified representation of farm conditions. By structuring the system into distinct layers — including data collection, preprocessing, LLM interfacing, and user-facing modules — we ensured modularity, scalability, and user accessibility.

We demonstrated how the LLM not only interprets natural language prompts but also tailors its responses based on real-time data tied to specific farm locations. For example, when a farmer selects "yellowing leaves" as a concern, the system correlates this issue with potential nutrient deficiencies or diseases based on local NPK, temperature, and humidity values, and offers actionable advice.

From a system architecture standpoint, we implemented a clean integrated with SQLite as the primary local database to ensure offline functionality in rural areas. The mobile-first design implemented in Flutter made the platform intuitive and responsive across devices.

Ultimately, our project validated the viability of using LLM-based assistance systems in agricultural settings, especially when supported by real-world, real-time environmental data. GHALATY represents a foundational step toward smarter, more autonomous farming in Algeria and similar contexts worldwide.

3.2 Future Perspectives

While GHALATY has reached a functional and deployable state, several enhancements and research directions remain to be explored. Below, we outline promising avenues:

- Enhanced Contextual Learning in LLMs:

Current implementations rely on prompt engineering to personalize advice. Future work may integrate a retrieval-augmented generation (RAG) pipeline, allowing the LLM to query external structured documents (weather trends, pest knowledge bases, soil health databases) before generating responses.

- Advanced Reasoning over Time-Series Data:

To improve predictive capabilities, we aim to integrate deep learning architectures such as LSTM (Long Short-Term Memory) or Transformer-based temporal models to analyze evolving conditions (e.g., rainfall over seasons) and provide more nuanced advice.

- Expanded Data Sources:

Integration of satellite-derived vegetation indices (e.g., NDVI) and hyperspectral drone imagery could enrich the decision-making process. This would enable the system to diagnose plant stress even before visual symptoms occur.

- Gamification for Farmer Engagement:

A promising area is the use of gamified incentives to encourage continuous interaction with the platform. For instance, farmers could receive virtual achievements for implementing sustainable practices, which over time could lead to actual financial or cooperative incentives.

- Interoperability and Open APIs:

To promote wide adoption, future versions of GHALATY should expose RESTful APIs and conform to agro-informatics interoperability standards (such as ISO 11783 or AgGateway) to integrate with other agricultural systems, equipment, or platforms.

- AI Ethics, Explainability, and Trust:

As AI becomes embedded in decision-making, especially in critical sectors like agriculture, explainability becomes essential. Our future research will explore XAI (Explainable AI) techniques that allow farmers to understand why the AI made a specific recommendation — not just what it recommended.

3.3 Final Remarks

By integrating domain-specific data with human-language understanding, GHALATY creates a new paradigm in user-AI collaboration in agriculture. This system serves as a robust prototype not only for precision farming but also for future intelligent systems in other critical domains, such as climate adaptation, rural health, and sustainable development. Our ambition is to continue this line of work in collaboration with local universities, startups, and agricultural cooperatives, turning GHALATY from a project into a widely adopted digital farming companion.

Annexes

فهرس المحتويات **الصفحة**

المحور الأول: تقديم المشروع

.1فكرة المشروع (الحل المقترح)

يهدف مشروع "غلتي" إلى تطوير منصة ذكية متكاملة تستخدم تقنيات الذكاء الاصطناعي، إنترنت الأشياء، وبيانات الأقمار الصناعية لدعم اتخاذ القرار الزراعي وتحسين إنتاجية المحاصيل. تركز المنصة على دمج مصادر بيانات متعددة تشمل بيانات الطقس، التربة، الصور الجوية، وحالة النباتات، من أجل تقديم توصيات دقيقة وشخصية للمزارعين.

تتمثل الفكرة الأساسية في توفير حل رقمي متكامل يمكن استخدامه عبر تطبيق ويب أو هاتف ذكي، يُمكِّن المستخدمين من مراقبة مزارعهم في الوقت الحقيقي، توقع الإنتاج الزراعي، وتلقي نصائح آلية مدعومة بالذكاء الاصطناعي.

.2القيم المقترحة

- تحسين دقة التوقعات الإنتاجية للمزارع بفضل النماذج الذكية.
- تقليل الخسائر الزراعية الناتجة عن الأمراض أو الظروف المناخية القاسية.
- رفع جودة المحاصيل من خلال التوصيات الفورية المدعومة بالذكاء الاصطناعي.
- تسهيل اتخاذ القرار عبر لوحة تحكم تفاعلية متاحة في كل مكان وزمان.
- تشجيع الزراعة المستدامة من خلال ترشيد استهلاك الموارد (الماء، الأسمدة...).

.3فريق العمل

يتكون فريق "غلتي" من طلاب وخبراء في مجالات الذكاء الاصطناعي، تطوير البرمجيات، وتحليل البيانات الزراعية.

- **لكح نور الدين** :مهندس بيانات ومطور ذكاء اصطناعي، مسؤول عن تصميم النماذج والتكامل بين البيانات.
- دعم خارجي من مختصين في الزراعة وتقنيات الأقمار الصناعية لضمان الدقة والملاءمة الميدانية.

.4أهداف المشروع

- تصميم نظام ذكي يساعد الفلاحين على اتخاذ قرارات مدروسة.

- دمج مصادر البيانات الزراعية المختلفة في منصة واحدة سهلة الاستخدام.
- رفع الإنتاجية الزراعية مع تقليل التكاليف والخسائر.
- تسهيل ولوج الفلاحين الصغار إلى أدوات التحليل الحديثة.
- تحضير أساس قوي لتوسيع المشروع ليصبح شركة ناشئة تكنولوجية متكاملة.

5.جدول زمني لتحقيق المشروع

المرحلة	الوصف	المدة الزمنية
المرحلة 1	تحليل الاحتياجات وجمع البيانات	شهر واحد
المرحلة 2	تطوير النموذج الأولي للمنصة	شهران
المرحلة 3	اختبار المنصة وتحسين النماذج	شهر ونصف
المرحلة 4	تقديم النموذج التجريبي ومراجعته	أسبوعان
المرحلة 5	إعداد العرض النهائي والتقرير	أسبوع

المحور الثاني: الجوانب الابتكارية

1.الابتكار التقني

- استخدام دمج مصادر بيانات متعددة (مثل الأقمار الصناعية، الاستشعار عن بعد، بيانات الطقس، بيانات التربة، إلخ).
- تطبيق تقنيات الذكاء الاصطناعي (مثل التعلم العميق، النماذج التنبؤية، ومعالجة اللغة الطبيعية) في تحليل ودعم اتخاذ القرار الزراعي.
- تطوير نموذج متكامل يجمع بين التحليلات الوصفية والتشخيصية والتنبؤية والتوقعية.
- توظيف تقنيات الأتمتة الذكية في العمليات الزراعية، مما يقلل الحاجة للتدخل اليدوي.

2.الابتكار في التصميم والنموذج التشغيلي

- إنشاء منصة رقمية متكاملة تجمع بين تحليل البيانات، التنبؤات، والتفاعل مع المستخدم عبر واجهة سهلة الاستخدام.
- دمج نظام دعم القرار الزراعي الذكي الذي يساعد المزارعين على اتخاذ قرارات مستنيرة في الوقت الحقيقي.
- تضمين مساعد ذكي قائم على نماذج اللغة الكبيرة (LLM) لتوفير استشارات زراعية مخصصة.

.3الابتكار في الاستخدام والاستفادة

- تمكين المزارعين من الوصول إلى تحليلات دقيقة وعملية تساعد في تحسين الإنتاج وتقليل الهدر.
- تقديم تقارير وتحليلات مخصصة بناءً على موقع وخصائص كل مزرعة.
- تسهيل دمج البيانات والأنظمة المختلفة لتوحيد مصادر المعلومات وتبسيط العمل الزراعي.

.4الابتكار في الجانب البيئي والاستدامة

- استخدام البيانات الذكية لتحسين ممارسات الري والتسميد بما يحقق استدامة الموارد.
- تقليل الأثر البيئي عن طريق التنبؤ المبكر بالمشكلات الزراعية مثل الآفات أو نقص المياه.

المحور الثالث: التحليل الاستراتيجي للسوق

يُعد التحليل الاستراتيجي للسوق من الركائز الأساسية لنجاح أي مشروع ناشئ، حيث يوفر رؤية واضحة حول البيئة التنافسية، الفرص، والتهديدات التي يمكن أن تؤثر على مسار المشروع. في إطار مشروع"Ghalaty" ، تهدف هذه الدراسة إلى فهم سوق الزراعة الرقمية في المنطقة، وتحليل احتياجات المستخدمين، وتقييم المنافسين لتحديد المواقع المثلى للتميز والابتكار.

.1حجم السوق وفرص النمو

تشهد الزراعة الذكية وتطبيقات تكنولوجيا المعلومات الزراعية نمواً متسارعاً على مستوى العالم، خاصة مع ازدياد الاهتمام بالتقنيات المستدامة وتحسين الإنتاج الزراعي. تشير الدراسات إلى أن السوق المحلي والإقليمي يشهد طلباً متزايداً على حلول رقمية متكاملة تدعم المزارعين بمعلومات دقيقة وفورية، مما يوفر فرصاً كبيرة لمشروع "Ghalaty"لتلبية هذه الاحتياجات.

.2تحليل المنافسين

يوجد عدد من الشركات والمنصات التي تقدم حلولاً زراعية رقمية، لكن معظمها يفتقر إلى التكامل الكامل بين الذكاء الاصطناعي، الإنترنت الأشياء، وتحليل البيانات متعددة المصادر. يتميز "Ghalaty" بدمج هذه التقنيات بشكل متكامل، مما يمنحه ميزة تنافسية واضحة في تقديم خدمات شاملة ودقيقة.

3.تحديد العملاء المستهدفين

تتوجه منصة "Ghalaty" إلى الفئات التالية:

- المزارعون الصغار والمتوسطون الباحثون عن تحسين الإنتاج وتخفيض التكاليف.
- الشركات الزراعية الكبرى التي تسعى لأتمتة وتحليل عملياتها.
- الجهات الحكومية والمؤسسات البحثية المهتمة بمراقبة وتحسين الأداء الزراعي.

4.العوامل المؤثرة في السوق

تتضمن العوامل المؤثرة التحديات التقنية، قلة الوعي بالتكنولوجيا الحديثة، محدودية البنية التحتية الرقمية في بعض المناطق، بالإضافة إلى الحاجة إلى تدريب المستخدمين على استخدام المنصة بشكل فعال. ومع ذلك، فإن الدعم الحكومي والزيادة في الطلب على الإنتاج المستدام يمثلان فرصاً هامة للنمو.

5.استراتيجيات الدخول إلى السوق

يخطط المشروع لاعتماد استراتيجية تسويق قائمة على التوعية، التعاون مع الجمعيات الزراعية، وعقد شراكات مع الجهات الحكومية والمؤسسات الأكاديمية لتسريع تبني التكنولوجيا الزراعية الحديثة، مما يضمن انتشاراً سريعاً وتأثيراً مستداماً.

المحور الرابع: خطة الإنتاج والتنظيم

تعتبر خطة الإنتاج والتنظيم من العناصر الحيوية التي تحدد كيفية تحويل الفكرة إلى منتج ملموس وخدمة فعالة. يركز مشروع "Ghalaty" على بناء منصة متكاملة تجمع بين التكنولوجيا الحديثة والعمليات الزراعية لضمان جودة الخدمات واستمرارية الأداء.

1.مراحل الإنتاج

- **مرحلة التحليل والتصميم** :تشمل جمع وتحليل المتطلبات التقنية والزراعية، وتصميم هيكل المنصة والواجهات بما يتناسب مع احتياجات المستخدمين.

- **مرحلة التطوير** :تطوير النماذج الأولية والبرمجيات باستخدام تقنيات الذكاء الاصطناعي، إنترنت الأشياء، وقواعد البيانات متعددة المصادر.
- **مرحلة الاختباروالتقييم** :اختبار المنصة على بيانات حقيقية وتحليل الأداء لتحسين الدقة والموثوقية.
- **مرحلة الإطلاق والمتابعة** :نشر المنصة وتوفير الدعم الفني والتحديثات المستمرة بناءً على ملاحظات المستخدمين.

.2الهيكل التنظيمي

- **الإدارة العليا** :مسؤولة عن التخطيط الاستراتيجي واتخاذ القرارات النهائية.
- **فريق التطوير التقني** :متخصص في برمجة النماذج الذكية، واجهات المستخدم، وقواعد البيانات.
- **فريق البحث الزراعي** :يضم خبراء زراعيين لتحليل البيانات وتقديم الاستشارات الفنية.
- **فريق التسويق والدعم** :مسؤول عن نشر المشروع والتواصل مع المستخدمين وتقديم الدعم الفني.

.3الموارد المطلوبة

أ. الموارد البشرية

- **فريق التطوير** :مطورون برمجيات متخصصون في الذكاء الاصطناعي، تحليل البيانات، تطوير الواجهات، وربط الأنظمة.
- **خبراء الزراعة** :للاستشارات الزراعية وتحليل البيانات البيئية والميدانية.
- **فريق التسويق والمبيعات** :لتنظيم الحملات التسويقية والتواصل مع العملاء والشركاء.
- **فريق الدعم الفني** :لتقديم الدعم والصيانة للمنصة ومتابعة تحديثاتها.
- **الإدارة** :مدير مشروع، مسؤول مالي، ومسؤول موارد بشرية.

الملاحظات	العدد	الوظيفة
لتطوير المنصة، النماذج، والتطبيقات	3	مطور برمجيات Backend) و(Frontend
لبناء نماذج التنبؤ والتعلم العميق	2	مهندس ذكاء اصطناعي
لجمع وتنظيف وربط البيانات	1	مهندس بيانات(Data Engineer)

استشارات، تحليل بيانات ميدانية	2	خبير زراعي
إدارة حملات التسويق الرقمية	1	مسؤول تسويق
دعم المستخدمين وصيانة الأنظمة	1	مسؤول دعم فني
تنسيق الفرق ومتابعة التنفيذ	1	مدير مشروع
متابعة الميزانيات والإدارة المالية	1	مسؤول مالي وإداري

مجموع الفريق 12 :شخصاً

ب. المكان والمر افق

- **مكتب العمل:**
  - مساحة مكتبية مناسبة لاستيعاب الفريق (يُفضل موقع مركزي يسهل الوصول إليه).
  - تأجير المكتب حسب المنطقة (مكتب بمساحة 50-70 متر مربع عادةً كافية في البداية).
- **الأثاث والمعدات المكتبية:**
  - مكاتب وكراسي مريحة للفريق.
  - طاولات اجتماعات.
  - خزائن وأدراج لتخزين المستندات.
  - أجهزة كمبيوتر حديثة (للمطورين والمصممين) ذات مواصفات قوية.
  - طابعات وماسحات ضوئية.
  - أجهزة هواتف مكتبية أو نظم اتصال داخلية.

الملاحظات	**العدد/الوحدة**	**التفاصيل**	**البند**
موقع مركزي، مجهز جيداً	1	70متر مربع	مساحة مكتب
مناسبة لكل فرد	12	مكاتب فردية لكل موظف	مكاتب عمل
	12	مريحة وعملية	كراسي مكتبية
تتسع لـ 8-10 أشخاص	1	طاولة متوسطة الحجم	طاولة اجتماعات

خزائن ومستندات	لتخزين الملفات والوثائق	4	
أجهزة كمبيوتر	حواسيب بمواصفات قوية	12	مع معالجات حديثة و RAMعالي
طابعة وماسح ضوئي	جهاز متعدد الاستخدام	1	
معدات اتصال	هاتف مكتبي ونظامVOIP	1نظام	

ج. المعدات التقنية والاشتراكات

- **الخوادم والاستضافة:**
  - اشتراك في خدمات استضافة سحابية) مثلAWS ، Google Cloud، أو (Azure لضمان استقرار التطبيق وقابليته للتوسع.
- **برمجيات وأدوات تطوير:**
  - تراخيص أدوات برمجة وتطوير) مثلIDEs ، مكتبات الذكاء الاصطناعي، أدوات تحليل البيانات.(
  - برامج إدارة المشاريع) مثل Jira أو.(Trello
- **خدمات الإنترنت والاتصالات:**
  - اشتراك إنترنت عالي السرعة في المكتب.
  - خدمات اتصالVOIP) ، البريد الإلكتروني الرسمي.(
- **اشتراكات البيانات:**
  - شراء أو الاشتراك في مصادر بيانات الطقس، صور الأقمار الصناعية، بيانات استشعار الأرض.
  - خدمات API للحصول على البيانات المحدثة والموثوقة.

البند	**التفاصيل**	**الكمية**	**الملاحظات**
استضافة سحابية (AWS/GCP/Azure)	سيرفرات سحابية ذات أداء عالي	اشتراك شهري	2-3خوادم افتراضية على الأقل

لكل عضو في فريق التطوير	12تراخيص	IDEs، مكتبات، أدوات تحليل بيانات	تراخيص أدوات تطوير البرمجيات
لتنسيق العمل والمتابعة	1اشتراك	Jira/Trelloأو ما شابه	أدوات إدارة المشاريع
سرعة لا تقل عن 100 ميجابت	1اشتراك	للمنزل والمكتب	اشتراك إنترنت عالي السرعة
خدمات مختلفة للحصول على بيانات دقيقة	3-4 اشتراكات	APIsمتجددة وحقيقية	اشتراكات بيانات الطقس والأقمار الصناعية
لضمان أمان البيانات	1اشتراك	حلول سحابية أو محلية	برامج النسخ الاحتياطي

د. المستلزمات المادية والتشغيلية

- أدوات مكتبية: أوراق، أقلام، أدوات تنظيم.
- أجهزة التخزين الاحتياطية HDD) أو SSD خارجي.(
- نظام نسخ احتياطي دوري للبيانات.

الملاحظات	العدد	التفاصيل	البند
للاستخدام اليومي	كميات مناسبة	أوراق، أقلام، ملفات	أدوات مكتبية
للنسخ الاحتياطي والتخزين	2وحدة	أقراص صلبة SSD أو HDD	أجهزة تخزين خارجية
مع جدولة دورية للنسخ	1نظام	سيرفر أو خدمات سحابية	نظام نسخ احتياطي دوري

هـ. التنقل واللوجستيات

- **السيارات:**
  - في حال الحاجة لزيارات ميدانية للمزارع أو لجمع البيانات، يفضل وجود سيارة صغيرة أو مركبة مناسبة للطرق الزراعية.
  - إمكانية استئجار سيارة حسب الحاجة لتقليل التكاليف في البداية.
- **مصاريف التنقل** :ميزانية للنقل والزيارات الميدانية للفريق.

البند	التفاصيل	العدد	الملاحظات
سيارة ميدانية	سيارة صغيرة SUV) أو بيك أب(	1	لزيارات المزارع وجمع البيانات
مصاريف تشغيل السيارة	وقود، صيانة، تأمين	شهرياً	ميزانية مخصصة للانتقالات
مصاريف التنقل	مواصلات داخل المدينة	شهرياً	لتسهيل تنقل الفريق عند الحاجة

و. التكاليف الإضافية

- تكاليف التدريب والتطوير المستمر للفريق.
- مصاريف التسويق والإعلانات (رقمية وتقليدية).
- تكاليف قانونية وإدارية (ترخيص الشركة، المحاسبة، الضرائب).

البند	التفاصيل	العدد	الملاحظات
تكاليف التدريب	دورات لتطوير مهارات الفريق	حسب الحاجة	تدريب دوري على التقنيات الجديدة
التسويق والإعلان	حملات رقمية وتقليدية	مستمرة	تشمل وسائل التواصل والشراكات
المصاريف القانونية	تسجيل الشركة، المحاسبة، الضرائب	مرة سنوية	ضروري لاستمرارية العمل

المحور الخامس: الخطة المالية(PLAN FINANCIER)

1.تقدير التكاليف الاستثمارية(Capex)

البند	الكمية	السعر للوحدة (دج)	المجموع (دج)	الملاحظات
إيجار المكتب (شهريًا، 12 شهر)	1مكتب	50,000دج	600,000 دج	مكتب بمساحة مناسبة في منطقة وسط المدينة
أثاث المكتب (مكاتب، كراسي، طاولات، خزائن)	12 مجموعة	25,000دج	300,000 دج	لكل موظف + غرفة اجتماعات
أجهزة الكمبيوتر (حاسوب مكتبي أو لابتوب)	12جهاز	70,000دج	840,000 دج	أجهزة بمواصفات قوية للتطوير
طابعة وماسح ضوئي	1جهاز	40,000دج	40,000دج	جهاز متعدد الاستخدام
ترخيص البرمجيات والأدوات	12 ترخيص	30,000دج	360,000 دج	IDEs، أدوات الذكاء الاصطناعي،

تحليل البيانات				
AWSأو Google Cloudأو ما شابه	600,000 دج	600,000 دج	1 اشتراك	استضافة سحابية (سنة)
سيارة مستعملة بحالة جيدة تناسب الطرق الزراعية	2,000,000 دج	2,000,000 دج	1سيارة	سيارة ميدانية (شراء أو إيجار)
تسجيل الشركة، المحاسبة، الضرائب	200,000 دج	200,000 دج	1دفعة	تكاليف الترخيص القانوني والإدارية
برمجة، تصميم، اختبارات	1,500,000 دج	1,500,000 دج	1 مشروع	تطوير النموذج الأولي

إجمالي التكاليف الاستثمارية 6,440,000 :دج

2.التكاليف التشغيلية الشهرية(Opex)

الملاحظات	المجموع الشهري (دج)	السعر للوحدة (دج)	الكمية	البند
متوسط راتب لكل موظف (قد يختلف حسب التخصص)	840,000دج	70,000دج	12 موظف	رواتب الفريق (12 موظف)
	50,000دج	50,000دج	1مكتب	إيجار المكتب

تحديثات، دعم فني، أدوات تطوير	50,000دج	50,000دج	1اشتراك	اشتراكات الخدمات السحابية والبرمجيات
خدمة إنترنت عالية السرعة	15,000دج	15,000دج	1اشتراك	مصاريف الإنترنت والاتصالات
زيارات ميدانية للمزارع	25,000دج	25,000دج	1سيارة	مصاريف التنقل (وقود، صيانة)
إعلانات رقمية ومحلية	30,000دج	30,000دج	1حملة	مصاريف التسويق والدعاية
أدوات مكتبية، تكاليف صغيرة	15,000دج	15,000دج	1 مجموعة	مصاريف إدارية ولوجستية

إجمالي التكاليف التشغيلية الشهرية 1,025,000 :دج

.3مصادر التمويل

يعتمد مشروع "Ghalaty" بشكل كامل على التمويل الخارجي، من خلال مساهمات مالية من:

- **مستثمرين خواص**
- **صناديق دعم المشاريع الناشئة(Startup Funds)**
- **برامج حكومية أو تمويل دولي للمشاريع التكنولوجية والابتكارية**

ملاحظات	القيمة بالدينار الجز ائري (دج)	النسبة (%)	المصدر
يغطي جميع التكاليف الاستثمارية والتشغيلية للمراحل الأولى من المشروع	4,000,000دج	100%	تمويل خارجي (مستثمرين / دعم حكومي / منح)

.4توقعات الإيرادات

- إيرادات الاشتراكات الشهرية من المستخدمين (المزارعين والشركات):

من المتوقع بدءًا بإيرادات **200,000دج شهريًا** في السنة الأولى، مع نمو سنوي متوقع بنسبة 25%–30.%

- خدمات إضافية مدفوعة (استشارات، تحليلات متقدمة):
متوقع إضافة إيرادات إضافية **50,000دج شهريًا** خلال السنة الأولى.
- شراكات مع الجهات الحكومية والمؤسسات البحثية.
- النمو المتوقع يجعل الإيرادات تغطي التكاليف التشغيلية خلال 18-24 شهراً.

.5نقطة التعادل(Break-even Point)

من المتوقع تحقيق نقطة التعادل خلال **18-24شهرًا** من بدء التشغيل، حيث تبدأ الإيرادات في تغطية كافة التكاليف التشغيلية والاستثمارية تدريجياً.

.6إدارة المخاطر المالية

- تخصيص صندوق طوارئ يغطي 3 أشهر من التكاليف التشغيلية (~3,075,000 دج).
- متابعة دورية للخطة المالية مع مراجعة التكاليف والإيرادات.
- تنويع مصادر التمويل لتقليل المخاطر والاعتماد على مصادر متعددة.

المحور السادس: النموذج الأولي التجريبي

يهدف النموذج الأولي التجريبي لمشروع "Ghalaty" إلى تقديم نسخة عملية ومحدودة الوظائف من المنصة الرقمية التي تعتمد على تكامل البيانات المتعددة المصادر (الطقس، التربة، الأقمار الصناعية، بيانات المزارع) لتوفير حلول ذكية تدعم اتخاذ القرارات في المجال الزراعي.

.1أهداف النموذج الأولي

- اختبار الوظائف الأساسية للمنصة من جمع البيانات، معالجتها، وعرضها بطريقة تفاعلية.
- تجربة نماذج التنبؤ الزراعية باستخدام بيانات حقيقية لضمان دقة النتائج.
- تقديم واجهة مستخدم بسيطة وسهلة الاستخدام تسمح للمزارعين بالوصول للمعلومات الهامة.
- تقييم أداء النظام في بيئة تشغيل حقيقية والحصول على ردود فعل المستخدمين لتحسينه.

.2مكونات النموذج الأولي

- **قاعدة بيانات** :نظام تخزين البيانات متعدد المصادرCSV) ، قواعد بيانات SQL و.(NoSQL

- **نموذج تنبؤي** :نموذج تعلم آلي مدمج يقوم بتحليل بيانات الطقس والتربة لتوقع إنتاج المحاصيل.
- **واجهة المستخدم** :لوحة تحكم تفاعلية تعرض البيانات بشكل مبسط وتتيح خيارات التصفية والتحليل.
- **نظام تحميل الصور** :خاصية لتحميل صور المزارع أو المحاصيل لتحليلها باستخدام تقنيات تصنيف الصور.
- **لوحة إدارة** :واجهة لإدارة المستخدمين ومراقبة سير العمل.

.3خطوات تطوير النموذج الأولي

- جمع البيانات الضرورية من المصادر المختلفة وتجهيزها للتحليل.
- بناء النماذج الأولية للذكاء الاصطناعي وتدريبها على البيانات المجمعة.
- تطوير واجهة المستخدم باستخدام تقنيات حديثة لضمان استجابة وسهولة الاستخدام.
- اختبار النظام ميدانياً بالتعاون مع مجموعة من المزارعين لجمع الملاحظات وتحسين النموذج.
- تنفيذ دورات تدريبية للمستخدمين النهائيين لزيادة الفهم والفعالية.

.4الجدول الزمني لتطوير النموذج الأولي

التفاصيل	المدة	المرحلة
تجهيز مصادر البيانات وتنظيفها	1شهر	جمع وتحليل البيانات
بناء وتدريب النماذج باستخدام بيانات حقيقية	2أشهر	تطوير النموذج التنبؤي
تصميم وتطوير واجهة تفاعلية سهلة الاستخدام	1.5شهر	بناء واجهة المستخدم
تجارب ميدانية وجمع ملاحظات المستخدمين	1شهر	الاختبار والتقييم
معالجة الملاحظات وتحسين الوظائف	0.5شهر	التحسينات النهائية

.5النتائج المتوقعة من النموذج الأولي

- إثبات جدوى تقنية المشروع وقدرته على توفير حلول ذكية.
- توفير بيانات ميدانية حقيقية تساعد في تحسين دقة النماذج المستقبلية.

- بناء قاعدة مستخدمين أولية وتعزيز الثقة بالمنتج.
- إعداد قاعدة صلبة للتوسع والتطوير في مراحل المشروع القادمة.

➢ الجداول والأشكال

الجدول ل(01): خطة الإيرادات

STARTUP : GHALATY

	REALISATION			PREVISION				
Produit A destiné Client	N -2	N -1	N	N+1	N+2	N+3	N+4	N+5
Quantité produit A			500	1000	1500	2000	25500	3000
Prix HT produit A			1200	1200	1300	1400	1500	1500
Ventes produit A	-	-	600000	1200000	1950000	2800000	3750000	4500000
CHIFFRE D'AFFAIRES GLOBAL	-	-	600000	1200000	1950000	2800000	3750000	4500000

الشكل (01): تطور المبيعات والإيرادات المتوقعة حسب المنتج خلال فترة التوقع

قائمة الملاحق :

الملحق رقم 01: ميزانية المؤسسة الناشئة

BILANS DE STARTUP :GHALATY

ACTIF								
	REALISATION			PREVISION				
En milliers DZD	N -2	N - 1	N	N+1	N+2	N+3	N+4	N+5

Immobilistation Incorporelles	**-**	**-**	**0**	**0**	**0**	**0**	**0**	**0**
Immobilisation Corporelles	**-**	**-**	**1800000**	**0**	**0**	**0**	**0**	**0**
Terrain								
Bâtiment								
Autres Immobilisations Corporelles								
Immobilisations en concession								
Immobilisation en cours	**-**	**-**	**0**	**0**	**0**	**0**	**0**	**0**
Immobilisations Financières	**-**	**-**	**0**	**0**	**0**	**0**	**0**	**0**
Titres mis en équivalence								
Autres participations et créances rattachées								
Autres Titres immobilisés								
Prets et autres titres financiers non courants								
Impôts différés actif								
ACTIF NON COURANT	**-**	**-**	**1800000**	**1800000**	**1800000**	**1800000**	**1800000**	**1800000**
Stocks et encours	**-**	**-**	**200000**	**300000**	**400000**	**500000**	**600000**	**700000**
Créances et emplois assimilés	**-**	**-**	**0**	**0**	**0**	**0**	**0**	**0**
Clients								
Autres débiteurs								
Impôts et assimilés								

Autres créances et emplois assimilés								
Disponibilités et assimilés	-	-	2000000	2200000	2300000	2500000	2700000	3000000
Placements et autres actifs financiers courants								
Trésorerie								
ACTIF COURANT	-	-	2200000	2500000	2700000	3000000	3300000	3700000
TOTAL ACTIF	-	-	4000000	4300000-	4500000	4800000	5100000	5500000
PASSIF								
	REALISATION			PREVISION				
En milliers DZD	N -2	N - 1	N	N+1	N+2	N+3	N+4	N+5
CAPITAUX PROPRES								
Capital émis								
Capital non appelé								
Ecart de réevaluation								
Primes et réserves- Réserves Consolidées								
Résultat net- RN part du groupe								
Autres capitaux propores- report à nouveau								
Part de la société consolidante (1)								
CAPITAUX PROPRES	-	-	-	-	-	-	-	-
PASSIFS NON-COURANTS								
Emprunts et dettes financières								

impôt différé passif								
Autres dettes non courantes								
Provisions et produits constatés d'avance								
PASSIFS NON-COURANTS	-	-	-	-	-	-	-	-
PASSIFS COURNATS								
Fournisseurs et comptes rattachés								
Impôts								
Autres dettes								
Trésorerie passif								
PASSIFS COURANTS	-	-	-	-	-	-	-	-
TOTAL PASSIF	-	-	-	-	-	-	-	-
Verification de l'équilibre Actif/Passif	-	-	-	-	-	-	-	-

الملحق رقم 02: جدول حسابات النتائج المتوقعة

COMPTE DE RUSULTAT PREVISIONNELDE STARTUP : GHALATY

	N -2	N -1	N	N+1	N+2	N+3	N+4	N+5
Production de l'exercice			600000	1200000	1950000	2800000	3750000	4500000

Consommation de l'exercice			150000	300000	500000	700000	900000	1000000
Valeur ajoutée d'exploitation			450000	900000	1450000	2100000	2850000	3500000
Excédent Brut d'Exploitation			300000	600000	1000000	1500000	2000000	2500000
Résultat opérationnel			280000	580000	980000	1480000	1980000	2480000
Résultat net de l'exercice			250000	500000	850000	1300000	1800000	2300000

الملحق رقم 03: حسابات الخزينة

TABLEAUX DE FLUX DE TRESORERIE

STARTUP : GHALATY

Année	Entrées	Sorties	Solde Net
N	2000000	1800000	200000
N+1	2200000	1900000	300000
N+2	2500000	2100000	400000
N+3	2800000	2300000	500000
N+4	3000000	2500000	500000
N+5	3300000	2700000	600000

Business Model Canvas

Designed for:	Designed by:	Date:	Version:
Ghalaty	Lakha Noureddine	12/04/2025	2.1.0

Key Partners

- Space agencies and satellite imagery providers.
- Agricultural research centers.
- Meteorological offices.
- Ghalaty companies.
- Electronic payment service providers.

Key Activities

- Platform development and maintenance.
- Continuous updating of AI models.
- Collecting and analyzing diverse agricultural datasets.
- Providing customer support and user training.
- Executing digital marketing campaigns.

Key Resources

- Multi-source agricultural data (weather, soil, satellite imagery).
- Cloud servers and computing infrastructure.
- Technical team (AI specialists, software developers).
- Agricultural experts and data analysts

Value Propositions

- Smart and accurate crop yield predictions.
- Improved crop quality and reduced losses.
- Integrated platform for weather, soil, and crop data analysis.
- AI-based support for agricultural decision-making.
- Intelligent assistant offering automatic agricultural advice.

Customer Relationships

- Direct technical support (chat, WhatsApp, email).
- Short training courses for users.
- Regular updates and feature enhancements.
- Flexible subscription plans.

Channels

- Dashboard.
- Mobile application.
- Partnerships with cooperatives and agricultural centers.
- Digital marketing campaigns via social media.

Customer Segments

- Individual farmers (small and medium-sized).
- Agricultural companies.
- Farmers' cooperatives.
- Ministries and agricultural institutions.
- Seed and fertilizer suppliers.
- Agri-tech solution developers.

Cost Structure

- Server and cloud computing costs.
- Salaries for developers and agricultural experts.
- Marketing and advertising expenses.
- Licenses for satellite data and imagery.
- Application development and maintenance costs.

Revenue Streams

- Monthly and yearly subscriptions.
- Paid customized analytical reports.
- Agricultural consulting services.
- Partnerships and licensing deals with major agricultural organizations.

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