1. **INTRODUCTION**

In modern India's economy agriculture plays a pivotal role. More than 58% of rural households depend on jobs in the agricultural sphere as the principal means of livelihood. Moreover, 80% of these households are smallholder farmers with less than 2 hectares of farmland, from which more than a fifth is below poverty.

World population keeps growing. It's estimated that there will be 9.7 billion people by 2050. Food demands are expected to grow anywhere between 59% to 98%.

Climate change effects are predicted to impact everything across the food and farm systems, from productivity to livelihoods, predicting a 4% to 26% loss of net income for farmers by the end of the century.

Covid-19 pandemic has greatly highlighted the vulnerabilities and fragility of our food supply chains, telling us that we need a more resilient food system and that we can't forget about marginalized communities or smallholder farmers.

All these reasons call for a revamp of the entire mechanism that brings food from farms to our plates. It's more important, now than ever, that we develop and adopt innovative methodologies and technologies that can help bolster countries against food supply challenges and shocks.

In this contest we propose our solution for the Telangana food system, the 11th largest state in India with a geographical area of 112 077 km^2 and 35 193 978 residents.

1.1. **Purpose**

Our goal will be to design and develop a community-centric system that will support the agricultural community via a data-driven approach, bolstering both production and welfare of the farmer population.
Stakeholders of this project will be of three main categories:

- Farmers in the Telangana region. They will be aided in their work from the data that will be available to them. By accessing weather forecasts and critical information when necessary they will be able to both ease their work and get more in return.
- Agronomist involved in aiding farmers in the Telangana region. They will be aided in the organization of their daily visits and in responding to help requests, permitting more mirated and specific work on needing farmers.
- Policy makers in the Telangana region. By seeing specific performance data they will be able to check the results of the rule they applied, and through a direct connection to the farmers they will be able to quickly publish new advice and rules.

1.2. **Scope**

DREAM system will bolster Telangana state against food supply shocks and challenges, thanks to the involvement of multiple stakeholders. This will be translated into greater

production in order to face the problem of increasing food demand and climate adversities, but also in a way of helping farmers to achieve a better life outside of poverty.

In order to reach greater resilience to meteorological adverse events farmers have access to short and long term forecasts, and also to some “best practices” identified by those farmers who demonstrated to be resilient. Personalized suggestions carry in the same direction, helping to increase both resistance and production. In addition the system also assists farmers to help each other through discussion forums and to request for support and suggestions among themself and to agronomists.

Telangana state is indeed divided into zones assigned to experts (agronomist) exploiting a daily plan to visit the farms of the assigned area (at least twice a year each farm) considering their needs. DREAM system also helps agronomists to visualize and update their plan and analyze the best performing farmers in their area.

All those data, from production to best practices and meteorological resilience, are collected by policy makers, which use them in order to assign special incentives to worthy farmers and to understand if the steering initiatives carried out by agronomists with the help of good farmers produce significant results.

1.2.1. *Phenomena*

- *General Phenomenon*
  User login (user can be a farmer, a policy maker and a agronomist) [W S]
  User registration [W S]
  Check username and password [M N]

- *Farmer phenomenon*
  Visualize weather forecasts [W S]
  Visualize personalized suggestions [W S]
  Insert data about production (and problems) [W S]
  Request for help and suggestions by agronomists and other farmers [W S]
  Get notification for help answers [M S]
  Respond to a request for suggestions and help [W S]
  Create discussion forums with other farmers [W S]
  Read a discussion forum [W S]
  Respond in a discussion forum [W S]
  Get notification from forum answers [M S]
  Receive requests of best practises [M S]
  Send best practises to policy makers [W S]
  Work on the crops [W N]
  Get notification for new blog post [M S]
  Read blog post [W S]
  Receive incentive notification [M S]

- *Agronomist phenomenon*
  Choose responsibility area [W S]
  Receive help requests from farmers [M S]
  Respond with suggestions to farmers [W S]
  Visualize weather forecast in the area [W S]
  Visualize farmer performance data [W S]
  Visualize daily visit plan [W S]
  Modify daily visit plan (before the confirmation) [W S]
  Confirm the execution of the plan [W S]
  Specify deviations from the plan [W S]
  Visit farmers [W N]

- *Policy maker phenomenon*
  Visualize farmers performance data [W S]
  Request best practices to the “resilient” farmers [W S]
  Receive best practices [M S]
  Publish best practice on a blog [W S]
  Decide and send special incentives [W S]
  Visualize crops performance data [W S]

1.2.2. *Goals*

- G1: Increase the overall welfare and production of the Telangana region.
  By facilitating the communication and the collaboration between farmers, policy makers, and agronomists the aim is to increase the wellbeing of farmers inhabiting the Telangana region.
- G2: Aid policy makers in the decisional process.
  Policy makers can see production data in order to decide the incentives for farmers, or whether the current policies are performing well or should be changed (in order to constantly improve Telangana’s production).
- G3: Aid the farmers in the management of their productions.
  Farmers will receive personalized suggestions and best practices, and they will also have the possibilities to ask for help to both other farmers (by lending/renting equipment or giving advice) or to agronomists.
- G4: Aid agronomist works to help farmers and check crops production.
  Creating and modifying a daily plan will help them organize their visits and maximize their help in a well-specified zone of expertise.

1.3. **Definitions, Acronyms, Abbreviations**

1.3.1. *Definitions*

Farmer = a person who cultivates crops.

Resilient farmer = A farmer whose production is good despite meteorological adverse events.

Agronomist = an expert in the science of soil management and crop production.

Policy maker = a person in charge of formulating policies, related to the food system.

Production = total crops-output generated. Could be related to a single farmer, a zone or the entire Telangana's state.

Personalized suggestions = Indication directly focused on a specific farmer, such as specific crops to plant or specific fertilizers to use based on location and type of production.

Welfare = Overall well-being of farmers which translates into the reduction of poverty and simplification of work (discussion with other farmers, suggestions, personalized data based on location, …).

Best practices = Cultivation procedure that has been shown by experience to produce optimal results (not only in terms of achieved final production but also in terms of resilience to adversities) and that should be proposed for widespread adoption.

Responsibility area = Zone of which an agronomist is in charge of, with the purpose of increasing its welfare and production.

Visit = It refers to the agronomist going to a specific farm of his competence, and is identified by a date, a variable timeslot (deviations may occur) and a reason.

Notification = Alert that a certain event has occurred. Could be an email or an automated message sent to the smartphone when the app is not running.

1.3.2. *Acronyms*

1.3.3. *Abbreviations*

1.4. **Revision history**

December x, 2021: version 1.0 (first release)

1.5. **Reference Documents**

- Specification document: "R&DD Assignment A.Y. 2021-2022"
- Course slides
- Alloy official documentation: https://alloytools.org/documentation.html
- Paper: "Jackson and Zave: the world and the machine"
- UML official specification https://www.omg.org/spec/UML/
- BPMN official specification https://www.omg.org/spec/BPMN/2.0/

1.6. **Document Structure**

Chapter 1: Introduction. This section provides an overall description of the system scope and purpose, together with some information about this document.

Chapter 2: Overall Description. This section offers a summary description about the overall organization of the system, and it also contains a description of all the features offered by the application, and of the actors who use it.

Chapter 3: Specific Requirements. This section goes into detail about functional and nonfunctional requirements, also providing typical scenarios and use cases.

Chapter 4: Formal Analysis using Alloy. This section includes a presentation of the main objectives driving the formal modeling activity, as well as a description of the model itself, what can be proved with it, and why what is proved is important given the problem at hand.

2. OVERALL DESCRIPTION

2.1. Product perspective

2.1.1 User scenarios

1. Sunita is a farmer. The season is right and she needs to reap the harvest but the past days were very wet. She needs to find the perfect weather to work, so she logs in the DREAM app and quickly checks the weather forecast section. She looks at the following weeks and finds that the following week the weather should be sunnier and the temperature right. So she decides that next week will be the perfect time to collect the crops.
2. Sri it’s a farmer. He is unsure which is the best weather for sowing rice. He logs in the DREAM app and goes to the ask help section to ask for help from the expert. He writes his help requests, sends it and then goes to work. In the meantime Anita, the agronomist responsible for the area, receives a notification from the message the farmer sent. She opens the app to read the request and write the correct answer, sending it to the farmer. As soon as the message is sent, the farmer receives a notification and opens the app, reading the agronomist's response. Now

he knows when is the best weather to sow rice, without having lost too much time seeking for an answer or going to the agronomist.

3. Anita is an agronomist. She needs to plan the visit to her assigned area for the following week. She opens the app and goes to the performance section to check which farmer seems to need more help. Having found this information, she goes into the daily plan section and starts inserting the names of the farmers she needs to visit. When she is finished, she sends the list to the system which returns to her that she is forgetting to visit Sunita, because she needs the second visit of the year. Anita changes the list accordingly and sends it to the system. This time the system checks that the list is valid so returns to Anita a daily plan for the next week, where farmers were grouped by vicinity, to ease Anita work. She is ready for the next week.
4. Sanjay is a policy maker. He wants to check how the decisions his department is making are affecting the overall production. So he opens the DREAM app and goes to the performance section. He gathers from this section many useful insights and charts from which he can prepare a presentation for the next board meeting, where they can decide the best line of action.
5. Gita is a policy maker and she is responsible for managing the best practices. They have decided to publish weekly suggestions, and she needs to prepare the next week's advice. She goes in the performance section to check the most performing farmers, then goes in the best practice request section and writes some questions to the ones that she thought was the most suitable. These farmers will then receive the questions and answer them during the week. When Gita has collected all the answers, she prepares the story and then publishes it in the best practice section, pushing it to the homepage of all DREAM farmers.
6. Lakshmi needs help collecting the crops, he knows that the best time will be next week, but his harvester needs some fixing and will not be ready until the week after. So he opens the DREAM app and goes to the forum section. He finds the correct section and writes a post asking for help from another farmer, if someone is willing to rent him a harvester. Fortunately for him, Sri finds his post on the forum. Sri has already collected his crops and he is willing to rent his harvester. So he answers in the forum the request for help and then writes to Lakshmi a private message to make an agreement on the price for the rent. Lakshmi will receive a notification from the forum response and from the private message and he will respond accepting the help of Sri. His harvest is safe!
7. A strange crop disease is spreading quickly in some farmers' land. Fortunately Sunita notes this and writes a request for help to Anita the agronomists. Anita knows the disease and suggests to Sunita a solution. Knowing the danger Anita decides to write to her administration to warn them about the danger. They understand and write a blog post to warn about this disease and inform about its prevention, and push it on the homepage of all DREAM farmers, rapidly informing all of them in time to save many harvests.

2.1.2. User Interface

The system should interface with users through devices which must be connected to the Internet.

Everyone that needs to use this service would connect to it through a Web Interface (from an existent domain, like www.dream.com) or through a mobile application that can be installed on smartphones (both IOS and Android).

2.1.3. Hardware Interface

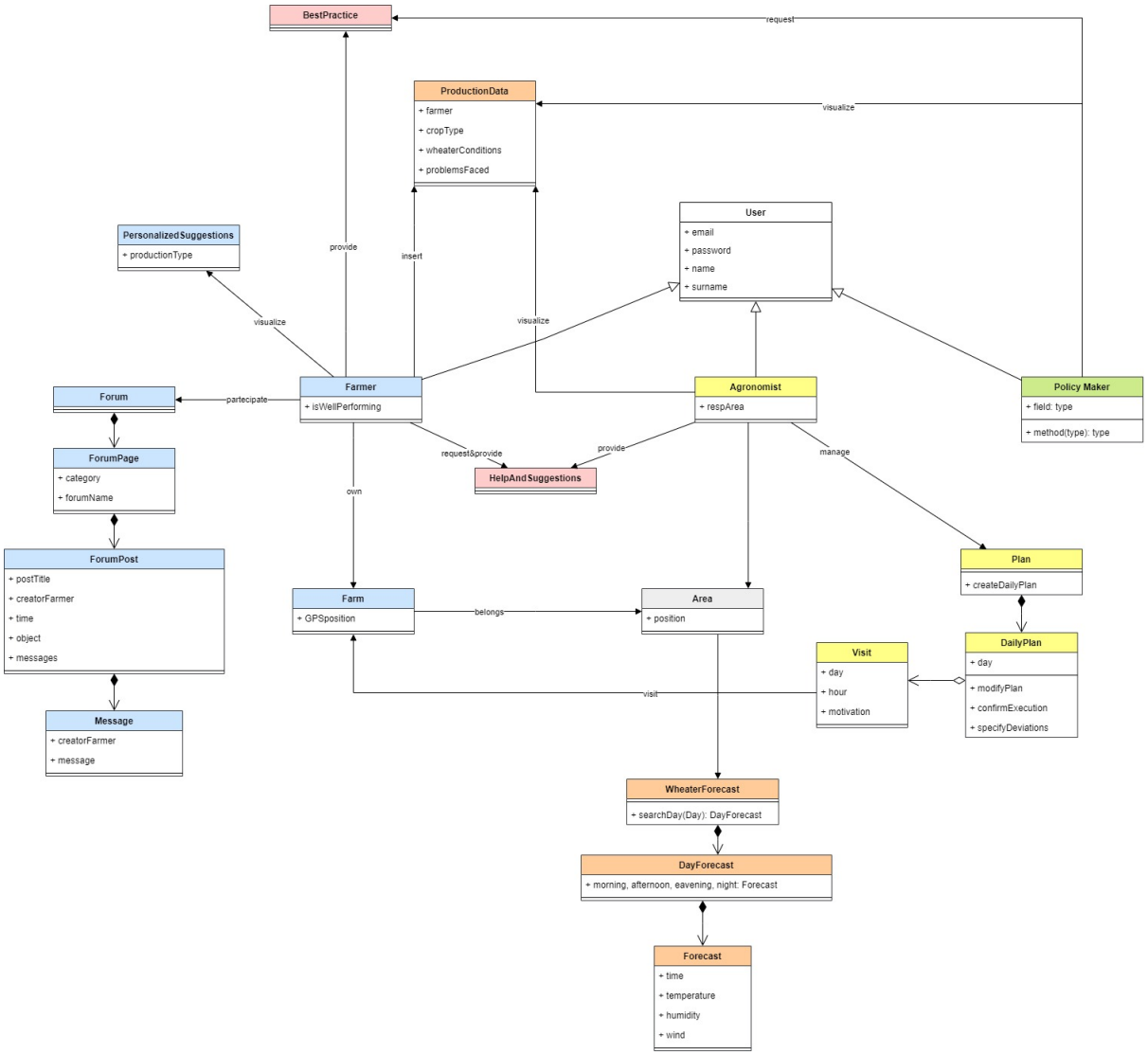
The main hardware interface of the system consists in an internet connection from smartphone/pc/tablet in order to access the functionalities provided.

2.1.4. Software Interface

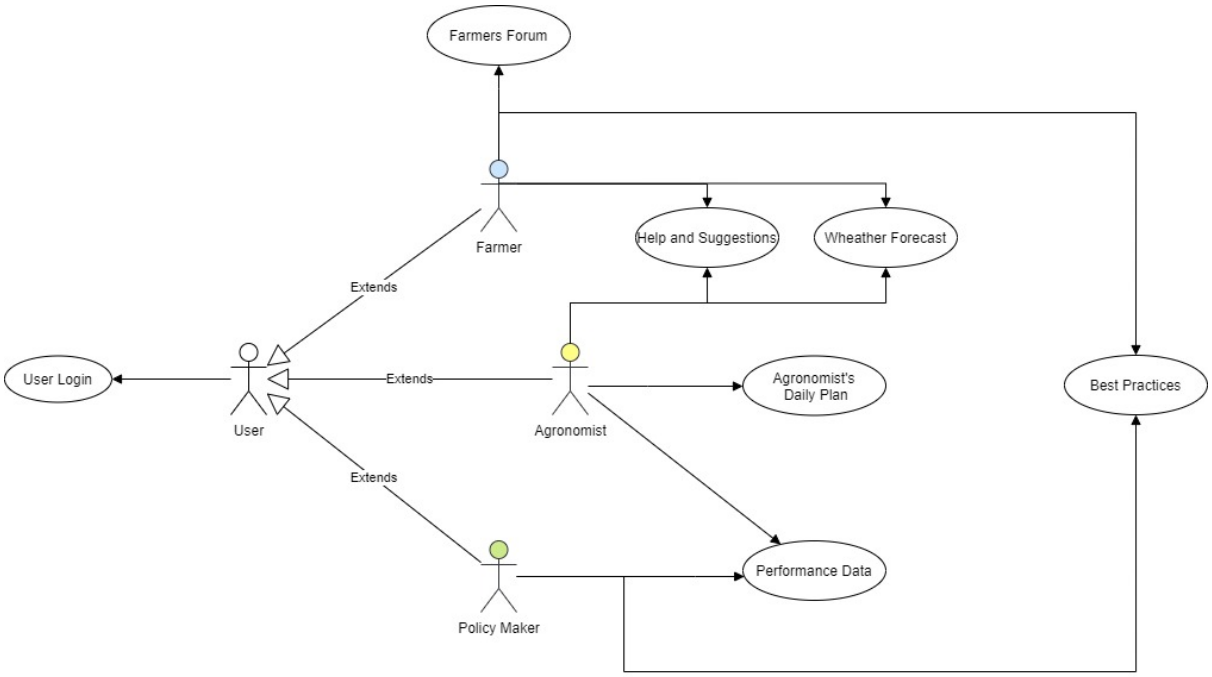
The mobile application must support Android and iOS. The web application works on any web server that supports Java.

The back-end stores its data in a RDBMS and can run on every platform that supports the JVM.

The back-end must over programmatic interfaces (APIs) for user interfaces and external modules.



class diagram



Use-case diagram

2.2. Product functions

General user can:

- Login
- Signup

Farmers can:

- Visualize relevant data
- Insert data about production and problems in the system
- Request for help and suggestions
- Participate in a discussion forum

Agronomists can:

- Receive and answer to farmers requests for help
- Visualize and update the daily plan
- Confirm the execution of the daily plan
- Specify the deviations from the daily plan

Policy makers can:

- See information about crops and farmers
- Select well performing farmers and ask them best practice
- Select bad performing farmers and send them suggestions

2.3. User characteristics (Actors)

2.3.1. Farmer

It’s a person engaged in agriculture, who is responsible for planting, cultivating, and managing plantations. In its work, it must take into account weather forecasts and personalized suggestions received by other farmers in order to make its production perform at its best. In addition to this, it should ask for suggestions if it has a problem, and help other farmers to resolve their own problems.

2.3.2. Agronomists

It’s a person responsible for monitoring and visiting the farmers under his area of responsibility. Its job is to plan the visits to the farmers, by taking into account that every farmer must be visited at least twice a year.
The primary role of agronomists are in research for the benefit of farms and food; they can provide technical advice for farmers such as in making crop calendars, prescribing fertilizers to avoid misuse, in order to optimize farm production.

2.3.3. Policy makers

It’s a person responsible for identifying those farmers who are performing well to take their best practices, and those farmers who are performing badly to help them. Its aim is to monitor the results of the work of the agronomists, in order to understand if the steering initiatives are producing good results.

2.4. Assumptions, dependencies and constraints

2.4.1. *Assumptions*

D1: Users (farmers, agronomists, and policy makers) do not insert false information in the system.

D2: Farmers reply as best as they can, giving the best advice, to requests for help and suggestions by other farmers (without providing unthruts).

D3: Agronomists know the area they are responsible for.

D4: Each area has at least one responsible agronomist.

D5: Each farm is assigned to a specific area and has a unique identifier.

D6: Users have access to a stable Internet connection (e.g. to visualize weather forecasts, to participate in a discussion, to send and receive help and suggestions).

D7: The location of a farm is known by the application, and the responsible agronomist is able to reach the farm.

2.4.2. Hardware constraints

The system has to run under the following worst-case conditions:

- App:
    - 3G connection, at 2 Mb/s
    - 100 MB of free space
    - 1 GB of RAM
- Web application:
    - 2 Mb/s Internet connection
    - 800x600 resolution