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BEng (Hons) in Software Engineering

Climate Crop Advisor: Smart Farming App for Climate-Informed Crop Selection

Initial Project Proposal

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List of Abbreviations

Abbreviations	**Acronym**
UX	User Experience
UI	User Interface
OOAD	Object-oriented analysis and design
IDEs	Integrated development environment
GAN	Graphics Processing Unit
GUI	Graphical User Interface
GPU	Graphics Processing Unit
OS	Operating system
ML	Machine Learning
AI	Artificial Intelligence
CNN	Convolutional Neural Network
SSADM	Structured Systems Analysis and Design Method
DAMSM	Deep Attentional Multimodal Similarity Model
SOTA	State of The Art
CICR	Climate-Informed Crop Recommendations
NLP	Natural Language Processing
DL	Deep learning
TinyML	Tiny Machine Learning
IoT	Internet of Things
CC	Cloud Computing
SaaS	Software as a Service
DIY	Do It Yourself
CRIS	Crop Recommendation and Information System
PRM	Predictive Recommendation Model
MLaaS	Machine Learning as a Service
GIS-IR	Geographic Information System for Irrigation
GPS	Global Positioning System
RFID	Radio-Frequency Identification
GIS	Geographic Information System
API	Application Programming Interface
LR	Literature Review

1. PROJECT PROPOSAL

1.1 Introduction

Farming has a major issues due to climate patterns that are becoming more unpredictable. The objective of this endeavor suggests creating a mobile application that uses mechine learning techniques for predicting climate changes and determine feasible harvests. This app's simply focus on climate data looks for to assist farmers in making decisions that will result in successful planting of crops.

1.2 Problem domain

Accurate plant options are required due to farming's risk to shifting climate conditions. Farmers are frequently left in the dark when choosing agricultural products due to the lack of accuracy and user-friendliness in existing methods.

Imagine a world where climate change is making farming a risky endeavor and the weather is becoming more unpredictable. This research proposal focuses on how to assist farmers in making better crop decisions in spite of the difficult circumstances.
The issue is serious for the following reasons: The threat posed by climate change is real and present right now. Extreme weather events are being brought on by it, along with disruptions to normal growing seasons and new pest and disease issues for farmers. It's basically making farming much more difficult. However, the issue is global in scope rather than just local. Agriculture is being impacted by climate change in every region of the world. We are all impacted by this problem because farming is the backbone of our food supply and employs countless people. To put it in perspective, agriculture has long served as the foundation of human civilization. It is how we provide for our families and make a living. We urgently need to come up with clever ways for farmers to adapt as a result of climate change.

By creating a user-friendly mobile app, this study seeks to accomplish precisely that. This app has the potential to increase crop yields, stabilize incomes, and advance sustainable farming by offering farmers data-backed recommendations. The belief that data-driven solutions can ensure a more resilient future for farming in our changing world underlies the problem domain, which is not just about theory but also a practical response to a global crisis.

1.3 Problem Definition

The main problem causing this research is the urgent requirement for a user-friendly, data-driven tool to help farmers choose crops sensibly in the face of climate change. Agriculture faces many difficulties, including those related to climate uncertainty, crop failures, income volatility, and financial issues. These problems affect economies and food supply chains globally and are not restricted to specific locations.

The suggested solution seeks to deliver precise, specific to the location crop recommendations, utilizing climate data and predictive technology to assist farmers in adapting to changing environmental conditions, reducing income volatility, and promoting environmentally friendly farming, ultimately enhancing food security and incomes for farmers in countries worldwide affected by climate change.

1.3.1 Problem Statement

As a result of the increasingly unpredictable climate patterns, farming communities face unprecedented challenges. Due to unpredictable weather brought on by climate change, conventional farming methods are no longer reliable. Farmers frequently experience significant financial losses as a result of poor decision-making regarding crop choice and planting times. Farmers are uncertain when selecting crops because current methods lack precision and user-friendly interfaces. These difficulties are made worse by the lack of precise, site-specific information, which makes it harder for farmers to make effective adjustments to the changing climate.

1.4 Research Motivation

The need to address the difficulties farmers face as a result of the increasingly unpredictable climate is the driving force behind the research motivation for this project. The livelihoods of farmers as well as the security of the world's food supply are seriously threatened by the negative effects of climate change on agriculture, which include unpredictable weather patterns and shifting planting seasons. By creating a data-driven mobile application, this research aims to equip farmers with the information and resources they need to decide on the best crops to plant and when to plant them based on the climate at the time. In addition to improving food security and economic stability, this strategy also promotes resilient and sustainable agricultural practices. A promising solution to these urgent problems is also provided by using data science and machine learning technologies to close the gap between climate data and farming decisions.

1.5 Existing work

Citation	Brief Description	Limitations	Contribution
(Dahiphale et al., 2023)	This study presents models for crop recommendations that make use of deep neural networks and cutting-edge machine learning techniques. The method is simple to modify for new data and for different regions or nations. The research paper identifies problems in agriculture and offers potential solutions. The study introduces a method that can be applied widely in agriculture and is scalable, precise, and easy to use.	Limited access to data in some regions. Availability and quality of the data can affect the performance of the model. It's possible that problems won't be fully addressed. Future concepts might need more development and study. In some circumstances, the scalability may be impacted by resource limitations. The quality of the data and the model parameters may have an impact on accuracy.	Gives farmers a useful tool to help them choose crops intelligently. Aids in the development of agricultural policy by governments. Provides opportunities for companies to develop goods and services that support agriculture. Aids in preserving price stability for agricultural products. Identifies significant issues in agriculture that require further study and innovation. Contributes significantly to the field of agriculture by giving different stakeholders, such as farmers, governments, and businesses, a useful and scalable tool.
(Johnson et al., 2023)	The paper explores differences among High, Moderate, and Low adopters of climate-smart agriculture practices. It	The research may not cover all possible factors influencing adoption.	Provides insights into the factors influencing adoption of climate-smart agriculture practices

	identifies factors such as parcel size and access to water sources that influence adoption levels. It also discusses variations in information sources and the importance of addressing uncertainties in promoting High adoption levels.	The study's findings might be context-specific and may not apply universally.	among different groups of farmers. Suggests strategies for targeting outreach efforts and interventions to promote higher levels of adoption. Recommends emphasizing practice benefits, addressing uncertainties, and developing incentive programs to enhance inclusivity in the adoption of climate-smart practices.
(Beveridge et al., 2018)	The challenge of creating locally relevant and climate-informed adaptation strategies for agriculture is complex due to the multidimensional nature of adaptive decisions. These decisions intersect with social, economic, and environmental systems and involve varying spatial and temporal scales. Cross-disciplinary approaches are crucial to better understand the driving factors and constraints of agricultural adaptation at the local level. These approaches can also help assess the potential impact of adaptive strategies across scales and under future climate change scenarios,	The complexity of cross-disciplinary approaches may result in challenges related to data integration and analysis. The practical steps for effective collaboration between crop-climate modeling and place-based communities need to be further elucidated.	Provides insights into the complexity of agricultural adaptation at local scales and the necessity of cross-disciplinary approaches. Highlights the need for a paradigm shift in crop-climate modeling to encompass a broader range of adaptation strategies beyond irrigation, planting date, cultivar, fertilization, and planted area. Emphasizes the importance of collecting consistent and accessible datasets on management and adaptation and building trust between researchers and stakeholders. Proposes the use of participatory and iterative modeling to facilitate

	informing policy decisions.		communication, shared understanding, and collaboration between researchers and stakeholders for more impactful and widely adopted adaptation science.
(Adamides et al., 2020)	Cypriot farmers are lagging behind in adopting smart farming technologies, with limited documentation of their benefits. This study presents a methodological framework tailored to Mediterranean farming systems, with a focus on smart farming as a service. The study also provides initial results from deploying IoT smart sensors in a potato pilot study in Cyprus.	The assessment process involved a relatively small number of experts, potentially limiting the generalizability of their findings. The study's focus on potatoes may not fully represent the diversity of crops in Mediterranean farming systems.	Demonstrates the potential benefits of smart farming technologies, including a significant reduction in irrigation needs and improved pesticide use efficiency. Highlights the positive reception of the gaiasense solution by experts, emphasizing the importance of real-time and accurate data presentation. Acknowledges the need for broader participation from experts, stakeholders, and end-users, especially farmers and agricultural extension officers. Provides insights into an ongoing project (IoT4Potato) with plans to expand to more pilot fields, which can facilitate the large-scale adoption of smart farming practices in Cyprus. Suggests that this work can foster innovation and support climate change

			adaptation efforts while helping farmers reduce their ecological footprint.
(Cordell et al., 2017)	Two major global challenges for food security, namely phosphorus scarcity and climate change, are posing significant threats to farmers' livelihoods, agricultural productivity, and environmental health. In Sri Lanka, a country with a large population of smallholder farmers who depend on rain-fed rice as a dietary staple, climate change projections indicate a potential 40% drop in rice yields. This could impact the majority of farmers and increase poverty levels by up to a third. Concurrently, the government is scaling back fertilizer subsidies, making farmers vulnerable to future price fluctuations, such as the 800% phosphate fertilizer price spike in 2008. The research project aims to enhance food system resilience to these challenges in Sri Lanka, spanning from farm-scale adaptations to policy-making. The report presents the first phase of the project, which assesses the capacity of smallholder farmers, policy-makers, industry stakeholders, and others in Sri Lanka to adapt to	Specific details about the results of the vulnerability assessment are not provided in the text. The report mentions the need for adaptations without detailing the specific adaptation strategies that may be considered.	Highlights the critical challenges facing Sri Lanka's agricultural sector due to climate change and phosphorus scarcity. Stresses the potential consequences of reduced rice yields and the scaling back of fertilizer subsidies. Outlines the research project's aim to build food system resilience through a collaborative approach involving various stakeholders. Emphasizes the use of a participatory, integrated, and rapid vulnerability assessment framework as a foundational step in addressing these challenges.

	these dual challenges using a participatory, integrated, and rapid vulnerability assessment framework.		
(Wimalasiri et al., 2023)	This paper presents the first study that estimates the climate sensitivity and potential production of Proso millet using a crop modeling approach. The results reveal that Proso millet yields increase with up to 2°C of warming in wetter conditions, but decrease with additional warming. A 1°C temperature increase in the Proso millet growing area led to a 5-10% yield reduction with no change in rainfall. Climate projections for the mid-21st century indicate increasing temperatures. The models suggest the possibility of a wetter future in the Proso millet growing area for specific emission scenarios. Various Proso millet accessions showed no significant deviations from baseline yields under these scenarios. Potential areas for Proso millet cultivation were identified under both current and future climates. Proso millet yields responded differently in various climatic zones, with the	The study does not provide specific details on the exact future scenarios or adaptations that may be required for Proso millet cultivation in response to climate change. It mentions the suitability of Proso millet in marginal areas, but the specific areas or regions are not identified.	Contributes valuable insights into Proso millet's response to climate change, suggesting that it remains viable under changing conditions. Demonstrates the potential of Proso millet as a resilient and promising crop for marginal areas in the mid-21st century, especially in low-input agricultural systems. Provides a framework that can be used as a starting point to assess the climate sensitivity of other underutilized crops, which can be crucial for food security and agricultural adaptation in changing climates.

	crop showing resilience in low-input agricultural systems without irrigation and fertilization. This indicates the continued suitability of Proso millet under changing climate conditions. In contrast, key crops like paddy are projected to experience yield reductions under similar climate changes, making Proso millet a promising option for marginal areas in the mid-21st century. The study's framework can serve as a baseline to assess the agroclimatic sensitivity of other underutilized crops.		
(Ratnayake et al., 2021)	The study findings indicate that climate change may result in a reduction in the suitable areas for the majority of the evaluated Crop Wild Relatives (CWR) species in Sri Lanka. Most of the assessed species exhibit high vulnerability to climate change, with the exception of P. sylvestre, which is predicted to expand its range. This potential reduction in suitable areas could negatively impact agriculture and food systems in Sri Lanka, raising concerns about food security. The study underscores the	The study does not provide specific details regarding the precise locations or regions where these changes in suitable areas are expected. It mentions the implications for ex situ conservation but does not elaborate on specific strategies or initiatives.	Highlights the potential adverse effects of climate change on CWR species in Sri Lanka, which have implications for agriculture and food security. Emphasizes the importance of habitat conservation and suggests that ex situ conservation measures should be considered. Provides valuable baseline data that can guide conservation planners in developing species recovery plans, contributing to better species management and

	importance of conserving the existing habitats of priority CWR species and provides implications for their ex situ conservation. Furthermore, it offers crucial baseline data that can aid conservation planners in developing species recovery plans, especially for high-risk species, to enhance their management.		overall conservation efforts.
(Wimalasiri, 2019)	This paper presents the first study estimating the climate sensitivity and potential production of Proso millet using a crop modeling approach. The results of the C3MP study reveal that Proso millet yields increase with up to a 2°C temperature rise in wetter conditions but decrease with additional warming. A 1°C temperature increase in Proso millet growing areas results in a 5-10% yield reduction with no change in rainfall. Projections for future climate, based on 20 General Circulation Models (GCMs) under different emissions scenarios (RCP4.5 and RCP8.5), indicate a clear increase in annual and seasonal temperatures by the mid-21st century. The study models suggest the possibility of a wetter future for Proso millet	The text does not provide specific information about potential limitations or challenges faced during the study. Although it discusses the differences in Proso millet yield behavior across climatic zones, it doesn't delve into the specific climatic zones or regions examined in the study.	Presents the first study to estimate climate sensitivity and potential production of Proso millet using crop modeling, contributing to the understanding of this crop's response to climate change. Highlights the impact of temperature and rainfall changes on Proso millet yields, providing insights into its adaptability under varying climatic conditions. Projects future climate scenarios and the potential for a wetter climate in Proso millet growing areas. Demonstrates that different Proso millet accessions perform comparably to baseline yields under varying emission scenarios.

	growing areas, particularly under the RCP4.5 (85% of GCMs) and RCP8.5 (75% of GCMs) scenarios. The study also examines multiple Proso millet accessions (L_1, L_11, L_12, L_14, and L_25) and finds that their yields do not significantly deviate from baseline yields under both emission scenarios. It identifies potential areas for Proso millet cultivation under both historical (1980-2009) and future climates, showing varying yield behaviors across different climatic zones. Proso millet, primarily grown in low-input agricultural systems, demonstrates resilience and adaptability under changing climate conditions, particularly in contrast to other key crops like paddy that are expected to experience yield reductions.		Identifies potential areas for Proso millet cultivation under both historical and future climates. Provides evidence of Proso millet's suitability and resilience in low-input agricultural systems, which may be crucial for future agricultural planning in the context of climate change.

(Sandhya et al., n.d.)	The study examines data mining methods for forecasting climate and demonstrates their potential to replace conventional meteorological techniques. Preprocessing, clustering, prediction, and classification are just a few of the algorithms that have been found to be effective at forecasting weather phenomena. Accuracy increases initially with larger training sets but declines over time. The suggested model performs admirably when managing short-term energy resources. The development of a hybrid system for greater accuracy and the expansion of applications to forecast thunderstorms and similar events are potential future improvements.	The text mentions the creation of a hybrid system and its potential application in thunderstorm forecasting, but it doesn't go into detail about the difficulties or intricacies involved in these improvements. It doesn't go into specifics about the data mining or preprocessing methods used in the study.	shows how data mining can be used to predict the climate. Identifies appropriate algorithms and studies the effect of training set size on accuracy. Provides a workable model for managing short-term energy resources. Suggests future improvements, such as hybrid systems and broader applications for weather prediction.
(Kamatchi and Parvathi, 2019)	Given the complexity of climate dynamics and climate prediction theories, weather prediction is a difficult field in technology and science. The study focuses on using artificial neural networks (ANN) to forecast the weather. It uses techniques like prediction, recommendation, and	Although regression models will improve prediction accuracy in the future, the text gives no specifics about these models. The size of the geographic area under study and	Uses artificial neural networks to overcome the difficulties associated with weather prediction. Makes use of classification, suggestion, and prediction techniques. Increases the recommender system's success rate through ANN regularization and a

	classification. The study employs Case-Based Reasoning (CBR) in combination with ANN regularization to increase the recommender system's success rate. The use of various regression models is anticipated to improve prediction accuracy in the future. The weather prediction model used in this study performs pattern recognition of meteorological parameters in a small geographic area, achieving impressive performance and logical accuracy.	the precise meteorological parameters are not specified.	hybrid strategy involving CBR. Indicates potential future advancements in regression model-based prediction accuracy. Exhibits exceptional performance and logical accuracy in forecasting weather for small geographic areas.
(Chana et al., 2023)	In order to help farmers make decisions, the paper investigates the use of IoT, machine learning, and weather forecasts for crop prediction. Using the Random Forest algorithm, it creates an architecture and IoT prototype for data collection and achieves high accuracy (99%). Recommendations are made by expert systems, and predictions are occasionally affected by weather forecasts. The goals of the study are validated by actual field tests. The dataset will be expanded, and the	The paper mentions plans to lengthen the weather forecast period and widen the dataset, but it makes no mention of any particular obstacles or potential problems in making these improvements. It doesn't say how many local towns or types of crops were at first included in the dataset.	Examines the use of machine learning and IoT to predict crops. Creates a reliable forecasting system. Shows how weather predictions affect predictions of crop yields. Uses field tests to confirm the study's goals. Suggests potential upgrades.

	weather forecast period will be prolonged.		

Table 1 Existing Work

1.6 Research Gap

Lack of an easily apparent mobile app that generates accurate predictions for crops mainly based on climate data is the identified research gap.

1.7 Contribution to the Body of Knowledge

The contribution of this undertaking is to fulfill the critical gap between choosing crops and information about climate. I aim to develop an app that assists farmers to choose a suitable plantation decisions by focusing specifically on changing climate patterns.

1.8 Research Challenge

The challenge lies with efficiently processing and analyzing lots of climate data to generate accurate predictions. Another challenging task is designing a user-friendly interface that delivers accurate suggestions based on the data provided.

1.9 Research question/s

1. How can machine learning be effectively used to predict climate changes and provide accurate crop recommendations for farmers?
2. What are the primary challenges that farmers face in selecting the right crops based on climate conditions, and how can a mobile app address these challenges?
3. What is the role of farmer feedback and usability testing in the development of agricultural mobile apps for crop selection?
4. What are the practical implications of using a deductive research approach in developing a climate-informed crop recommendation app?
5. How do climate-informed crop recommendations contribute to sustainable and climate-resilient farming practices?

1.10 Research Aim

The aim is to create a mobile app that uses machine learning to analyze climate data and provide accurate crop suggestions, empowering farmers to make well-versed planting decisions mainly based on climate conditions.

1.11 Research Objective

Research Objectives	Explanation	Learning Outcome
Problem Identification	This objective aims to explore and gain insights into the specific problems farmers encounter as a result of climate changes. It involves studying their experiences and challenges in adapting to shifting climate conditions. • Understand the challenges farmers face due to climate variability.	LO1
Literature Review	This objective involves studying existing research and literature to gain insights into the best practices and approaches in climate-informed crop recommendations. • Review literature on climate-informed crop recommendations to understand existing approaches and best practices.	LO1, LO6
Data Gathering and Analysis	This objective involves processing the collected climate data using machine learning techniques to find connections between climate patterns and the suitability of various crops. • Analyze the gathered data using machine learning algorithms to uncover correlations between climate patterns and crop suitability.	LO2, LO3, LO4, LO5, LO6
Research Design	This objective focuses on designing the mobile app in terms of its technical architecture, data integration, and user interface.	LO2,LO3, LO4,LO5, LO6

	• Develop a comprehensive research strategy that encompasses app architecture, data integration, and user interface design.	
Implementation	This objective involves the actual development of the mobile app, ensuring it aligns with the research findings and follows industry best practices. • Translate the research findings into a functional mobile app using best practices and selected development methodology.	LO3, LO4, LO6
Testing and Evaluation	This objective involves testing the mobile app for accuracy, functionality, and usability. It also includes gathering user feedback and evaluating the app's performance. • Conduct comprehensive testing and evaluation to ensure the app is accurate, functional, and user-friendly.	LO4, LO6

Table 2 Research Objectives

1.12 Project Scope

1. In-scope

- Creation of a mobile application dedicated to analyzing climate data only.
- Generation of crop recommendations using historical and current climate data.
- Easy-to-use interface for entering locations and receiving crop recommendations based on the climate.

2. Out-scope

- Additional to data analysis, detailed climate modeling.
- Complex algorithms for weather forecasting.

3. Diagram showing prototype feature

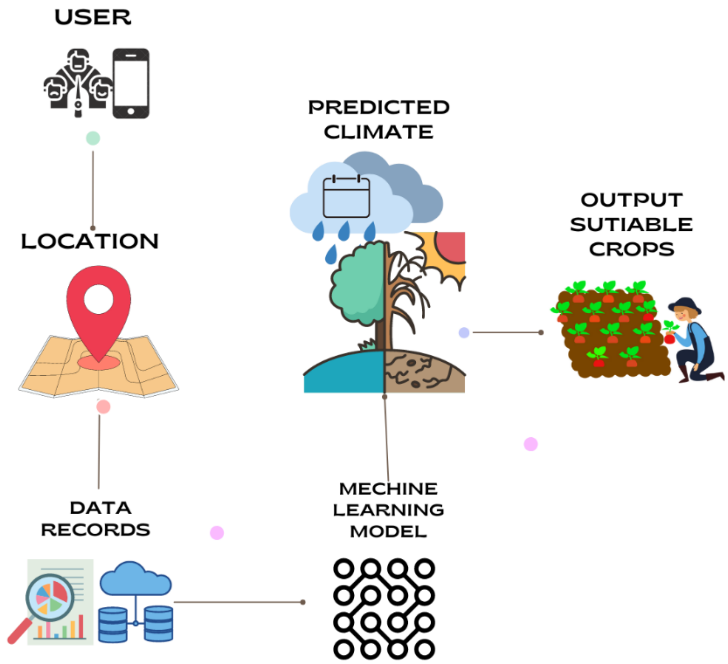

Figure 1 Prototype feature diagram

2. METHODOLOGY

2.1 Chapter Overview

The methodology chapter provides a thorough plan for carrying out your study or project. It describes your chosen research approach (deductive or inductive), methodological preference (mono, multi, or mixed-method), research strategy (data collection methods), time frame, and the research philosophy guiding your data collection and interpretation. Additionally, it explains your intended data collection and analysis procedures and delves into population and sample size issues. This chapter serves as the foundation of your research, ensuring a well-organized and rigorous approach to achieving your research objectives.

2.2. Research methodology

Layer	What is being using	Why you are using it
Philosophy	Positivism - quantitative	The choice of research philosophy guides our approach to data collection and analysis. In the context of your proposal, positivism is selected to quantitatively analyze climate data, treating climate variables as numerical values. This philosophy ensures that research outcomes are based on objective, factual data. It aligns with the quantitative nature of climate data and the need to provide farmers with accurate crop recommendations.
Approach	Deductive	The deductive approach is employed because your research aims to test the applicability of existing machine learning models and algorithms for climate prediction. It begins with established theories or models (in this case, machine learning algorithms) and assesses their effectiveness in predicting climate conditions. This approach is suitable for validating the utility of these models in your context.
Methodological choice	Mono Method - Quantitative	A mono-method approach, specifically quantitative research, is selected to maintain consistency with positivism and ensure the use of precise numerical data. The aim is to create a data-driven mobile app, and quantitative

		methods provide the means to analyze climate data and develop accurate crop suggestions.
Strategy	Survey, Experiment	The data collection strategy involves surveys and experiments. Surveys are used to gather quantitative data from farmers regarding their crop decisions and climate conditions. Experiments may be conducted to assess the effectiveness of the machine learning algorithms in predicting climate patterns. This strategy aligns with the research objective of understanding farmers' needs and validating the app's performance.
Time Horizon	Cross section	Cross-sectional data collection is chosen because it allows for the collection of data at a single point in time, which is suitable for understanding the current climate conditions and farmers' crop choices. This aligns with the need to provide real-time crop recommendations through the mobile app.
Data Collection and Analysis	Population size, Sample size, Data collection methods (surveys, experiments), Data analysis techniques (machine learning algorithms)	The decisions here relate to determining the population (farmers), sample size, and the methods for data collection and analysis. Large-scale surveys are conducted to obtain data from a substantial number of farmers. Experiments are utilized to evaluate machine learning algorithms' performance. Data analysis involves applying machine learning techniques to climate data. These choices enable the development of a robust mobile app that serves farmers effectively.

Table 3Research methodology

2.3. Development methodology

a. What is the life cycle model and why?

Implementing a life cycle model will help make the app development process more efficient and successful by ensuring that each step is well thought out and carried out.

b. Design Methodology

SSADM and OOAD are both functional. However, OOAD might be more appropriate given that your mobile app has a variety of components (objects) that must function properly as a whole. Making a complex system like a mobile app is well suited to OOAD's emphasis on reusable building blocks. It's similar to using Lego pieces to create a special structure that meets the requirements of your project.

c. Evaluation methodology

Using benchmarking and evaluation statistics, can ensure that app is performing as it should. It's comparable to making sure that it is superior to others in terms of taste, preparation time, and ease. Knowing if your app stands out and accomplishes your objectives is helpful.

2.4. Project management methodology

a. Gantt Chart

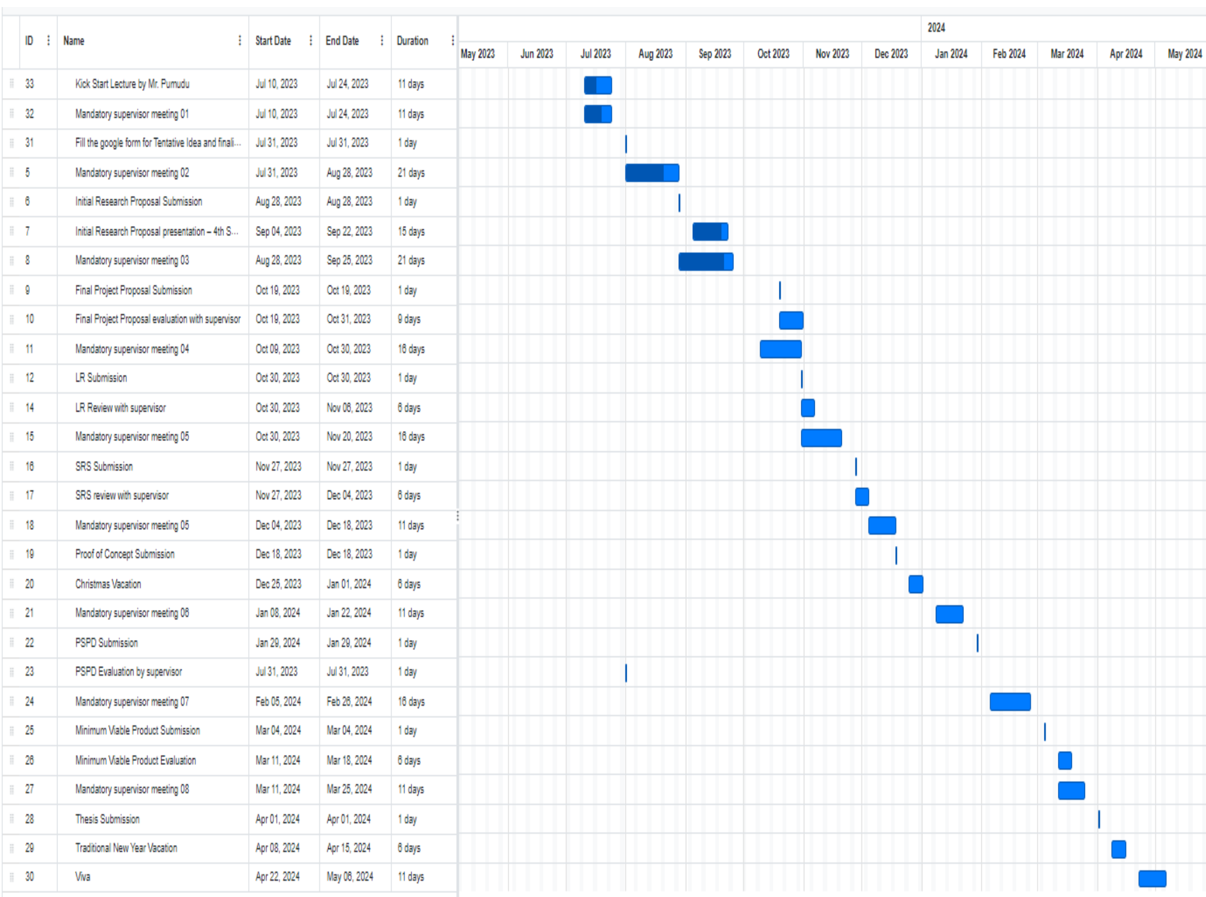

Figure 2 Research plan described in a Gantt chart. (Self Composed)

b. Deliverables, milestones and dates of deliverables

Deliverables	Delivery Date
Initial Research Proposal	1st September 2023
Final Project Proposal	5th October 2023
Literature Review	31st October 2023
Software Requirement Specification	27th November 2023
Proof of Concept	21st December 2023
PSPD	1st February 2024
Minimum Viable Product	7th March 2024
Thesis	4th April 2024

Table 4 Project deliverables and dates

c. Resource requirements

i. Hardware requirements

- High-end computers for testing and developing apps
- Mobile devices for testing and verifying user experience

ii. Software requirements

- Tools for development (IDEs, version control)
- (Python, R) data analysis software
- Libraries for machine learning (TensorFlow, Scikit-learn)
- Platforms for creating mobile apps (Android Studio, Xcode)

iii. Skills requirements

- App development (using languages like Swift and Java)
- Data analysis and science
- Expertise in machine learning
- Design for user experience (UX)
- Know-how in the agricultural domain

iv. Data Requirements

- Data from historical and current climate databases
- Databases of crop data and agronomic information

d. Risk Management

Risk Item	**Severity**	**Frequency**	**Mitigation Plan**
Technical challenges	**5**	**5**	Continuous monitoring and troubleshooting during field research studies; regular inspection and bug-fixing during the development time.
Incorrect data	**5**	**4**	Thorough cross-referencing and data validation; use of reputable and trustworthy data sources; and routine updates to guarantee data accuracy.
User disagreement	**5**	**1**	Farmers should be involved in the design process, receive thorough training and support, and feedback should be continuously gathered for iterative improvements.

Table 5 - Risk Management

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