

INTELLIFARM - FARM SUPERVISION & PRODUCTIVITY ANALYSIS PLATFORM



A thesis submitted by

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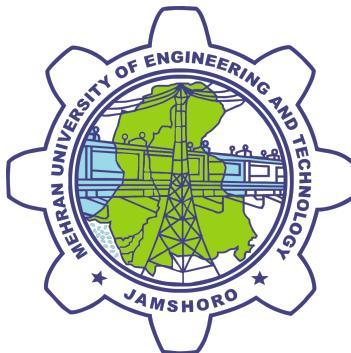
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DEDICATION



This thesis is wholeheartedly and proudly dedicated to the people we can take inspiration from including our beloved parents, respected faculty of Mehran University of Engineering and Technology, and mentors who assisted us in the midst of challenges while completing this thesis.

DEPARTMENT OF SOFTWARE ENGINEERING



CERTIFICATE OF APPROVAL

This is to certify that the Project / Thesis report on the **IntelliFarm - Farm Supervision and Productivity Analysis Platform** is submitted in partial fulfillment of the requirements for a Bachelor's degree in Software Engineering by the following students:

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ABSTRACT

IntelliFarm is a comprehensive farm management platform that aims to modernise and simplify farm operations by managing all collected data in one place and offering simple financial tools built on top. With a user-friendly interface to track financial transactions, generate detailed reports and increase operational oversight, the system focuses on bridging the gap between landlords and farmers. It consolidates disparate farm-related tasks into a single digital platform and therefore reduces inefficiencies, strengthens decision-making, and increases agricultural management transparency. It includes financial tracking, offline data synchronisation and automated report generation in PDF format. Identified challenges of traditional agricultural practises, It is designed to serve as a tool for landlords to provide actionable insight into productivity and financial health, and for tenant farmers, to simplify workflows. The platform is designed for accessibility and usability and works across multiple devices including even in rural areas with limited internet connectivity. IntelliFarm seeks to drive efficiency, boost farm productivity, and spur sustainability by harnessing technology and user-centric design. It is a major leap toward turning conventional farmland management into a more transparent, efficient, and data-driven effort.

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

For centuries, the Indus Valley has served as a manifestation of agricultural surplus, with great renown as one of the Earth's most productive and fertile areas.[1] This historically rich expanse nestles within the agriculture economy formation which is a mere reflection of the geographical positioning of the region in the Indus Valley. Pakistan's agricultural sector has turned into a lifeblood of the nation and low-income support for a significant part of its populace.[2]

Indeed, of Pakistan's population most have small or no link to any other work outside agriculture directly or indirectly either through the output of the product of agriculture or through consumption. A striking reflection of this dependency lies in the statistics: Agricultural pursuits utilise 27% of the country's total land area, employs 42.3% of the total labour force and makes up for a substantial 18.9% of the nation's Gross Domestic Product (GDP).[3]

Yet, notwithstanding Pakistan's dependence on agriculture, the sector suffers from inherent challenges emanating from obsolete and inefficient land management practices. Within this landscape, a fea-

ture we would like to mention is the disproportionate amount of private land owned by landlords and rented to tenant farmers. It is a traditional form of arrangement in which the burden of land management rests on the shoulders of landlords, who ordinarily conduct affairs using age-old techniques.

Many consider these traditional land management methods described as 'medieval'; an archaic way in the 'modern' today's agricultural face. These methods are rudimentary in their practice, and technologically inefficient, as they cannot adequately cope with the requirements of modern agriculture.

Though agricultural practices all over the world have changed, these traditional techniques remain a hindering factor to the growth of Pakistan's agricultural economy. Land management practices that have outlived their usefulness are being brought to the forefront as the nation grapples with the need to use the country's agricultural potential to drive economic growth. Unless we modernise, innovate, and adopt sustainable agriculture in Pakistan, its full promise and agricultural heritage established within the Indus Valley yet remains locked.

But there are inefficiencies in the management, and a lack of coordination between the farmers and the landlords. Furthermore,

such lands are usually too often subject to poor management by landlords while the traditional methods still depend on them largely, which deprives them of the maximum yield.

1.2 PROBLEM STATEMENT

There are impediments to effective communication between landlords and farmers often stemming from poor infrastructure and lack of connectivity. Without clear lines of communication, there can be misunderstanding and mismanagement of information like crop requirements, land utilisation plans and maintenance schedules.

However, the roles and responsibilities of landlords and farmers are equally ambiguous and are not well communicated. It can be an extremely ambiguous and overlapping duty, and as such will lead to conflicting priorities, and a breakdown in operational efficiency. Farmers may be in the dark about their duties when it comes to tending to the land, and landlords may be unaware of what happens on the properties they own on a day-to-day basis.

Also, the lack of coordination increases dispute and conflict risk. Disagreements could be caused by land tenure, lease agreements or revenue sharing and interrupt farm operations and complicate management inefficiencies.

Journals store data and records. The entries in these journals are unorganised. Since their reliance on outdated and inauthentic methods of documentation leads to errors, omissions, and inconsistencies – especially when working with massive quantities of data – we can see how not updating the cache can systematically slow the business's output. Furthermore, there is no effective oversight and supervision of these journals, and therefore they can be modified and/or stolen.

The absence of centralised records results in unconsolidated data collection procedures at different stages in agricultural processing. It may contain important information such as land ownership records, crop cultivation histories, input usage and yield outcomes, however, this information may be scattered across multiple sources, such as paper-based records, individual spreadsheets, or personal recollections. This fragmented data impedes our ability to compose comprehensive datasets necessary for informed decision-making.

In addition to this, there is a lack of a centralised management system which results in a high amount of redundancy and duplication which worsens inefficiencies and makes errors more likely. This can create datasets that are conflicting or inconsistent as several independent stakeholders may capture essentially the same informa-

tion. Wasting time and resources, duplicating data complicates the reconciliation of differences and contributes to data integrity.

Lack of surveillance is one of the chief consequences because it opens the door for tenant farmers to misuse resources. When landlords cannot closely monitor farming activities, tenant farmers may capitalise on this oversight to defraud the landlords by diverting agricultural inputs to personal use; misappropriating agricultural inputs; underreporting yields — which artificially lowers rental payments. These dishonest behaviours also destroy landlords' financial interests as well as the integrity of how an agricultural operation works, limiting the profitability and productiveness of the business.

Additionally, without surveillance collusion or corruption between tenant farmers and third parties is more likely. A landlord there usually keeps a man, an accountant also called a 'Munshi' and he keeps some records and generally stores them in the journal. Indeed, sometimes these accountants team up with external elements, for instance, suppliers, contractors, or middlemen in corrupt practices, like inflating input costs, coming up with false invoices and skimming profits from agricultural sales. Lack of proper surveillance mechanisms by the landlords to detect and prevent such activities can result in a high amount of financial loss faced by landlords.

1.3 MOTIVATION

The vision of a land management app for landlords is a pioneering idea that involves a modernised and enhanced way of managing land assets digitally by addressing the fast-changing situation around landlords and land assets. The inefficiencies and limitations associated with traditional land management practices drive the need to develop such an app. Landlords have historically found themselves mired in complicated paperwork, disparate systems for data management, and communication breakdowns with and amongst tenants however, such inefficiencies and errors fed the fuel of opportunities for optimization. With technology in our arsenal, there is a dedicated land management app that will revolutionise the way landlords interact with and control their land portfolios.

The benefits are more than just decreased administrative time, this digital repository increases data accuracy, integrity, and access, decreasing the chances for errors, and disputes, and, in turn, reducing compliance issues inherent in manual record-keeping systems. The app brings disparate data sources under a single interface allowing landlords to have real-time visibility and control over their land assets providing them with the ability to make informed decisions and implement proactive management strategies.

Additionally, the advancement of an app in land management is propelled by a need to promote better interaction between landlords and tenants in bridging the gap between stakeholders and smooth interaction on various land issues. The app uses intuitive features, like messaging functionality, task assignments, and document-sharing capabilities to provide landlords with transparent and efficient communication channels to respond to tenant inquiries, resolve maintenance issues and negotiate lease deals. The app promotes an open dialogue and collaboration that builds a trustful, mutually understanding and goal-oriented landlord / tenancy relationship leading to increased satisfaction and retention of the tenants and reduced conflict and disputes.

On top of that, the motivation to develop a land management app also extends to the fact that it can be a powerful decision support tool for landlords, providing valuable insights, analytics and reporting that can help them make the right strategic decisions, optimise resources spent to maximise the profitability of land assets. The app offers advanced features like financial performance analysis, and market trend forecasting as well as tools for portfolio management, allowing landlords to uncover opportunities for growth, guard against risk and balance in live time. Landlords have the opportu-

nity to leverage data-driven intelligence to make the right decisions with an impact on operational efficiency, increasing asset value and increasing agricultural production.

1.4 OBJECTIVES OF PROJECT

This project encompasses several key objectives aimed at modernizing and optimizing farmland management processes, enhancing communication between landlords and farmers, and improving inventory tracking and accountability measures:

A primary objective of this project is to develop a centralised system that integrates all facets of management in the agricultural process. This system will consolidate diverse tasks and data points into a single, integrated platform that will enable easy and seamless coordination and oversight of agricultural activities: from planting and cultivation to harvesting and post-production processes. A centralised approach is offered that aims to increase operational efficiency, reduce redundancy and augment the productivity of the agricultural value chain.

A second important objective is to facilitate comprehensive report generation to help landlords and farmers understand how farm operations work. The system collects and analyses data on crops,

finances, and activities and can produce customised reports to show trends, performance metrics and areas of improvement. These reports not only help as a basis to make informed decisions but also provide transparent information on farm activities enabling the stakeholders to have the correct and actionable data available at the time. The feature removes the requirement for manual tracking that is more precise and time-effective.

One more important goal of this project is to define ways to computerise the surveillance of accounting processes via a web review of the landlord. Through financial management features included in the centralised system, landlords can monitor and vouch for financial transactions, expenditures and revenue streams. That enhanced level of oversight and accountability will curtail fraud, expose anomalies, and strengthen financial transparency and integrity in the management of farmlands no matter its form.

1.5 SIGNIFICANCE OF PROJECT

Significant about this project is the possibility of revolutionising the way that farms are managed and practised by providing a comprehensive digital solution to address longstanding issues and inefficiencies inherent in conventional agricultural practices. This project

promises the ability to create a centralised system allowing all parts of management to be streamlined through the agricultural process increasing operational efficiency, using resources effectively and fostering sustainable growth in the agricultural sector.

Perhaps the most salient feature of this project is that it allows landlords to generate detailed financial reports on farmland operations and to oversee them better. Through the system, we collect and organise financial data regarding transactions, expenditures, and revenue streams to deliver landlords and stakeholders clear, actionable insights. These reports guide in identifying trends, allocation budgeting and making better financial decisions. The functionality on the other side of the coin here—depriving the user of the need to do manual tracking, which in turn lowers overall errors and the need to be accurate about the evaluation of economic activities—ultimately builds trust and transparency between stakeholders.

Additionally, the project's core concern in fiscal management complemented by real-time reporting has significantly filled a gap in issues of accountability and financial transparency in farmland management. It provides a mechanism for landlords to verify transactions, and look over their cash flow for any irregularities or fraud,

which helps to strengthen integrity throughout. The increased level of financial vigilance means there is no waste in the allocation of resources and that all the stakeholders receive an enhanced level of financial clarity and trust.

This project is significant overall for the modernization and optimization of farmland management practices, financial reporting and accountability measures, and decision management throughout the agricultural process. The project uses technology and innovation to facilitate higher agricultural productivity, efficiency and sustainability in food security, economic development and environmental stewardship.

1.6 THESIS ORGANISATION

The contents of the thesis are organized as follows:

1.6.1 Chapter 1 - Introduction

This chapter covers a brief introduction to the proposed system with its background, problem statement, objectives, motivation, significance and deliverables.

1.6.2 Chapter 2 - Literature Review

This chapter covers past studies related to the proposed work.

1.6.3 Chapter 3 - Tools & Technologies

This chapter covers the software tools and technologies which are used to develop the project. All technologies used for the project are briefly mentioned.

1.6.4 Chapter 4 - Methodology

This chapter covers the processes, methods that are implemented and designs of the proposed solution.

1.6.5 Chapter 5 - Implementation

This chapter covers the UI implementation. It covers how users practically can use the platform.

1.6.6 Chapter 6 - Testing

In this chapter, testing of application and website is performed and results are evaluated.

1.6.7 Chapter 7 - Conclusion & Future Work

This chapter summarizes all the project work along with the future suggestions to make it more useful.

CHAPTER 2

LITERATURE REVIEW

This chapter summarizes all the project work along with the future suggestions to make it more useful.

2.1 RELEVANT WORK

Through the review and analysis of relevant work in the land management field we gain valuable insights into the context and existing efforts that inform and support proposed system.

2.1.1 xFarm

xFarm is a cutting-edge farm management platform that brings agriculture processes into the future via digitization & precision agriculture. It gives the farmer a central tool for managing all his operation aspects — field management, economic planning, crop protection and sustainability practices. xFarm integrates advanced technology to increase efficiency, improve decision making and support environmental stewardship across agricultural enterprises. Features of the platform include digital field mapping where nodes and traces can be used to describe field boundaries, record cadastral data and record soil characteristics. They come with a wide angle imaginable of

farm conditions which help the farmers make informed decisions regarding crop rotation and resource allocation. xFarm provides additional real-time monitoring through sensor integration, being able to monitor irrigation needs, pest control and machinery performance in real-time. xFarm also takes care of economic management with cost tracking, revenue tracking, and crop margin tracking tools. Farmers can create financial reports at the farm level, assess the profitability of different fields and compare the cultivation strategies. For budgeting and resource optimization, these functionalities make planning easier and better financial oversight. In addition to this, the platform puts a strong focus on sustainability, allowing users to keep track of how environmentally friendly their farming routine is — i.e. by water usage, soil health, carbon emissions, etcetera. The focus of precision agriculture enables the farmer to use such strategies as satellite-based field monitoring and prescription mapping to increase productivity without waste. xFarm provides a user-friendly interface and powerful analytics that offer farmers an opportunity to modernise their operations, be more efficient and specifically react to current issues.

2.1.2 AGRIVI

AGRIVI is a leading global digital agriculture company, undertaking the mission of solving critical issues in the agricultural sector. Its farm management tools suite features: tools to improve efficiency, profitability and sustainability of the functions of the agri-food value chain. AGRIVI's solutions are trusted by Fortune 500 companies and used by farmers, agribusinesses and food production companies worldwide, providing them with the data-driven decision-making power they need.

The main of AGRIVI's key offerings include AGRIVI 360 Farm Management Suite which combines the tools for crop planning, real-time field monitoring and operational analytics. AGRIVI's precision agriculture comes with support from features such as satellite-based field insights, IoT integration of weather stations and temperature and soil pH sensors and automated compliance reporting. Full traceability of crops is offered by the platform, enabling official control of food safety and sustainability standards like Global GAP and ISO 9001, making it a must-have tool for modern agriculture.

We find some of AGRIVI's strengths include its ability to manage inventories and track expenses to optimise farm profitability as well as its capacity to analyse crop economics. Overall, owners can also

reap benefits by gaining the ability to view crucial farm data from any device through their user-friendly interface and improving transparency within the farm itself. AGRIVI helps to address supply chain challenges to cooperatives, food companies and agronomic advisors by providing technology solutions specific to them to improve collaboration and operational efficiency in the agricultural ecosystem.

AGRIVI's approach similarity is very similar to how IntelliFarm envisioned modernising farm management through tech. Exploring data insights for sleuthing, approaches to sustain and boost bankability offer a paradigm for scaling up agriculture to cater rising global need for food without depleting environmental resources. Looking to adopt such systems, farms of all sizes can see better operational outcomes as well as contribute to making food production around the world more sustainable.

2.1.3 FarmERP

FarmERP is a complete farm management software solution that helps to streamline and optimise farm operations. We have developed a platform which includes a suite of tools that cover many of the aspects of farm management, from planning, purchasing, inventory management, and production to post-production processes. In

addition to contract farming functions, human resources management and product quality control, the solution is comprehensive and versatile for different agribusiness.

One thing to be highlighted about FarmERP is that it is scalable and customizable enough to suit various types of agribusiness and smallholder farmers. These technologies include artificial intelligence, machine learning, as well as satellite imagery analysis and allow real-time insights and predictive analytics to be offered through the platform. By integrating these two technologies, decision-making is facilitated, productivity is enhanced and sustainability in the agricultural sector is promoted.

Reduction of carbon footprint is one of the commitments that FarmERP has demonstrated in this direction. FarmERP gives businesses ways of managing their environment and optimising their resources to be more resilient to climate change. Files on this belief in agro-friendly practises are a fit with international initiatives to support eco-friendly farming and food security.

The platform's user-friendly interface and comprehensive support services provide users with simple and easy access and use of the functions of the platform. FarmERP's focus on innovation and the all-inclusive nature of its approach to farm management sets it apart

as a great way to modernise agribusiness practices as well as increase the efficiencies and profitability of farms.

2.1.4 Farmbrite

Farmbrite is a powerful, one-stop farm management solution that is useful for making farm tasks simpler and more effective. Purpose-built in 2012 by farmers for farmers, it was launched to tackle the myriad of issues on the modern farm. Farmbrite has tools for managing crops and livestock, tracking farm finances, monitoring inventory and scheduling tasks, and even integrated e-commerce solutions to sell products from their farm.

Moreover, one of the most important elements of Farmbrite is that it can combine data and improve the operation. With the platform, farmers can plan for crops, monitor yield and know about their livestock health, breeding, and grazing patterns. It is used for livestock producers supporting multi-species farms with features such as health tracking, genealogy records and grazing optimization. And they help with better decisions and improve productivity.

Farmbrite also excels at insights on money. Users can utilise the integrated features of accounting to help track expenses, keep tabs on their cash flow and generate reports so that working in taxes becomes

easier as well as they have better insight into their profitability. Additionally, the platform delivers more than 85 customizable reports and dashboards giving real-time insights into farm performance and compliance management.

E-commerce functionality of the software enables farmers to sell goods directly to consumers online without any interference from sales and inventory management. With offline accessibility it's possible to use critical tasks in areas with less mobile internet, being good when it comes to remote farm locations.

Farmbrite's farmer-focused design, affordability, and sustainability are a perfect fit for all sizes of farms. A good reason why it is a model for how to improve modern agriculture practises is because it is in line with IntelliFarm's goal to be more efficient, more profitable and more data-driven. Using tools such as Farmbrite, farmers can have more control over their business allowing for a sustainable and thriving agricultural ecosystem.

2.2 CONCLUSION

Finally, the work that has been conducted is reviewed as relevant to supporting the development of understanding the complicated dynamics and progress made in farm management. Since then,

the research journey through several scholarly articles, studies, and projects helped discern the changing realm of web and app-based systems in terms of rental services. In particular, the review of current literature shows that there is an increasing need for new platforms that serve the varied needs of both the service providers and consumers.

The technological convergence and the convenience that the works discuss consistently seem to converge. Evidence shows that owing to the widespread availability of smartphones and the internet, we have entered an age wherein people want services that are not only efficient but also easily accessible with which they can click their fingers.

Based on the relevant functionalities of the aforementioned guides, the design, development, and evaluation of the proposed system are synthesised.

CHAPTER 3

TOOLS & TECHNOLOGIES

3.1 OVERVIEW

This chapter will provide a thorough examination of the various tools, frameworks, programming languages, and databases employed through the software development lifecycle of IntelliFarm. Without these technologies, the project would have been a failure due to the inability to maintain optimal performance and user-friendliness at the same time. Tools and technologies selected for this project were based on the ability to fulfil the particular demands for the project from conception and development through to final deployment, until then, maintenance, etc.

In this chapter, we will not only detail the technical stack used to build out IntelliFarm but also explain the rationale for choosing each component. The next will be about how we have combined several integrated development environments (IDE), frameworks, programming languages, and databases in the development process to reduce development time and enhance software development productivity.

This chapter will give you a thorough understanding of how cutting-edge technologies, industry-standard best practices, and modern de-

velopment tools all helped create IntelliFarm. It also will impart valuable knowledge on how these components work together to support the continuation of the operation and growth of the platform as the demand increases.

3.2 INTEGRATED DEVELOPMENT ENVIRONMENTS (IDEs)

3.2.1 Visual Studio Code (VS Code):

Throughout the development process, we mostly worked with an integrated development environment (IDE) called Visual Studio Code (VS Code). VS Code was an adaptable, highly productive open source, feature-rich IDE. Compared to recognized IDEs, its large library of extensions, intuitive code editor, and powerful debugging capabilities made the development team at least 10 times more efficient. Features such as live sharing collaboration in this made things easier while its compatibility with multiple programming languages meant all sides of the project were also flexible.

3.2.2 Android Studio

Although it's not the main platform for the IntelliFarm project, Android Studio is used for parts of the Android-related tasks to ensure Android devices have increased compatibility and optimisation. It

is easy to use, comes with the Android Software Development Kit (SDK), and is the first must-have when a developer wants to develop for Android. The application keeps its SDK Manager simple and streamlined for the up and down gradation of platform tools, system images and build tools.

The set of features for the development and testing phase of IntelliFarm is supported by a robust set of features in the IDE. Also included are the Android Emulator to simulate specific device configurations, advanced debugging tools like the Memory Profiler and Layout Inspector, and the Gradle build system to automate application builds. Being a lightweight platform, Visual Studio Code is the primary platform for IntelliFarm however, Android Studio has specialised capabilities specifically for Android-specific development tasks. The IntelliFarm team achieves this by utilising Android Studio alongside other tools to make sure their application provides a smooth experience on Android devices and is also easy to develop.

3.3 FRAMEWORKS

3.3.1 Flutter

When deciding on the front end of the mobile application, Flutter, a product development toolkit that allows you to develop and deliver

an app with ease on both Android and iOS at the same time, was the choice as it can provide a consistent and high-performance user experience. One of the things about Flutter that stood out to me is the ability to create natively compiled apps from a single codebase. It took out the ability to maintain separate code bases for each platform which saved literally days of development time and greatly simplified the maintenance complexity.

The architecture of Flutter is based on performance and responsiveness. Flutter apps are natively compiled, and that means they can have full performance access to device processing power, meaning fast load times and smooth interactions — both fundamentally important on a real-time platform like "IntelliFarm", where users demand instant responses and consistent workflow. The library of pre-built, customizable widgets in the framework gave us the ability to put together a visually engaging and user-intuitive user interface.

Among the many things that made developers happy is Flutter's "hot reload" capability which lets developers see changes in the app instantly, without having to restart the whole thing. This real-time feedback helped fine-tune UI elements and debug issues and got us developing a lot faster.

Additionally, Flutter embraces an open-source nature that has

attracted a huge, vibrant community of developers. However, this supportive ecosystem proved an asset during development, providing access to a bounty of resources for solving problems, examining best practices, and introducing new features to the platform. It's a community-driven innovation that ensures that the app remains updated with the latest technologies and security enhancements.

3.4 LANGUAGES

3.4.1 Dart

Specifically for speed and performance, the programming language Dart was chosen since it is the main coding language for Flutter framework. Dart's key advantage lies in its dual compilation modes: Basically, Just-In-Time (JIT) and Ahead-Of-Time (AOT). JIT compilation allows us to develop much faster, with a nice and simple hot reload feature to watch the immediate impact of code changes. It saves time minimizes downtime and accelerates the iterative development process.

Dart's AOT compilation code compiles into a highly efficient, fast-running format before the code is run on devices, resulting in faster app startup times and higher overall performance. As it is in the case of a mobile application like "IntelliFarm" where responsiveness

and speed are of the utmost importance, this feature takes care of the fact that users will get a smooth journey in the app from the time they open it.

The performance improvements of Dart and Flutter go hand in hand with many other great features to bring to your app. Building responsive, aesthetically pleasing interfaces is easy with Dart's compatibility with Flutter's widget-based architecture. It kept development overhead reduced and eliminated inconsistency in the user experience across both Android and iOS platforms.

Secondly, the type system of Dart allows flexible type checking, from dynamic to static. However, this flexibility opens the door for rapid development when it is needed, while at the same time taking advantage of static-type checks to catch potential issues early in the development life cycle. The balance between energy and type safety resulted in an “IntelliFarm” platform that was agile enough to stay relevant, efficient enough to be competitive, and maintainable to continue meeting the requirements of new customers.

3.4.2 YAML Ain't Markup Language (YAML)

IntelliFarm utilises YAML in a variety of ways: defining dependencies, configuring settings etc. With a simplistic and human-readable

syntax, it makes dependency management for different application modules easier. With YAML, IntelliFarm then ensures that critical dependencies such as libraries, frameworks and APIs are written and maintained in a structured format that's easy to understand.

YAML's flexibility means that it can cleanly represent hierarchical dependency, which makes it perfect for building, package management, and env vars. For example, YAML is used to define dependencies for IntelliFarm's backend and frontend systems for defining versions, compatibility and installation instructions. This means development, testing, and production environments are consistent, reduce errors and increase the reliability of deployment.

In addition, it is particularly useful in the Continuous Integration/Continuous Delivery (CI/CD) pipelines, where it is used in automating scripting of automation tasks. The YAML files point the pipeline to where tests, builds and deployments are run so that as you're doing the development lifecycle the dependencies are resolved correctly and quickly for each step.

IntelliFarm manages application requirements via dependency with YAML, making it easier to keep up with actions like maintaining and updating dependencies between application requirements. YAML is a highly readable and integrated component of modern tools that is

thus required in the technical infrastructure of IntelliFarm.

3.5 DEPENDENCIES

3.5.1 Image Picker

Flutter's `image_picker` package is used to simplify image capture and selection in IntelliFarm. It is integral to functionalities like uploading field status updates and receipts, and so this package gives us an efficient way to access media from a device's gallery or camera. It returns media files as `XFile` objects containing file path info to easily merge into the workflows within IntelliFarm. Also, the media properties like maximum dimensions, and quality can be customised with the `image_picker` package along with permission and file access management. So that when users interact with image-related features, IntelliFarm gives a smooth and reliable experience.

3.5.2 Flutter Image Compress

Due to the need to manage storage efficiently, image compression is applied through the `flutter_image_compress` package in IntelliFarm. For mobile platforms like IntelliFarm where the primary concern is reducing bandwidth, this package offers very good compression using native methods for Android and iOS. IntelliFarm compresses large

images before upload to prevent the storage from filling up when an image is uploaded, while still maintaining control over the image quality and dimensions.

For mobile, flutter_image_compress provides platform-specific optimizations, making it a great fit for IntelliFarm's needs. The image package can also perform image compression directly from the Dart frontend and has basic manipulations like resizing and cropping (while not supported natively in Flutter), providing cross-platform compatibility. flutter_image_compress gives you native optimization depending on your platform needs while the image package is for a wider compatible range. To avoid impacting the storage footprint for IntelliFarm, the flutter_image_compress package was selected to maintain quality while minimising size.

3.5.3 Pdf

Flutter pdf package helps us to generate custom, multi-page PDF documents to display reports in IntelliFarm. It provides the format interface to the creation of output like invoices and detailed reports keeping the data integrity. The package also permits the placing of images, text, tables, and vector graphics and provides for complex document layouts, given the package's modular layout structure, by

the particular needs of IntelliFarm.

The pdf package also includes advanced styling options e.g. controlling fonts, colours and alignment to make the reports both look pretty and prepared smartly. When local PDFs are generated, they can be saved and used from within the app or can be shared. This versatility of IntelliFarm's reporting function is great! Secondly, integration with packages like printing offers in-app preview and printing functionality through seamless integrated options. IntelliFarm adopts/pdf as the standard format for reports to ensure data integrity and produce a reproducible solution for its users to access their farm management insights.

3.5.4 Firebase Core

In Flutter, the firebase_core package is used to initialize and connect your app with Firebase services and have access to Firebase Authentication, Firestore, Cloud Storage including other services. Setup across iOS, Android, and the web, and a stable, secure connection of your app to Firebase's backend is taken care of here. Using Firebase_core helps developers get a consistent and stable start to integrating Firebase features, handling configuration files, and platform-specific initialization. Once set up, it allows for easy use

of other Firebase packages, making it the base of Firebase-powered Flutter applications.

3.5.5 Firebase Auth

For authentication of farmers and landlords, the `firebase_auth` package is being used in IntelliFarm to manage the users securely and efficiently. This package handles various sign-in methods such as email password, email and phone number. All of the complexities of registering and logging in a user, should they exist, are handled by Firebase, eliminating the need for a complicated backend set-up when using Firebase's secure token-based infrastructure.

It provides session persistence so that when the app restarts, farmers and landlords continue to remain logged in. The goal of delivering a seamless and secure experience for users is well-matched with the integration of `firebase_auth` which provides robust multi-provider authentication with minimum configuration.

3.5.6 Shared Preferences

In IntelliFarm, we use the `shared_preferences` package to store lightweight, local, persistent data on the user's device. This package acts as a key-value store, managing types such as strings, integers, booleans and lists, and is perfect for managing whether before or after a user

is returning. For existing users, shared_preferences provides a seamless login experience; they can't get asked to log in again every time.

IntelliFarm implements wrapper classes to deal with shared_preferences in the desired manner, avoiding complex code and improving code architecture. With this approach, we utilise the package capability to store data for the app session, which in turn stores user preference and login flag so that the experience is less hands-off for the user. shared_preferences is an important building block of local data management in IntelliFarm for such lightweight data, and it can save and restore data simply and reliably.

3.5.7 Intl

The intl package is used in IntelliFarm to perform time conversions and locale-based formatting. This package is a must-have for internationalisation and localisation, offering help to format dates, times, numbers and currencies according to given locales. .intl helps IntelliFarm avoid time conversions and other locale-sensitive data by ensuring they are used in a way that makes the application friendly for people in different regions.

3.5.8 Path Provider

The path_provider package is used in IntelliFarm to access device directories in order to save those reports that were generated by the application. This package helps by giving platform-specific paths to common folders like the documents folder to house the user's persistent data and the downloads folder for external stuff.

IntelliFarm makes this seamless access possible to device storage using path_provider for saving reports in local storage in a user-friendly way. The package will take care of the variations inherent to the platform — the user won't have to worry about compatibility across devices. This is crucial for making path_provider an essential asset for how file storage and user-generated content can be intentionally saved, both in terms of saving and retrieving it.

3.6 DATABASES

3.6.1 Firebase Storage

Firebase Storage is the primary storage mechanism utilised in IntelliFarm, securing a wide spectrum of data and media assets. The feature also provides a space to allow landlords and farmers to upload, organise, and manage tenant identification documents, crop images and receipts, among others. Firebase Storage centralises these re-

sources in a more secure covered space to make it simpler to work with media. The structure of this information provides fast and on-demand access to necessary information that helps optimise farm management and decision-making in IntelliFarm.

3.6.2 Cloud Firestore

All of the backend data is stored and managed in IntelliFarm, and Cloud Firestore is the backbone back-end for storing and managing all of the data. The flexible and schema-less architecture of IntelliFarm can take on different types of data: farmer information, land records and financial data ignore strict data structure. This will make all the information stored and retrieved easily and according to the requirements of a platform with diverse requests.

Because any updates made by landlords are instantly reflected across the platform. Cloud Firestore's real-time synchronisation here is doing the job. With this capability, additional users can collaborate and the data can be shared more smoothly. In addition, Cloud Firestore is a scalable solution that extends well to growing data volumes without degrading performance — perfect for a growing platform like IntelliFarm. Cloud Firestore through its fast, reliable data transactions, helps intelligent operations and maintains a smooth

user experience in the system.

CHAPTER 4

SYSTEM METHODOLOGY

4.1 PROJECT OVERVIEW

IntelliFarm is an integrated farm management platform to help solve the question of being spread thin across farmland operations. The goal of the system is to ease the coordination between landlords, client farmers, and farm resources, financial data and farm performance. IntelliFarm consolidates many of the farm management elements into a single platform that allows for the efficient oversight of farm activities and increased operational efficiency.

IntelliFarm is centred on centralised farm management. All these critical farm data like financial transactions, production records and resource usage are brought together in an accessible platform form. By using a centralised approach, landlord and tenant farmers have real-time visibility of all farm operations. IntelliFarm is also a hub for keeping everything in check from tracking income and expenses to monitoring land usage and more.

One of the key IntelliFarm features is the opportunity to create reports based on live financial data ensuring users have a clear line of view to the farm's financial state. Stakeholders can then analyse

trends, monitor revenue, and study expenditures to make informed decisions. IntelliFarm allows users to customise and produce reports based on their own needs.

IntelliFarm also provides mobile access to farm management tools, so users can track operations and look at reports from anywhere without an internet connection or connectivity problems in remote areas. It makes sure that all the stakeholders have access to the latest information which reduces the risk of delay and improves decision-making.

IntelliFarm is a centralised platform to manage all of the operations of a farm. IntelliFarm consolidates key data, provides real-time insights and simplifies report generation to improve operational transparency, resource efficiency and profitability.

4.2 SYSTEM FUNCTIONALITIES

4.2.1 Landlord Functionality

4.2.1.1 Landlord Authentication

Landowners are authenticated into the system, where they manage the overall farm operations, this includes overseeing the activities of tenant farmers.

4.2.1.2 Farmer & Field Management

Landowners can add farmers, crops, and fields to the system. Each field must have at least one crop associated with it before planting and variety details can be added. This structure ensures the farm's activities are well-documented and properly organized.

4.2.1.3 Data Entry for Operations

Landowners are responsible for adding plantings, harvests, treatments, transactions, and tasks to the system. These entries allow for detailed record-keeping of all farm activities, making it easier to track progress and ensure accurate data.

4.2.1.4 Report Generation & Management

Based on the data entered by farmers and landowners, IntelliFarm automatically generates detailed reports on various farm activities. These reports cover areas such as financial transactions, crop performance, and resource management, and they can be saved in PDF format after user permission for storage access.

4.2.1.5 Receipt & Inventory Management

Landowners can review receipts uploaded by farmers and integrate them into the farm's original inventory. This ensures that all pur-

chased items are properly accounted for and maintains up-to-date records of supplies. Additionally, landowners can track the status of receipts to ensure that transactions are completed accurately.

4.2.1.6 Miscellaneous Data Entry

Landowners can add additional data that supports farm operations. This includes details not directly related to crops or inventory but crucial for farm management, ensuring all relevant information is stored in one system.

4.2.2 Farmer Functionality

4.2.2.1 Farmer Authentication & Linkage

Farmers are authenticated through the system and must be associated with a landowner. A farmer's profile cannot exist without being linked to a landowner, ensuring a structured relationship between both entities.

4.2.2.2 Field Status Update

Farmers can update the status of their fields by uploading pictures. These images provide a visual representation of the field's current condition, which can be shared with the landowner in real time.

4.2.2.3 Inventory Receipts

Farmers have the ability to add inventory receipts into the system. This helps to keep track of all farm-related purchases, ensuring proper documentation of resources and supplies.

4.2.3 Common Features

4.2.3.1 Data Synchronisation

Both farmers and landowners benefit from a data synchronisation feature. When network connectivity is lost, data is stored locally on the device until the connection is restored. This ensures no information is lost, even during temporary network failures.

4.3 SYSTEM DESIGN

4.3.1 System Architecture

IntelliFarm is based on a Client-Server architecture. This architecture ensures a clear separation between the user interface and the backend systems, providing both flexibility and scalability in farm management operations. It consists of two main components:

4.3.1.1 Client-Side

This component comprises the mobile application (built with Flutter). The client side allows farmers and landlords to interact with the system's features and functionalities.

4.3.1.2 Server-Side

The server side is implemented using Firebase, which serves as the backend infrastructure. It manages user authentication, data storage, and real-time communication between the client applications and the backend.

4.4 DIAGRAMS

4.4.1 Use-Case Diagram

This use-case illustrates the interactions of the actors (Landowner and Farmer) with IntelliFarm. The Landowner provides management of crops, field, plantings, harvestings, treatments, and sale transactions, with a chance to generate reports as shown in Figure 4.1. A Farmer provides liveliness status and receipt upload. Shared actions include viewing statuses and receipts, and managing miscellaneous tasks to enhance core functionalities.

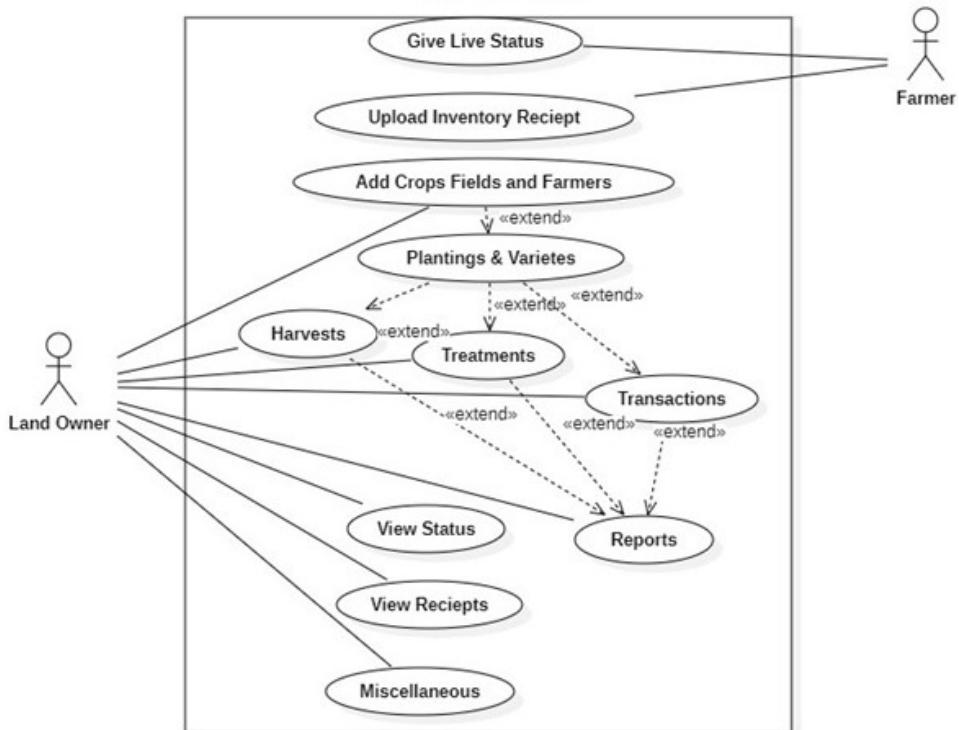


Figure 4.1: Use-Case Diagram

4.4.2 Flowchart

This flow chart shows the proceeding with agricultural operations control: everything from registering the landlord to management of farmers, controlling Crops/Fields/ Plantings/Harvesting and transactions as shown in Figure 4.2. A farmer logs in, uploads his receipt or leaves the status in it. A variety of reports may be generated by the end of this process.

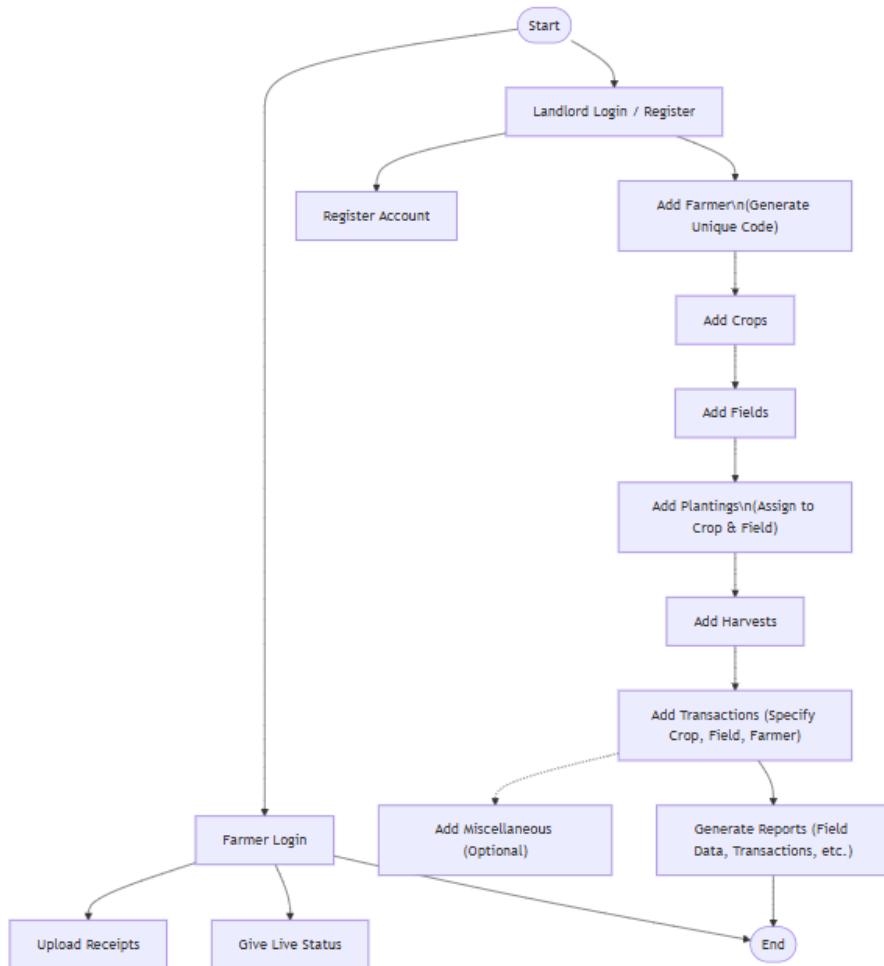


Figure 4.2: Flowchart

4.4.3 Class Diagram

Class diagram of agricultural data management as shown in Figure 4.3 has the main entity of Landlord, who owns the fields and manages crops, registers farmers, while plantings and harvests are connected with crops and fields. Transactions and reports give the possibility to track activity and make summaries. Miscellaneous is an additional supporting entity.

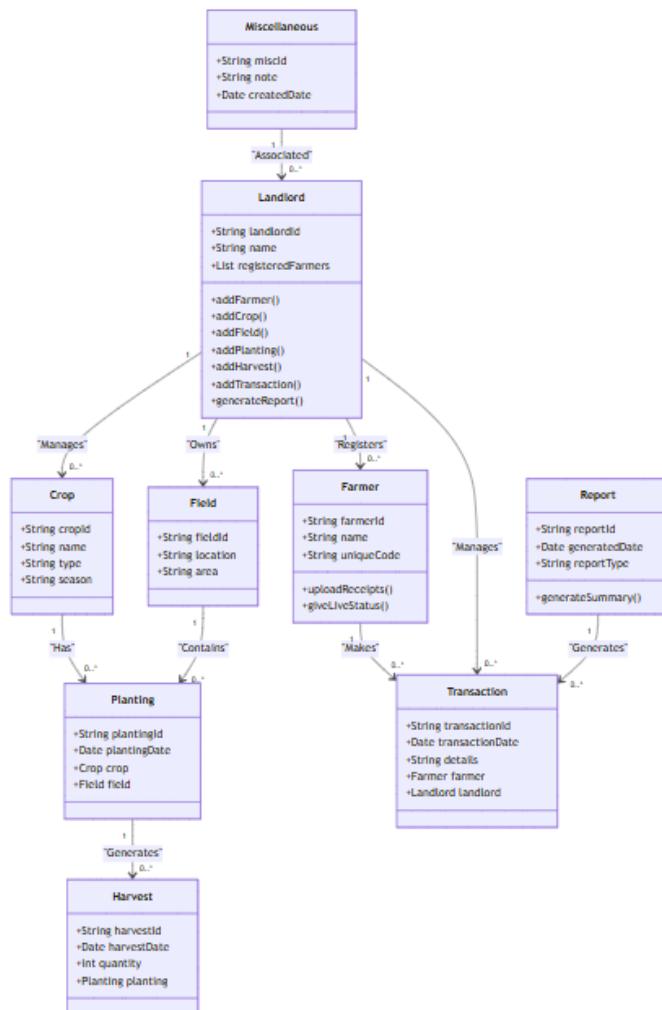


Figure 4.3: Class Diagram

CHAPTER 5

IMPLEMENTATION

5.1 USER INTERFACE

The user interface (UI) of IntelliFarm is constructed to be easy to use, easy to understand and easy for both landlords and farmers using the platform. It gives us a simple UI with full functionality on farm operations management.

Central hub dashboard in the form of a low for an overview of important metrics namely, financial summaries, crop updates and recent activities. The dashboard provides quick access for landlords to add farmers, crops, and fields, and manage financial data. Farmers have an easy path to upload field pictures, submit receipts and check up-to-date farm information.

The design is built with a responsive and clean layout which ensures it is compatible with multiple devices such as smartphones and tablets. For users in rural areas, mobile devices are often the only mode of access, and it's these users who this adaptability is critical for. Navigation menus are clear and give users clear direction to essential features such as report generating and data synchronising.

Readability is improved by the colour scheme (and typography)

and reduced visual fatigue (especially during long use). Icons and buttons are positioned carefully so that even those with very little technical expertise can still benefit from the system.

5.2 SCREENS

The IntelliFarm application includes the following screens. These screens together provide an intuitive interface for users to work on operations in a seamless manner in across a variety of devices:

5.2.1 Account Type Selection Screen

This screen in Figure 5.1 allows the user to select the type of account they will be using: Farmers will select the farmer account and landlords will user the landlord account.

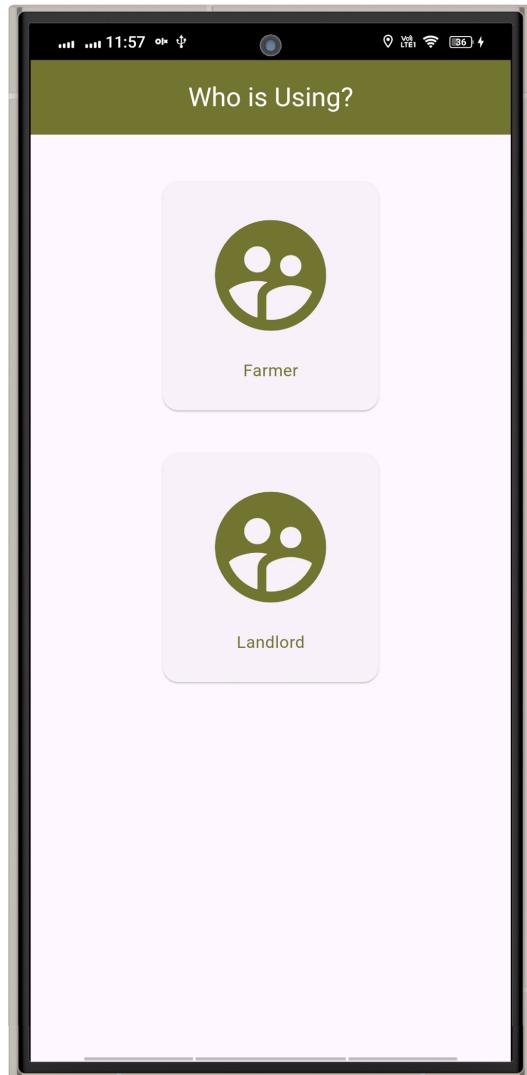


Figure 5.1: Account Type Selection Screen

5.2.2 Farmer Login Page

This screen in Figure 5.2 shows the farmer login screen where the farmer will have to enter a unique 10-digit code generated by their landlord to create an account and be linked to them.

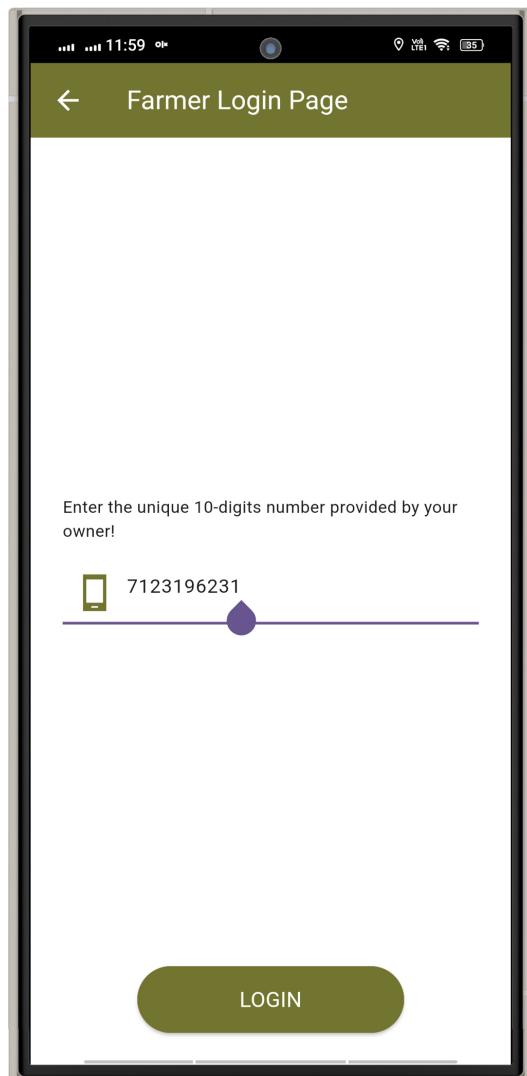


Figure 5.2: Farmer Login Page

5.2.3 Farmer Dashboard

This screen in Figure 5.3 is the menu from which farmers can select the activity they will be performing.

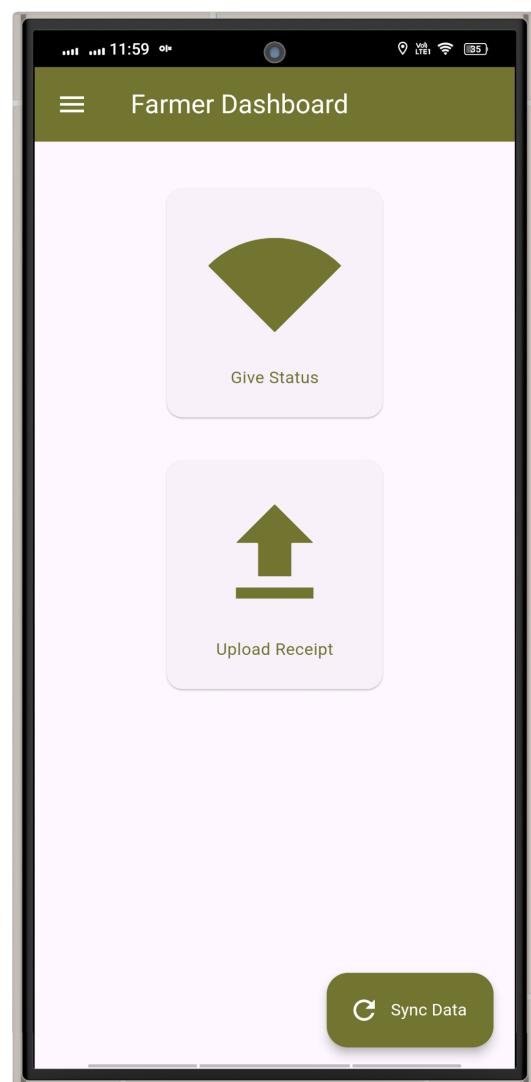


Figure 5.3: Farmer Dashboard

5.2.4 View Status Image Screen

In order to upload a status, farmers are required to use their cameras to take a photo as shown in Figure 5.4.

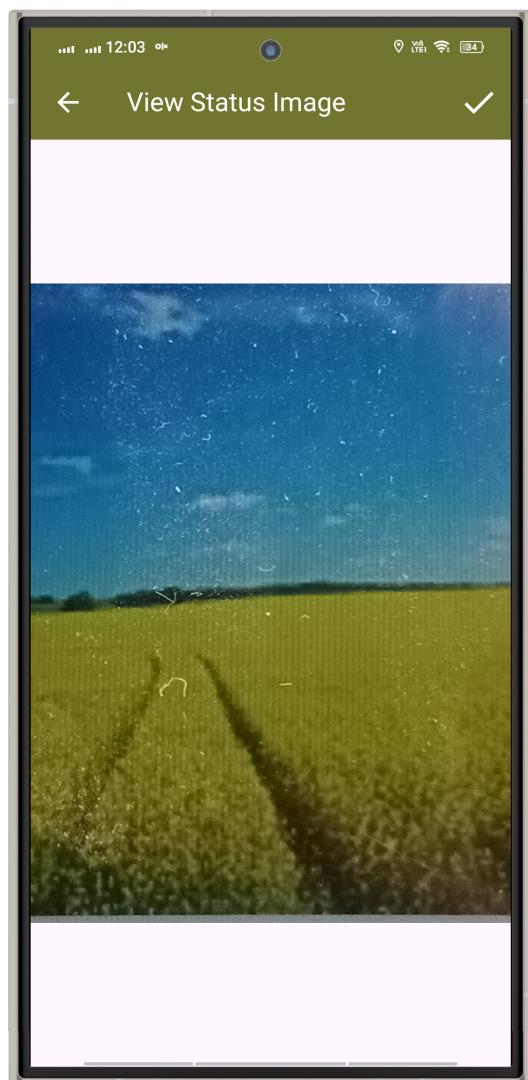


Figure 5.4: View Status Image Screen

5.2.5 Image Selection Screen

In order to upload receipts a farmer must select an image, either from the gallery or use their camera to take a photo as shown in Figure 5.5.

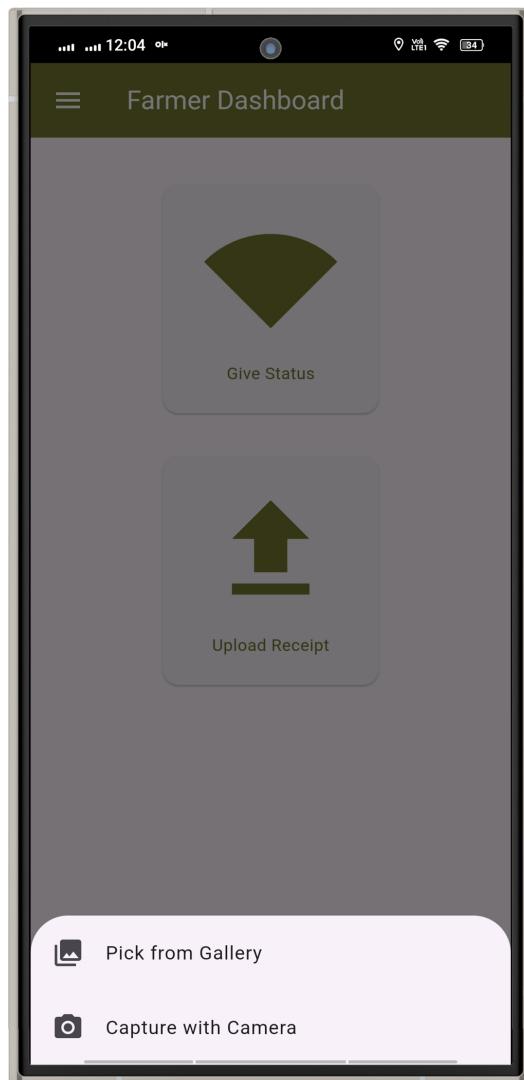


Figure 5.5: Image Selection Screen

5.2.6 Landlord Login Page

The screen displayed in Figure 5.6 is used by the landlord to log into their account using either their phone number or email.

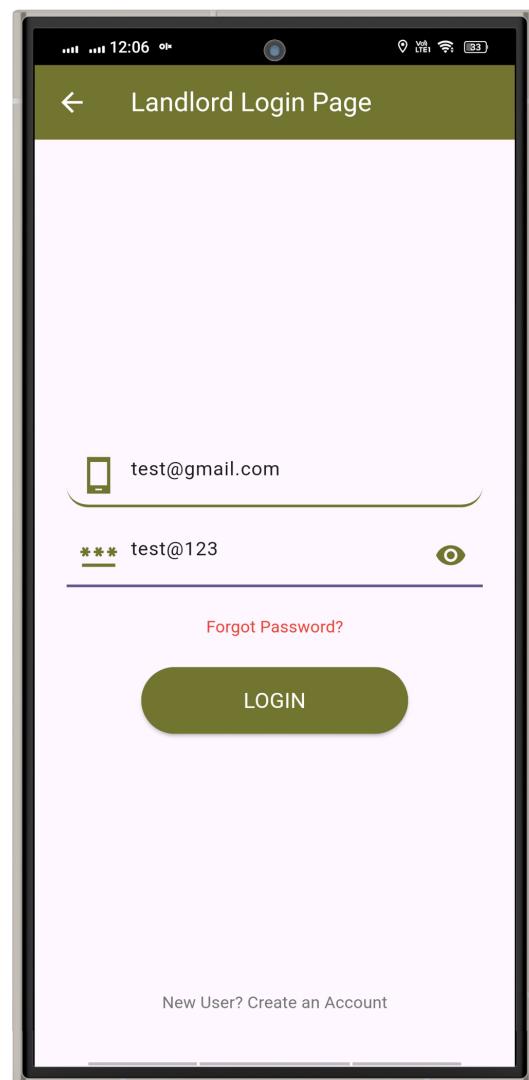


Figure 5.6: Landlord Login Page

5.2.7 Landlord Sign-up Page

The screen depicted in Figure 5.7 allows landlords to create their accounts on the app by entering their phone number, email and password.

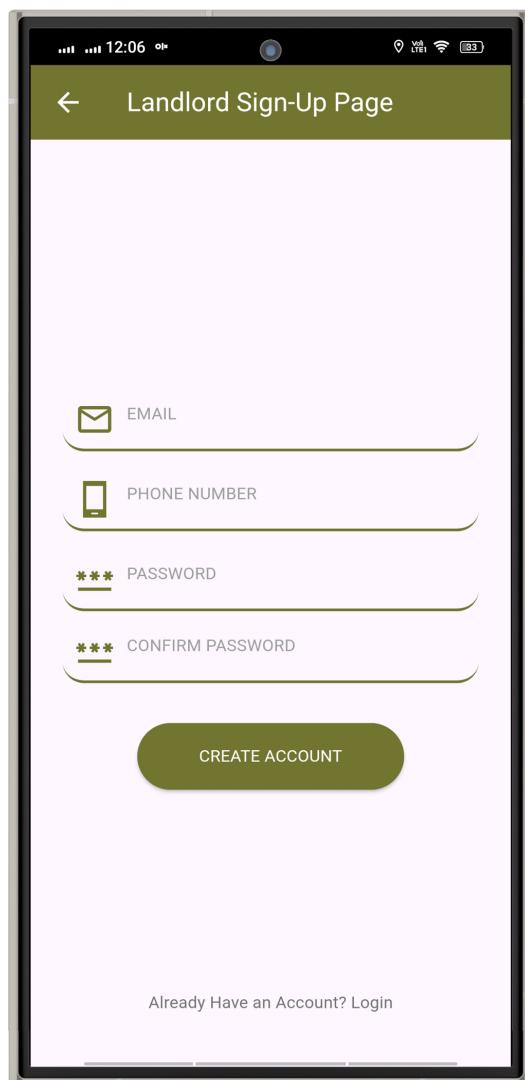


Figure 5.7: Landlord Sign-up Page

5.2.8 Landlord Dashboard

This is the central menu from which landlords can manage the operations of their farm as shown in Figure 5.8.

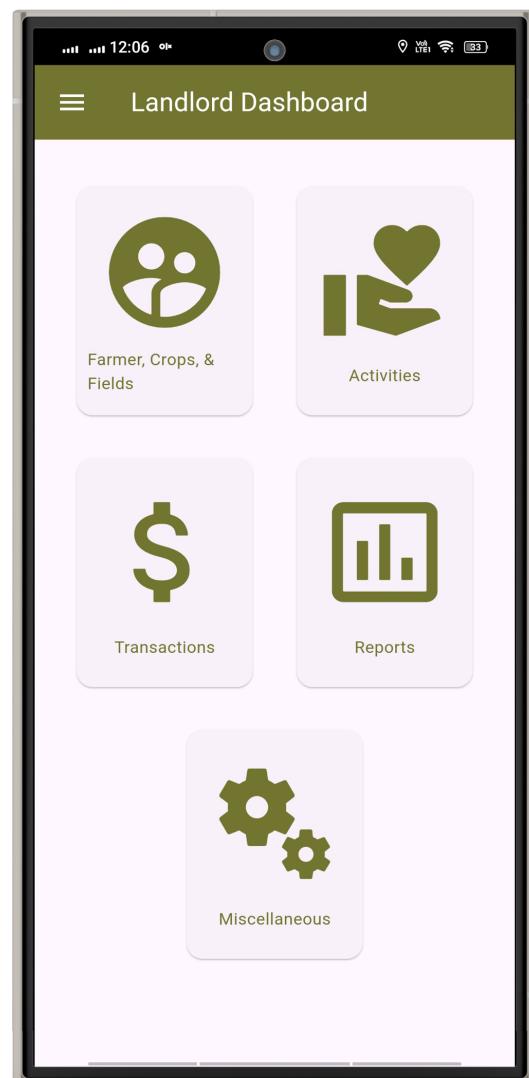


Figure 5.8: Landlord Dashboard

5.2.9 Farmers, Crops & Fields Subscreen

The subscreen shown in Figure 5.9 contains a menu which includes screens related to farmer, crops and their associated fields.

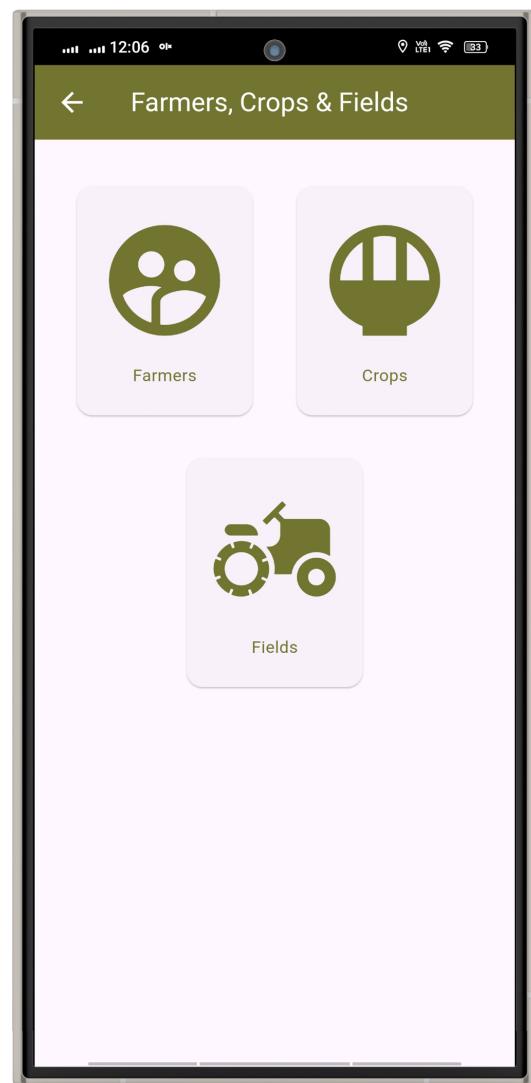


Figure 5.9: Farmers, Crops & Fields Subscreen

5.2.10 Farmer List Screen

The screen depicted in Figure 5.10 is used to show the list of farmers (in addition to their details) that have been linked to a landlord.

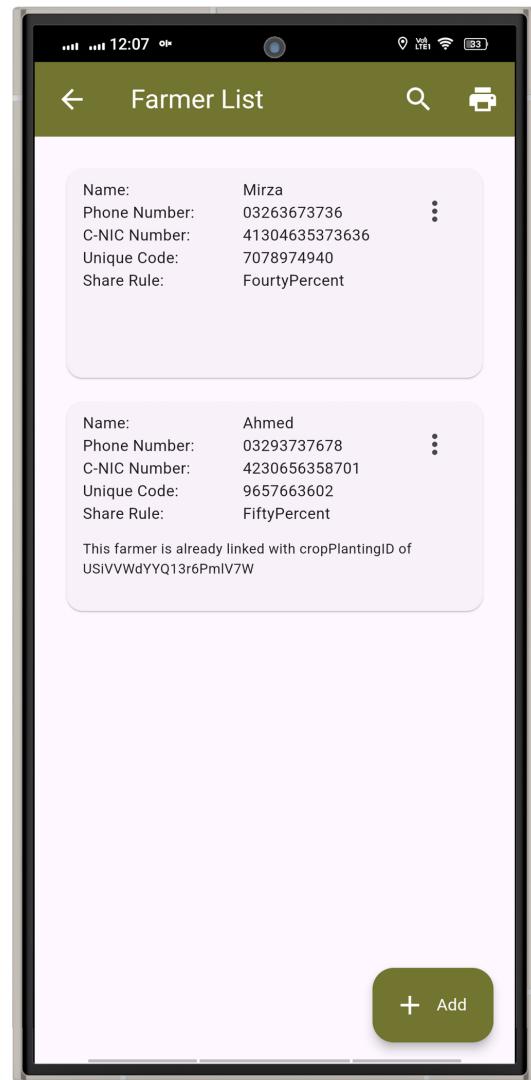


Figure 5.10: Farmer List Screen

5.2.11 Crop List Screen

The screen displayed in Figure 5.11 lists the crops grown on the farm and also shows the unit they will be harvested in alongside the variety of the crop grown as well as all the plantings.

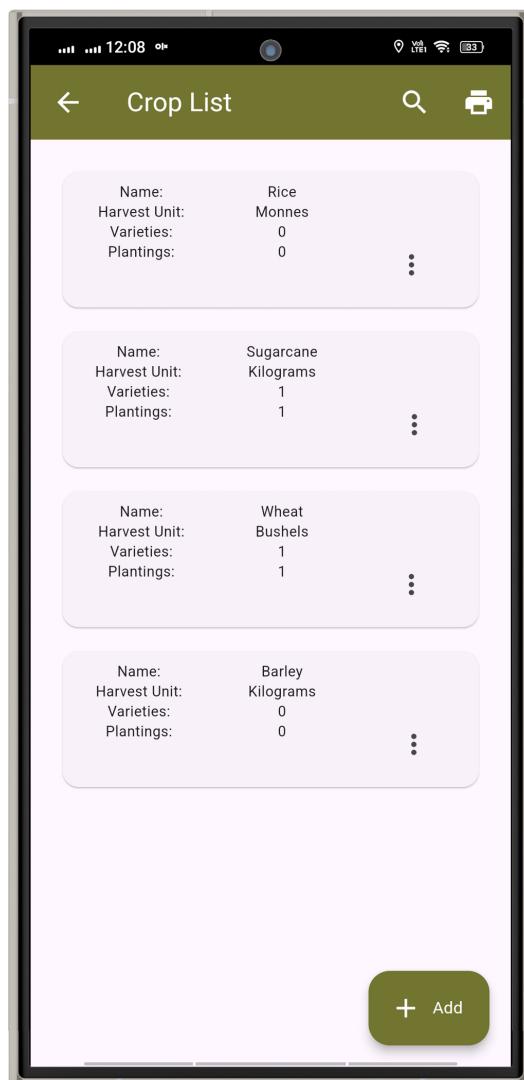


Figure 5.11: Crop List Screen

5.2.12 Add New Crop Screen

The screen shown in Figure 5.12 allows users to define and add new crops to the crop list screen.

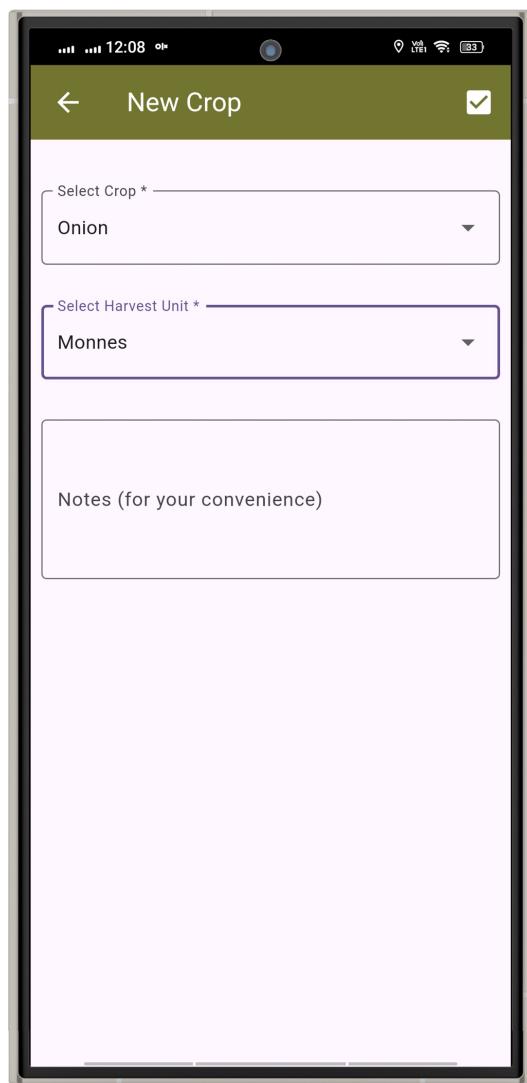


Figure 5.12: Add New Crop Screen

5.2.13 Field List Screen

This screen depicted in Figure 5.13 depicts a list of all fields and their relevant details.

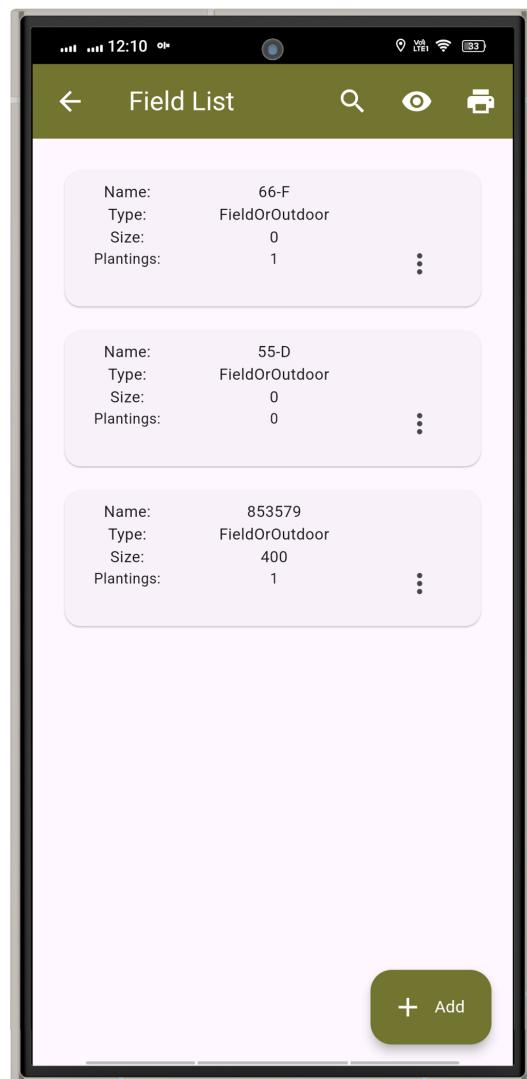


Figure 5.13: Field List Screen

5.2.14 Add New Fields Screen

The screen displayed in Figure 5.14 is used to add new fields to the field list screen.

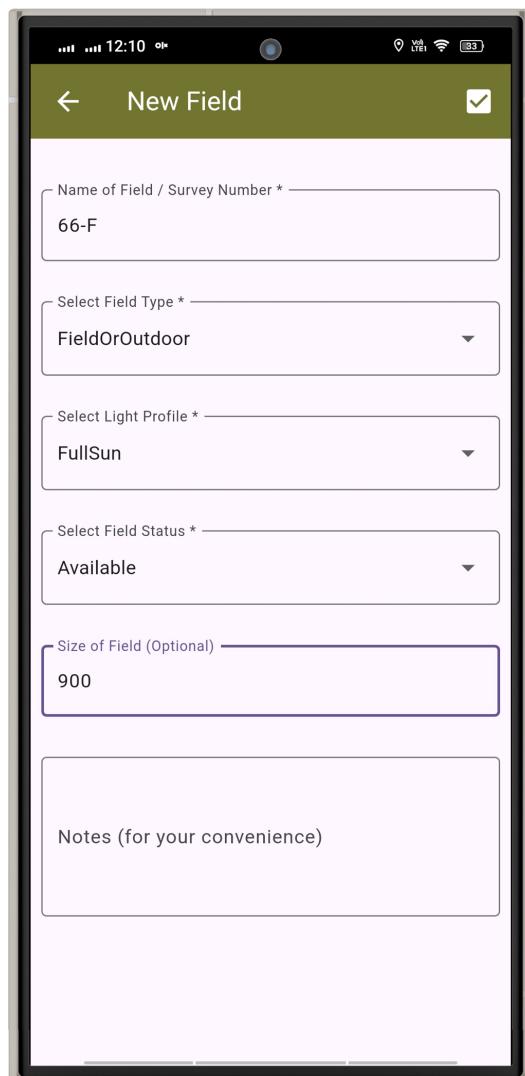


Figure 5.14: Add New Fields Screen

5.2.15 Treatment List Screen

The screen shown in Figure 5.15 is used to note down and list all the treatments carried out on a field.

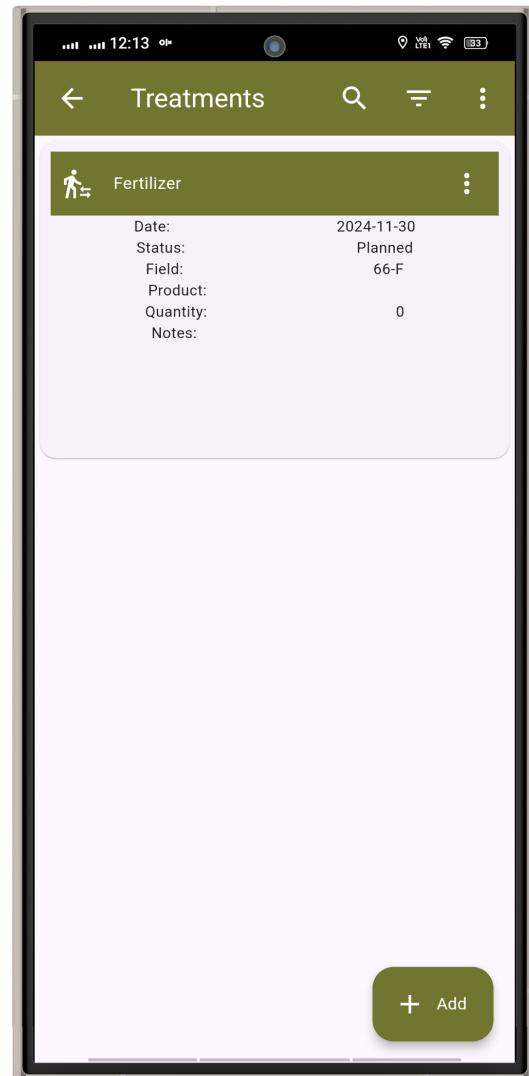


Figure 5.15: Treatment List Screen

5.2.16 Add Treatment Screen

The screen depicted in Figure 5.16 is used to add new treatments to the treatments list screen.

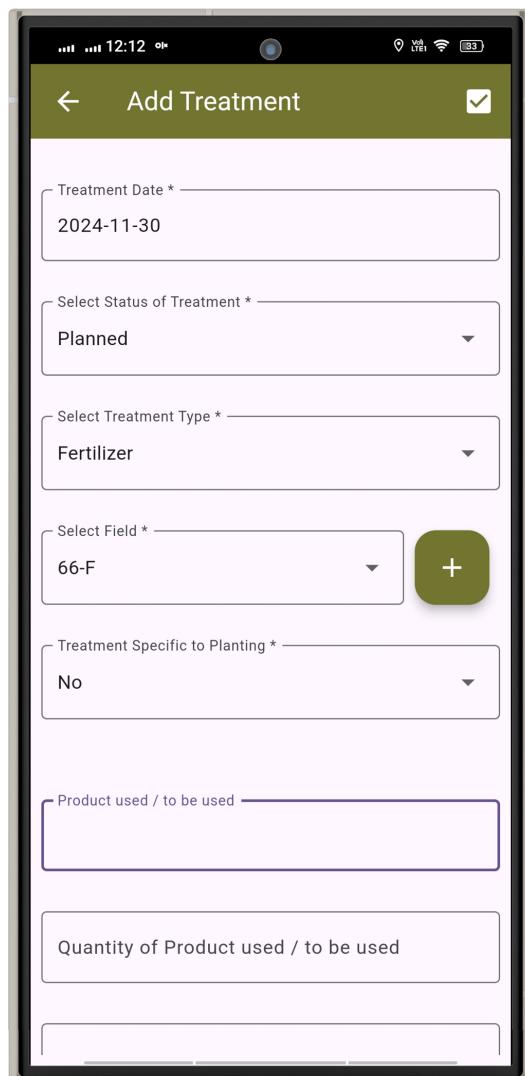


Figure 5.16: Add Treatment Screen

5.2.17 Transaction List Screen

The goal of this screen is to list all of the expenses of growing each crop such as costs of fuel for tractors, pesticide and fertilizer costs etc. as shown in Figure 5.17.

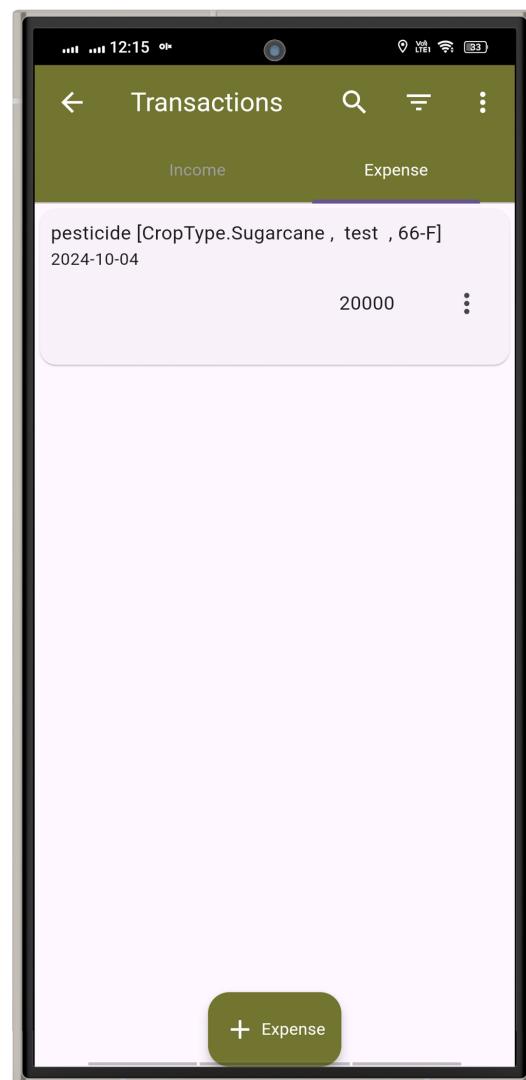


Figure 5.17: Transaction List Screen

5.2.18 Add New Expense Screen

The screen seen in Figure 5.18 allows users to add additional expenses to the transactions screen.

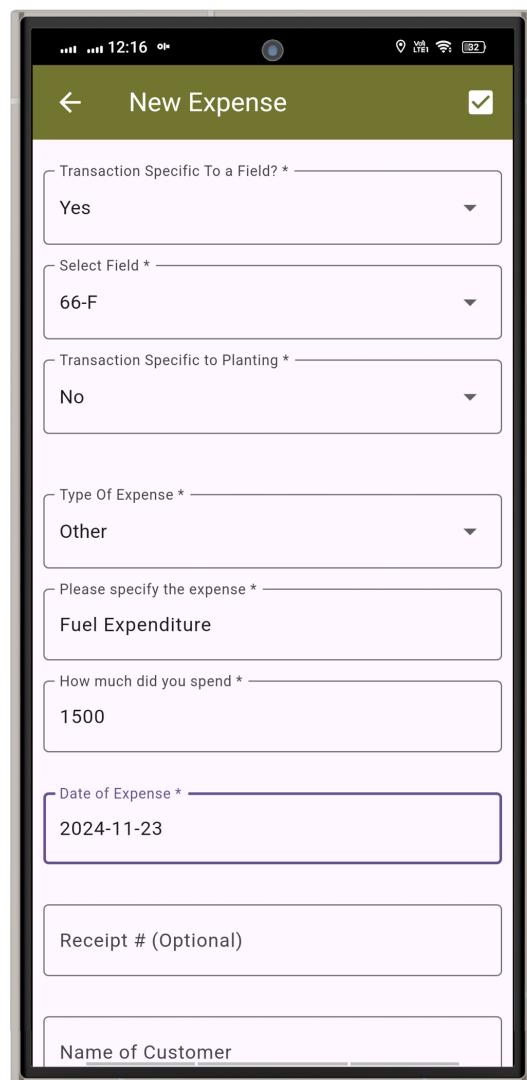


Figure 5.18: Add New Expense Screen

5.2.19 Plantings List Screen

This screen represents the plantings of each crop as shown in Figure 5.19.

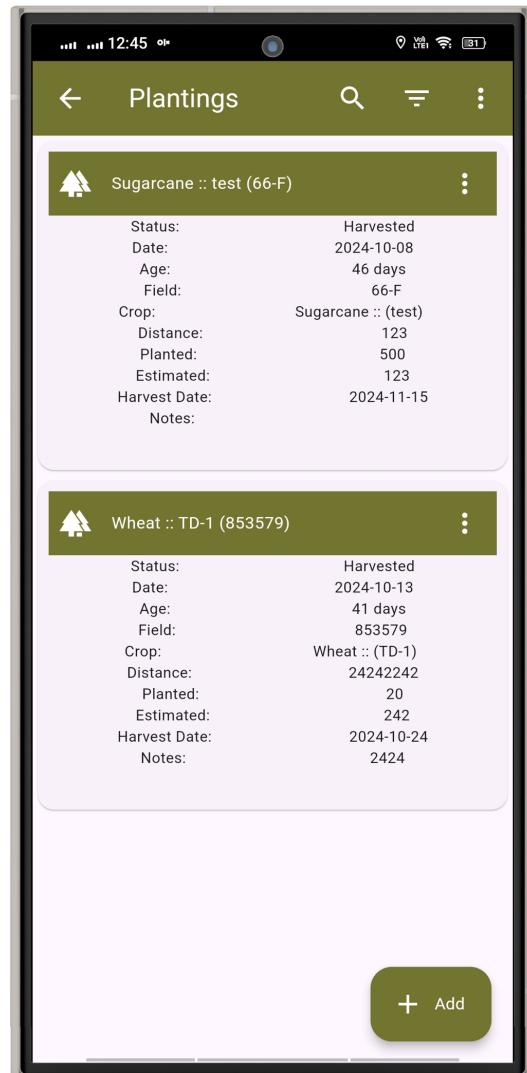


Figure 5.19: Plantings List Screen

5.2.20 Add New Plantings Screen

The screen shown in Figure 5.20 is used to add new plantings of a particular crop.

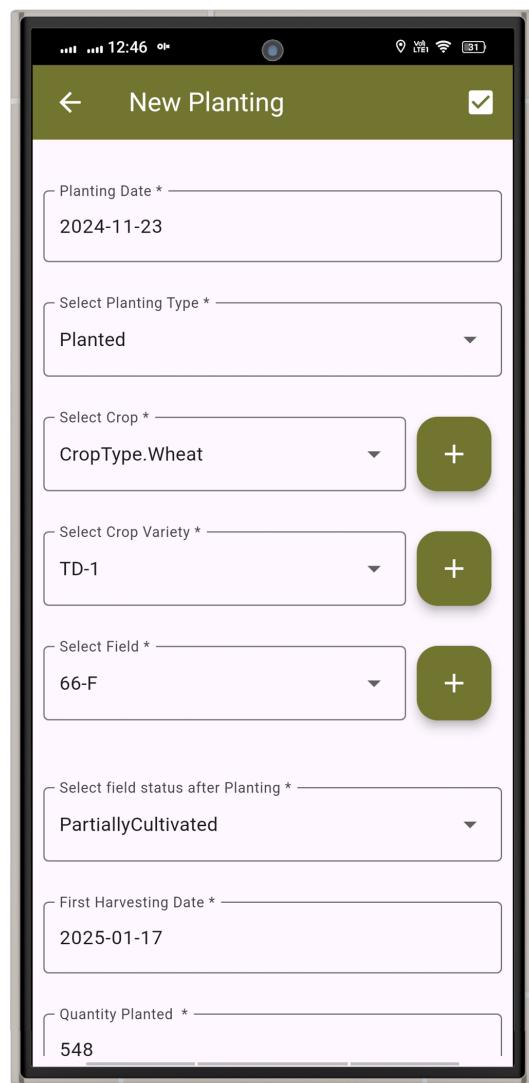


Figure 5.20: Add New Plantings Screen

5.2.21 Crop Status Screen

The screen depicted in Figure 5.21 is used to represent the status of each field growing a particular crop.

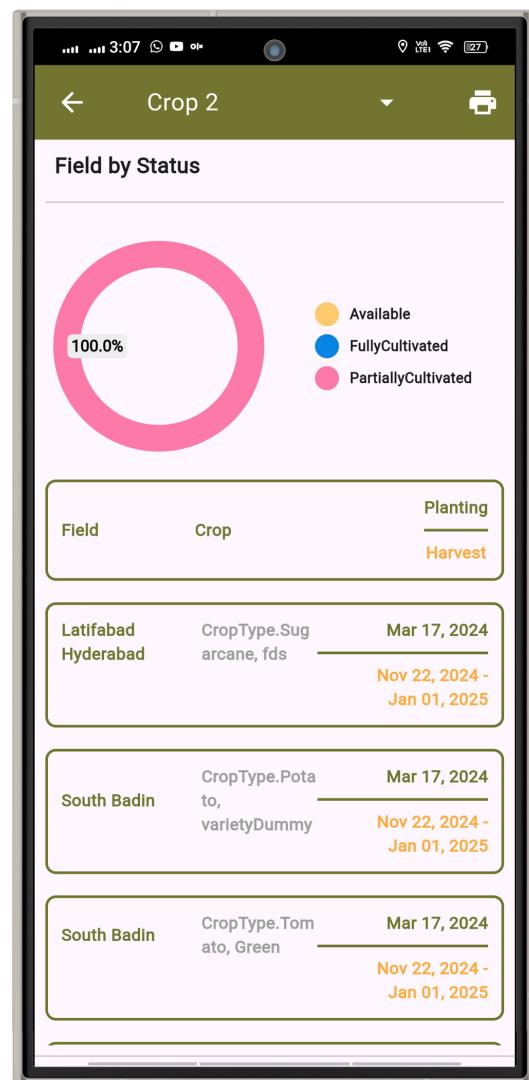


Figure 5.21: Crop Status Screen

5.2.22 Field Profitability Report Screen

The screen displayed in Figure 5.22 generates a report of income, expenditure and net profit from each field.

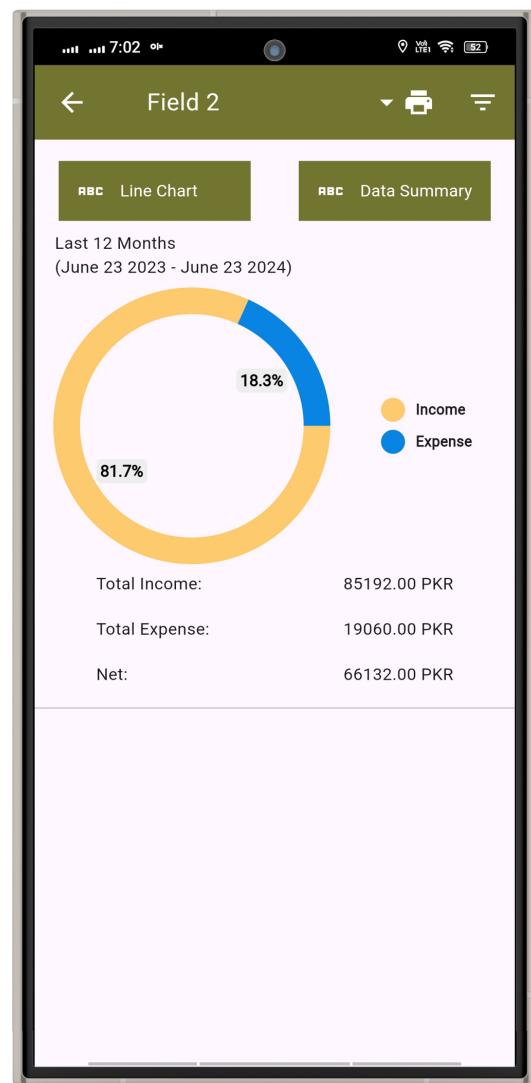


Figure 5.22: Field Profitability Report Screen

5.2.23 Tasks Screen

The screen in Figure 5.23 depicts the tasks that must be completed on each field such as using tractor, pesticides, fertilizer etc.

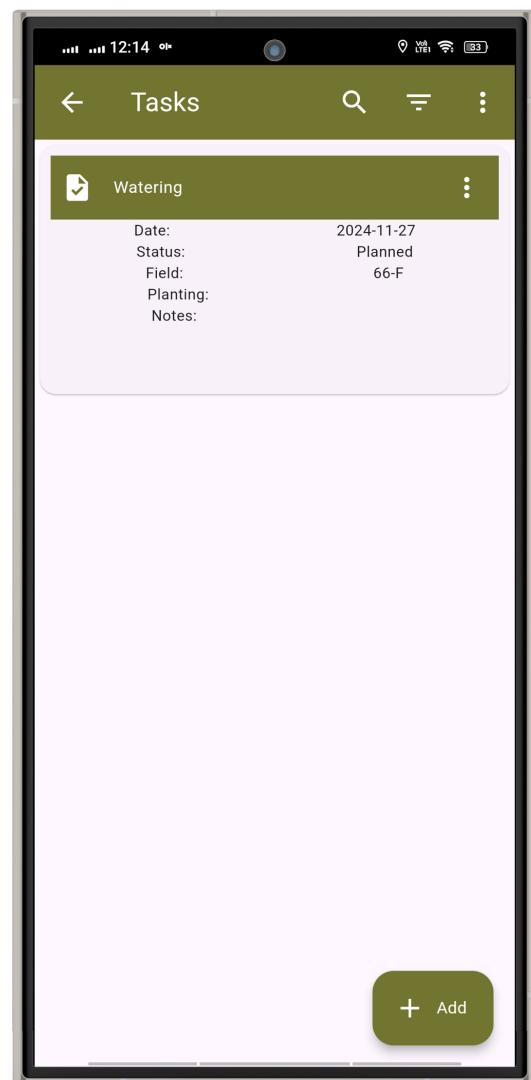


Figure 5.23: Tasks Screen

5.2.24 Add New Task Screen

The purpose of this screen is to allow user to add new tasks to the tasks screen that must be carried out with regards to the field as shown in Figure 5.24.

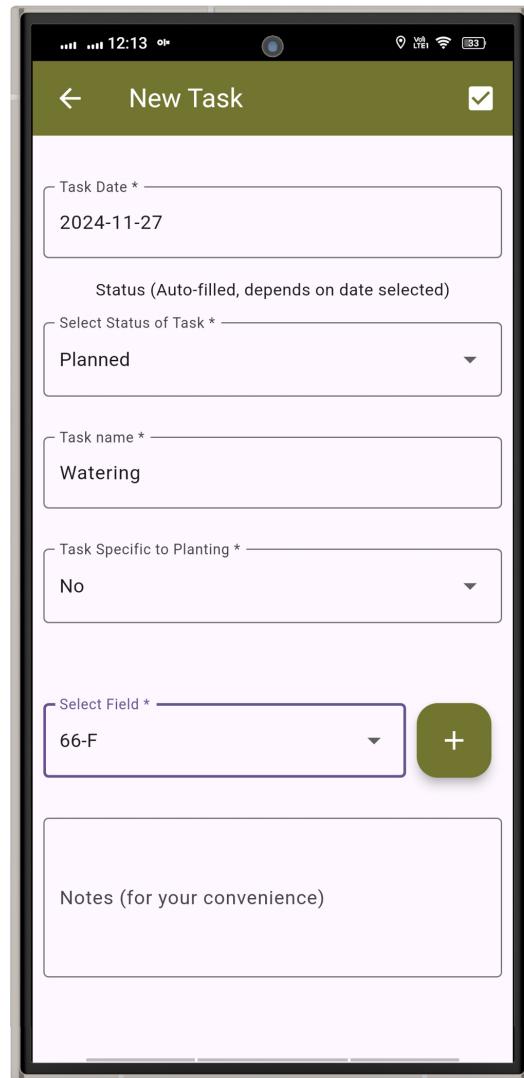


Figure 5.24: Add New Task Screen

5.2.25 Report Selection Screen

The screen in Figure 5.25 is essentially used to select the kind of report a landlord wants to generate.

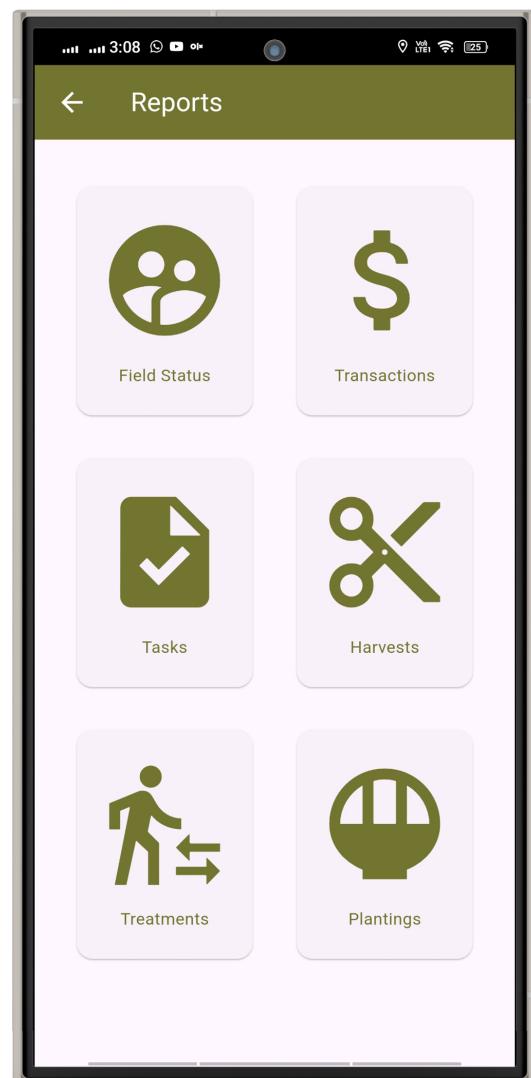


Figure 5.25: Report Selection Screen

5.2.26 Miscellaneous / Transaction Categories Screen

The screen in Figure 5.26 allows landlords to specify the category of transaction that they are going to make.

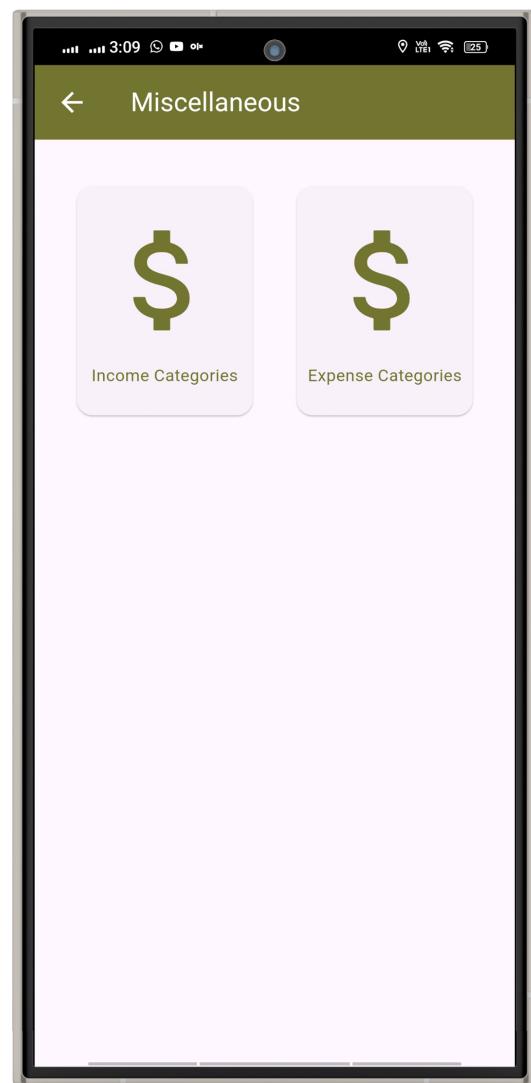


Figure 5.26: Miscellaneous / Transaction Categories Screen

CHAPTER 6

TESTING

6.1 INTRODUCTION

During our testing of IntelliFarm, we assessed the system to check how it functioned, and whether it was reliable and would be a good user experience. It is critical to this phase of building the platform as all of these objectives are met via the platform. All important features were tested comprehensively for issues and performance validation to identify and address problems and prove the performance.

The testing process methodologies and the test cases designed to test various scenarios are discussed in this chapter along with the observed outcomes. IntelliFarm's ability to deliver an efficient, reliable farm management solution is demonstrated through the results provided, and these results point the way for both weaknesses and strengths which can be refined in the future. The chapter further highlights consistency between the testing outcomes and the project's goals of modernising farmland management and increasing operational efficiency for landlords and farmers.

6.2 TEST OBJECTIVES & GOALS

The testing phase of IntelliFarm was guided by specific objectives and goals to ensure the platform meets its functional and non-functional requirements. These objectives were designed to validate the system's performance, reliability, and usability in real-world scenarios.

- To confirm that IntelliFarm provides a centralized, user-friendly platform for managing farmland activities.
- To ensure the system operates effectively in offline and online modes, maintaining data consistency across devices and sessions.
- To guarantee that financial reports generated by the system are comprehensive, accurate, and customizable to meet user needs.
- To identify and address any bugs, inconsistencies, or bottlenecks in the system before deployment.
- To validate that the system adheres to its design principles, offering a scalable and reliable solution for landlords and tenant farmers.

By achieving these objectives and goals, the testing phase ensures that IntelliFarm is well-equipped to deliver a robust, efficient, and

reliable farm management solution.

6.3 FUNCTIONAL TESTING

Functional testing for IntelliFarm was conducted to ensure that all implemented features perform as expected and meet all of the specified requirements. This phase involves validating individual components and their integration into the system by designing test cases, all of which are grouped under the relevant test suite which deal with specific functions. Below are the key areas tested:

- Farmer Authentication
- Landowner Authentication
- Add Crops
- Add Farmers
- Add Fields
- Add Crop Plantings
- Add Crop Variety
- Add Harvests
- Add Transactions
- Generate Reports & Download

6.3.1 Farmer Authentication

Table 6.1 shows the Test Suite associated with farmer authentication while Table 6.2 shows all the test cases with their respective results.

Table 6.1: Test Suite - Farmer Authentication

Test Case ID	Title	Description	Preconditions	Postconditions
TC10-1	Farmer Login with Valid Unique Code	Validate that a farmer can log in using a valid unique code.	The farmer is registered in the system and assigned a 10-digit unique code by the landlord.	The farmer is logged in and redirected to their dashboard.
TC10-2	Restrict Login for Invalid Unique Code	Ensure the system rejects login attempts with an invalid unique code.	The farmer enters an incorrect unique code.	An error message is displayed, and the login is unsuccessful.
TC10-3	Restrict Login for Incorrect Code Length	Verify that the system rejects unique codes that are not exactly 10 digits long.	The farmer enters a code that is shorter or longer than 10 digits.	An error message is displayed, and the login is unsuccessful.

Table 6.2: Test Cases - Farmer Authentication

S/N	Input	Expected Outcome	Actual Outcome	Test Result (Pass/Fail)
1	Unique Code: 1234567890	Farmer logs in successfully and is redirected to their dashboard.	Farmer logged in successfully and was redirected to their dashboard.	Pass
2	Unique Code: 9876543211 (not assigned)	Error message: "Invalid unique code. Please try again."	Error message: "Invalid unique code. Please try again." Was displayed.	Pass
3	Unique Code: 12345	Error message: "Unique code must be exactly 10 digits."	Error message: "Unique code must be exactly 10 digits." Was displayed.	Pass

6.3.2 Landowner Authentication

Table 6.3 shows the Test Suite associated with landowner authentication while Table 6.4 shows all of the test cases along with their respective results.

Table 6.3: Test Suite - Landowner Authentication

Test Case ID	Title	Description	Preconditions	Postconditions
TC9-1	Landowner Signup with Valid Data	Ensure a landowner can successfully sign up with valid credentials.	The user is on the Sign Up screen.	The account is created, and the user is redirected to the dashboard.
TC9-2	Landowner Login with Valid Data	Validate the landowner can log in with correct credentials.	The user is registered and on the Login screen.	The user is logged in and redirected to the dashboard.
TC9-3	Handle Invalid Login Attempts	Verify the system displays appropriate error messages for invalid login credentials.	The user attempts to log in with incorrect credentials.	An error message is displayed.

Table 6.4: Test Cases - Landowner Authentication

S/N	Input	Expected Outcome	Actual Outcome	Test Result (Pass/Fail)
1	Name: Ali, Email: ali@gmail.com, Password: Strong123	Account is created, and the user is redirected to the dashboard.	Account was created, and the user was redirected to the dashboard.	Pass
2	Email: ali@gmail.com, Password: WrongPass	Error message: "Invalid credentials. Please try again."	Error message: "Invalid credentials. Please try again." was displayed.	Pass
3	Login with Remember Me Checked	User remains logged in for subsequent sessions.	User remained logged in for subsequent sessions.	Pass

6.3.3 Add Crops

Table 6.5 shows the Test Suite associated with adding crops while Table 6.6 shows all of the test cases with their respective results.

Table 6.5: Test Suite - Add Crops

Test Case ID	Title	Description	Preconditions	Postconditions
TC1-1	Add Crop with Valid Data	Validate that the user can successfully add a crop using valid input for crop name, harvest unit, and optional notes.	The user is logged in as a landlord and on the Add Crops screen.	The crop is added to the database and appears in the crop list.
TC1-2	Add Crop with Missing Data	Verify the system displays an error when required fields are missing.	The user is logged in as a landlord and on the Add Crops screen.	An error message is shown; the crop is not added.
TC1-3	Add Duplicate Crop Name	Ensure that the system flags a duplicate crop name for the same landlord.	The user is logged in as a landlord and a crop with the same name already exists.	An error message is displayed, and the crop is not added.

Table 6.6: Test Cases - Add Crops

S/N	Input	Expected Outcome	Actual Outcome	Test Result (Pass/Fail)
1	Crop Name: Wheat, Harvest Unit: kg, Notes: Optional	The crop "Wheat" is added and appears in the crop list.	The crop "Wheat" was added and appeared in the crop list.	Pass
2	Crop Name: [Empty], Harvest Unit: [Empty]	Error message: "Please fill all required fields."	Error message: "Please fill all required fields." was displayed.	Pass
3	Crop Name: Wheat (already exists), Harvest Unit: kg	Error message: "Crop name already exists."	Error message: "Crop name already exists." was displayed.	Pass

6.3.4 Add Farmers

Table 6.7 shows the Test Suite associated with adding farmers while Table 6.8 shows all of the test cases along with their respective results.

Table 6.7: Test Suite - Add Farmers

Test Case ID	Title	Description	Preconditions	Postconditions
TC2-1	Add Farmer with Valid Data	Validate that the user can successfully add a farmer using valid input for every field.	The user is logged in as a landlord and on the Add Farmers screen.	The farmer is added to the database and appears in the farmer list.
TC2-2	Add Farmer without Association	Verify that the system restricts adding farmers without landlord association.	The user is logged in but not associated with any landlord profile.	The system displays an error, and the farmer is not added.
TC2-3	Add Farmer with Invalid Phone	Ensure the system flags invalid phone number formats.	The user is logged in as a landlord and on the Add Farmers screen.	The system shows an error message for invalid format.

Table 6.8: Test Cases - Add Farmers

S/N	Input	Expected Outcome	Actual Outcome	Test Result (Pass/Fail)
1	Farmer Name: Ali, Phone: 03001234567, Share Rule: 50%, CNIC: Optional	The farmer "Ali" is added successfully and appears in the farmer list.	The farmer "Ali" was added successfully and appeared in the farmer list.	Pass
2	Farmer Name: Ahmed, Phone: 03001234567	Error message: "Landlord association required."	Error message: "Landlord association required." Was displayed.	Pass
3	Farmer Name: Sana, Phone: 12345	Error message: "Invalid phone number format."	Error message: "Invalid phone number format." Was displayed.	Pass

6.3.5 Add Fields

Table 6.9 shows the Test Suite associated with adding fields while Table 6.10 shows all of the test cases along with their respective results.

Table 6.9: Test Suite - Add Fields

Test Case ID	Title	Description	Preconditions	Postconditions
TC3-1	Add Field with Valid Data	Validate the user can add a field using field name, field type, field status, size of field, and notes.	The user is logged in as a landlord and on the Add Fields screen.	The field is added to the database and appears in the field list.
TC3-2	Upload Image for Field	Ensure the system allows uploading an image while adding a field.	The user is on the Add Fields screen.	The uploaded image is saved and linked to the field.
TC3-3	Avoid Duplicate Field Names	Validate that duplicate field names under the same landlord are not allowed.	A field with the same name exists under the landlord's profile.	An error message is displayed, and the field is not added.

Table 6.10: Test Cases - Add Fields

S/N	Input	Expected Outcome	Actual Outcome	Test Result (Pass/Fail)
1	Field Name: West Plot, Type: Fertile, Status: Active, Size: 10 acres	The field is successfully added and appears in the field list.	The field was successfully added and appeared in the field list.	Pass
2	Field Name: East Plot, Upload Image: "field.jpg"	The field and its image are added successfully.	The field and its image were added successfully.	Pass
3	Field Name: West Plot (already exists)	Error message: "Field name already exists under your profile."	Error message: "Field name already exists under your profile." Was displayed.	Pass

6.3.6 Add Crop Plantings

Table 6.11 shows the Test Suite associated with adding crop plantings while Table 6.12 shows all of the test cases along with their respective results.

Table 6.11: Test Suite - Add Crop Plantings

Test Case ID	Title	Description	Preconditions	Postconditions
TC4-1	Add Valid Crop Planting	Validate successful addition of crop planting linked to a specific field.	The user is logged in as a landlord and on the Add Crop Plantings screen.	The crop planting is added to the database and appears in the planting list.
TC4-2	Avoid Duplicate Planting Records	Ensure the system prevents duplicate planting records for overlapping dates in the same field.	A planting with the same field and overlapping date exists.	An error message is displayed, and the planting is not added.
TC4-3	Validate Planting Data Storage	Check that planting data is accurately stored in Firestore.	The user has added planting data.	Data appears correctly in the database and reports.

Table 6.12: Test Cases - Add Crop Plantings

S/N	Input	Expected Outcome	Actual Outcome	Test Result (Pass/Fail)
1	Field: East Plot, Crop: Wheat, Dates: 2024-01-01 to 2024-02-28	Planting is added and appears in the planting list.	Planting was added and appeared in the planting list.	Pass
2	Field: East Plot, Crop: Wheat, Dates: 2024-01-15 to 2024-02-15	Error message: "Duplicate planting record for overlapping dates."	Error message: "Duplicate planting record for overlapping dates." Was displayed.	Pass
3	Add Planting Data and View in Firestore	Data is correctly stored and accessible in Firestore reports.	Data was correctly stored and was accessible in Firestore reports.	Pass

6.3.7 Add Crop Variety

Table 6.13 shows the Test Suite associated with adding crop variety while Table 6.14 shows all of the test cases along with their respective results.

Table 6.13: Test Suite - Add Crop Variety

Test Case ID	Title	Description	Preconditions	Postconditions
TC5-1	Add Crop Variety after Selecting Crop	Validate that crop variety can only be added after selecting a crop.	The user is logged in as a landlord and on the Add Crop Variety screen.	The crop variety is added to the database and appears in the variety dropdown.
TC5-2	Ensure Variety Name Uniqueness	Verify that duplicate variety names under the same crop are not allowed.	A variety with the same name exists under the crop.	An error message is displayed, and the variety is not added.
TC5-3	Confirm Display of Added Variety	Check that the newly added variety appears in the variety dropdown in related screens.	The user has added a new variety.	The variety appears in all relevant screens.

Table 6.14: Test Cases - Add Crop Variety

S/N	Input	Expected Outcome	Actual Outcome	Test Result (Pass/Fail)
1	Crop: Wheat, Variety Name: IRRI-6	The variety "IRRI-6" is added successfully and appears in the dropdown.	The variety "IRRI-6" was added successfully and appeared in the dropdown.	Pass
2	Crop: Wheat, Variety Name: IRRI-6 (exists)	Error message: "Variety name already exists under this crop."	Error message: "Variety name already exists under this crop." Was displayed.	Pass
3	View Drop- down After Adding Variety	Newly added variety is visible in all relevant variety dropdowns.	Newly added variety was visible in all relevant variety dropdowns.	Pass

6.3.8 Add Harvests

Table 6.15 shows the Test Suite associated with adding harvests while Table 6.16 shows all of the test cases along with their respective results.

Table 6.15: Test Suite - Add Harvests

Test Case ID	Title	Description	Preconditions	Postconditions
TC6-1	Add Harvest with Valid Data	Validate that a harvest can be added for a specific planting.	The user is logged in as a landlord and on the Add Harvests screen.	The harvest is added and appears in reports.
TC6-2	Mandatory Fields for Harvest	Ensure that quantity and date are mandatory for adding a harvest.	The user attempts to add a harvest without providing mandatory fields.	An error message is displayed, and the harvest is not added.
TC6-3	Cumulative Harvest Data	Check for the correct display of cumulative harvest data in reports.	Multiple harvests have been added.	Cumulative data appears accurately in reports.

Table 6.16: Test Cases - Add Harvests

S/N	Input	Expected Outcome	Actual Outcome	Test Result (Pass/Fail)
1	Planting: Wheat, Quantity: 500 kg, Date: 2024-01-01	Harvest is added successfully.	Harvest was added successfully.	Pass
2	Planting: Wheat, Quantity: [Empty], Date: 2024-01-01	Error message: "Please provide mandatory fields."	Error message: "Please provide mandatory fields." Was displayed.	Pass
3	Add Multiple Harvests and View Reports	Reports display accurate cumulative data.	Reports displayed accurate cumulative data.	Pass

6.3.9 Add Transactions

Table 6.17 shows the Test Suite associated with farmer authentication while Table 6.18 shows all of the test cases along with their respective results.

Table 6.17: Test Suite - Add Transactions

Test Case ID	Title	Description	Preconditions	Postconditions
TC7-1	Add Transaction with Valid Data	Validate that income or expense transactions can be added for a specific crop or field.	The user is logged in as a landlord and on the Add Transactions screen.	The transaction is added and reflected in reports.
TC7-2	Validate Mandatory Fields	Ensure the system requires amount, transaction type, and date to add a transaction.	The user attempts to add a transaction without filling mandatory fields.	An error message is displayed, and the transaction is not added.
TC7-3	Categorize Transaction by Type	Check if the system correctly categorizes transactions as income or expense based on transaction type.	Transactions of both types (income and expense) are added.	Transactions appear under their respective categories.

Table 6.18: Test Cases - Add Transactions

S/N	Input	Expected Outcome	Actual Outcome	Test Result (Pass/Fail)
1	Crop: Wheat, Type: Income, Amount: 1000, Date: 2024-01-01	Transaction is added and reflects in reports under income.	Transaction was added and was reflected in reports under income.	Pass
2	Field: West Plot, Type: Expense, Amount: [Empty]	Error message: "Please provide all required fields."	Error message: "Please provide all required fields." Was displayed.	Pass
3	Crop: Wheat, Add Income and Expense Transactions	Transactions are categorized and displayed in the respective sections of the report.	Transactions were categorized and displayed in the respective sections of the report.	Pass

6.3.10 Generate Reports & Download

Table 6.19 shows the Test Suite associated with report generation and download while Table 6.20 shows all of the test cases along with their respective results.

Table 6.19: Test Suite - Generate Reports & Download

Test Case ID	Title	Description	Preconditions	Postconditions
TC8-1	Generate Filtered Reports	Validate that reports can be generated based on filtered criteria like date range or crop.	The user is logged in as a landlord and on the Reports screen.	The report is generated successfully.
TC8-2	Download Reports as PDF	Ensure the user can download the report in PDF format.	The user has generated a report.	The report is downloaded successfully.
TC8-3	Validate Report Accuracy	Check if the downloaded report maintains accurate data formatting and structure.	The user has downloaded a report.	The report is accurate and correctly formatted.

Table 6.20: Test Cases - Generate Reports & Download

S/N	Input	Expected Outcome	Actual Outcome	Test Result (Pass/Fail)
1	Filter by Date: 2024-01-01 to 2024-02-01	A filtered report is generated displaying relevant transactions.	A filtered report was generated which displayed relevant transactions.	Pass
2	Click Download Button for Generated Report	Report is downloaded in PDF format.	Report was downloaded in PDF format.	Pass
3	Open Down-loaded Report	Report displays correct data, structure, and formatting.	Report displayed correct data, structure, and formatting.	Pass

CHAPTER 7

CONCLUSION & FUTURE WORK

7.1 CONCLUSION

IntelliFarm project represents a significant step change over traditional farm management. The platform powers the Agriculture and Technology intersection, modernising the practice of agriculture that has been hindered by outdated practices when it comes to operational efficiency and landlord and farmer communication. An example of such an offering is IntelliFarm which has conjured a centralised system with technologies such as Flutter for the mobile interface, Java for the desktop application, and Firebase to manage the database making it all a robust solution catered to the specific needs of stakeholders in the agricultural sector.

Digitalizing and consolidating previously disparate data management processes is one of the most critical achievements of this project. IntelliFarm has achieved this through a unified platform that enables the tracking, record-keeping and analysis of crop yields, input usage, financial transactions, and much more. The centralization eliminates the niggles otherwise associated with manual keeping of records, improves data accuracy and helps landlords to take advantage of better

resource allocation and land utilisation.

IntelliFarm is another core feature that's able to help close the communication gap between landlords and tenant farmers. Real-time messaging and task managing is the capability in which it fosters the transparency and collaboration between both parties who are assigned in their joint efforts to optimise their productivity. IntelliFarm enables landlord-tenant direct communication and centralised oversight, eliminating conflicts and misunderstandings between landlords and tenants.

Improving operational efficiency is just part of what IntelliFarm does. The platform refers to financial tracking and fraud prevention mechanisms to enhance accountability and compel tenant farmers and other stakeholders to act in an honourable manner. Online verification tools integrated with the platform enable landlords to monitor transactions online, approving the same in real-time, cutting down corruption and introducing a culture of transparency.

From this broader perspective, IntelliFarm looks at the systemic inefficiencies that have plagued Pakistan's agricultural sector for a long time. Through its modernization of traditional practices, the platform is in step with international efforts to facilitate sustainable farming, raise food security, and improve economic returns for

all the players in the agricultural value chain. In addition, the platform features a user-friendly interface with an accessible design, thus bridging the digital divide in rural areas, and enabling techno-less users as well to adopt the platform without requiring any technological knowledge.

In addition, IntelliFarm is more than a technological solution, rather it is a strategic enabler to growth, sustainability, as well as modernisation in the agriculture industry. With a strong focus on solving the biggest problems in data storage, poor communication, and resource mismanagement, IntelliFarm creates a foundation for a more productive and pleasant future for agriculture. This is the potential of technology — of application of thought — to revolutionise an important industry such as agriculture, and how innovation applied appropriately can have transformative results. The evolution of IntelliFarm as it pursues sustainability in agriculture, continues to be a pillar of driving sustainable agricultural practises, economic resilience, and a collaborative farming ecosystem.

7.2 FUTURE WORK

IntelliFarm's future extensions will add functionality, enhance the user experience, and increase farm efficiency with outstanding fea-

tures. The real-time inventory tracking will enable land owners and farmers to monitor stock levels, thus enabling better resource allocation, reducing wastage and bringing more transparency. It will also implement a deferred payment system, which will match future profits with inventory costs, or with loans they take so that landowners can manage advances smoothly and see how they are repaid on the platform itself. By introducing a chat or notes system, communication between farmers and landowners will improve and allow farmers to post instant updates, instructions and collaborative record keeping. 3D visualisation features will allow intuitive and interactive views of farm layout, crop performance and land use to be utilised for planning and performance analysis. The payment integration will make payment transactions fast and secure and eliminate the financial workflow for landowners and farmers. A warning system will catch the repeated losses of which farmers should take corrective measures, to improve accountability. Additionally, the tools to diagnose and compare productivity for farmers will allow landowners to identify trends, recognise high-performing practices, and optimise resource allocation. Taken together, these improvements will allow IntelliFarm to continue maturing into a more feature-rich user-focused and data-driven farm management solution.

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