Agritology: A Decision Support System for Local Farmers in Malta and Palestine

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1. Introduction

We aim to provide a platform to act as a single-source of information to support decision making in the growth and cultivation of crops in local farms. The primary objective of our work is to promote sustainable development, by encouraging local farmers in Malta and Palestine to adopt seasonal and organic farming, in line with the second Sustainable Development Goal (SDG2) of the United Nations. Through SDG2, the United Nations aims to "end hunger, achieve food security and improved nutrition and promote sustainable agriculture". The secondary objective of this study is to promote the local language and terminology. Accordingly, the information on the dashboard will be displayed in English, Maltese and Arabic.

1.1. Research Questions

Following a thorough analysis of related work, we have defined the following research questions for this study:

1. **RQ1** – How to improve the sustainability of farming in Malta and Palestine?
2. **RQ2** – How to provide simple and efficient support for farming decision-making?
3. **RQ3** – How to preserve the ecosystem of the soil and improve its quality?

2. Methodology

The work required in realising this project can be divided into two main components: the development of the agricultural **ontology** and the implementation of the **dashboard application**. Competency questions were identified to be able to construct requirements and, at a later stage, evaluate our ontology.

Prior to developing the ontology, we carried out a data collection exercise through exploratory research. Data sources were considered relevant if they fulfilled the requirements according to the competency questions. The main data sources used are the following:

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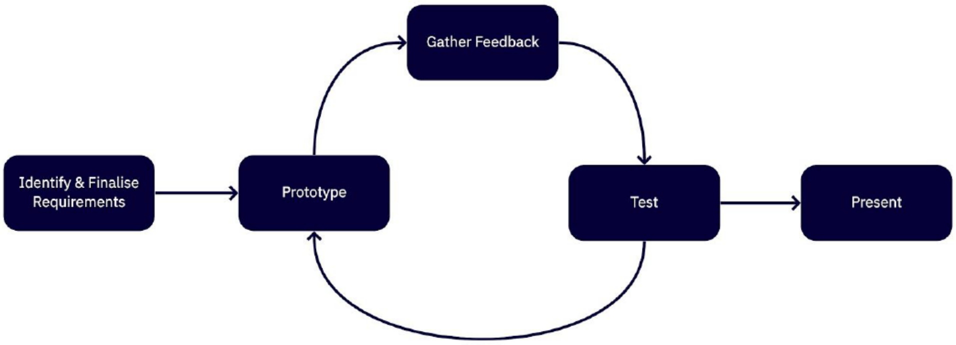

Figure 1: Rapid application development.

- Season log sheets of a local farm in Palestine (Omm Sleiman)
- Personal communication with local Palestinian farmer Yara Dowani
- Sharaka, a Palestinian volunteer-run initiative to support local farming
- Palestinian Agronomist Saad Dagher
- Friends of the Earth Malta [1]
- When2plant.com
- The Maltese Code for Agricultural Practice[2]
- We Eat Responsibly initiative by Nature Trust Malta[3]

In terms of dashboard application development, we have adopted a Rapid Application Development (RAD). It was conducted in five main steps, illustrated in Figure 1. Firstly, an analysis of the research area was conducted to identify and finalise requirements. This was followed by an iterative cycle of three steps: prototyping, gathering feedback, and testing. The final step involves the presentation of the final application.

3. User Flow and Dashboard

We employed an iterative prototyping approach to build the optimal user flow. Prototyping was conducted in three phases. Firstly, a user persona was defined to represent the target user of the dashboard, a set of wireframes were built using Figma[4], a collaborative prototyping software. Once the design was finalised, development on the user interfaces was initiated[5].

[1] https://foemalta.org/whats-in-season/
[2] https://agrikoltura.gov.mt/en/agricultural_directorate/Documents/nitratesActionProgrammeRegulations/ntr001.pdf
[3] https://www.ekoskola.org.mt/partners/we-eat-responsibly-nieklu-bresponsabbilta/
[4] http://figma.com/
[5] A semi-functioning prototype is available on: http://agritology.herokuapp.com

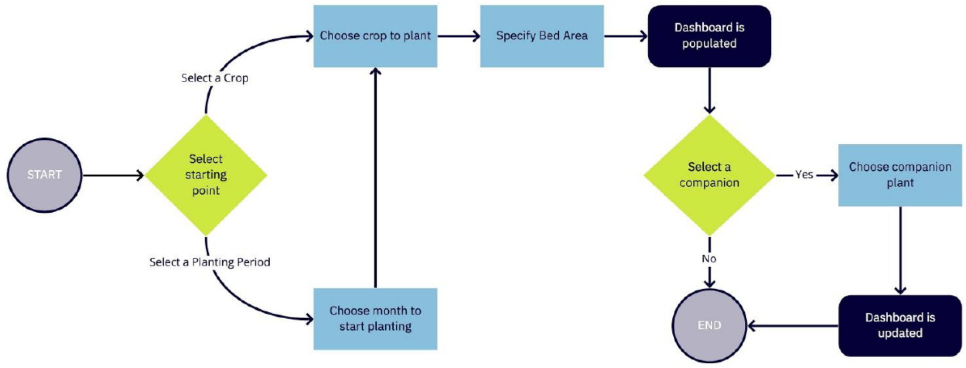

Figure 2: Flow chart of the core user journey.

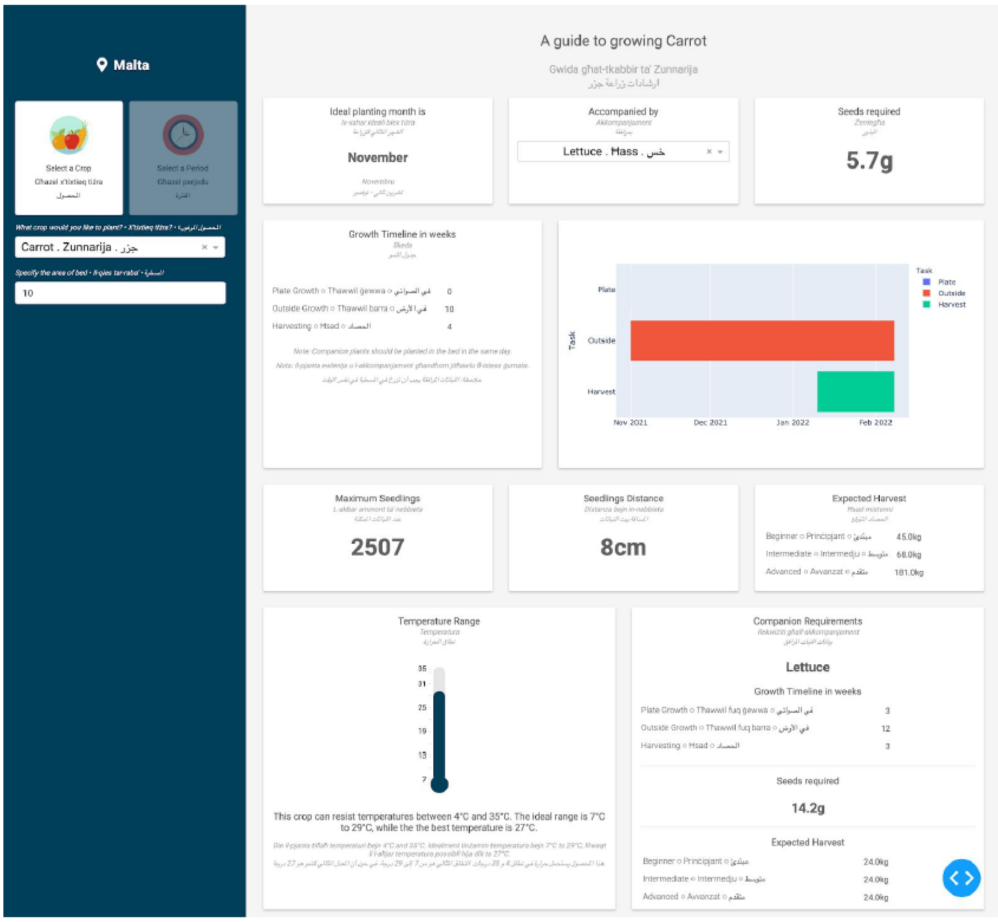

Figure 3: The Agritology dashboard.

4. Ontology

We constructed the ontology using Protégé 5.5.0, an open-source software developed by Stanford University. Agri ontology was implemented using the Web Ontology Language (OWL).

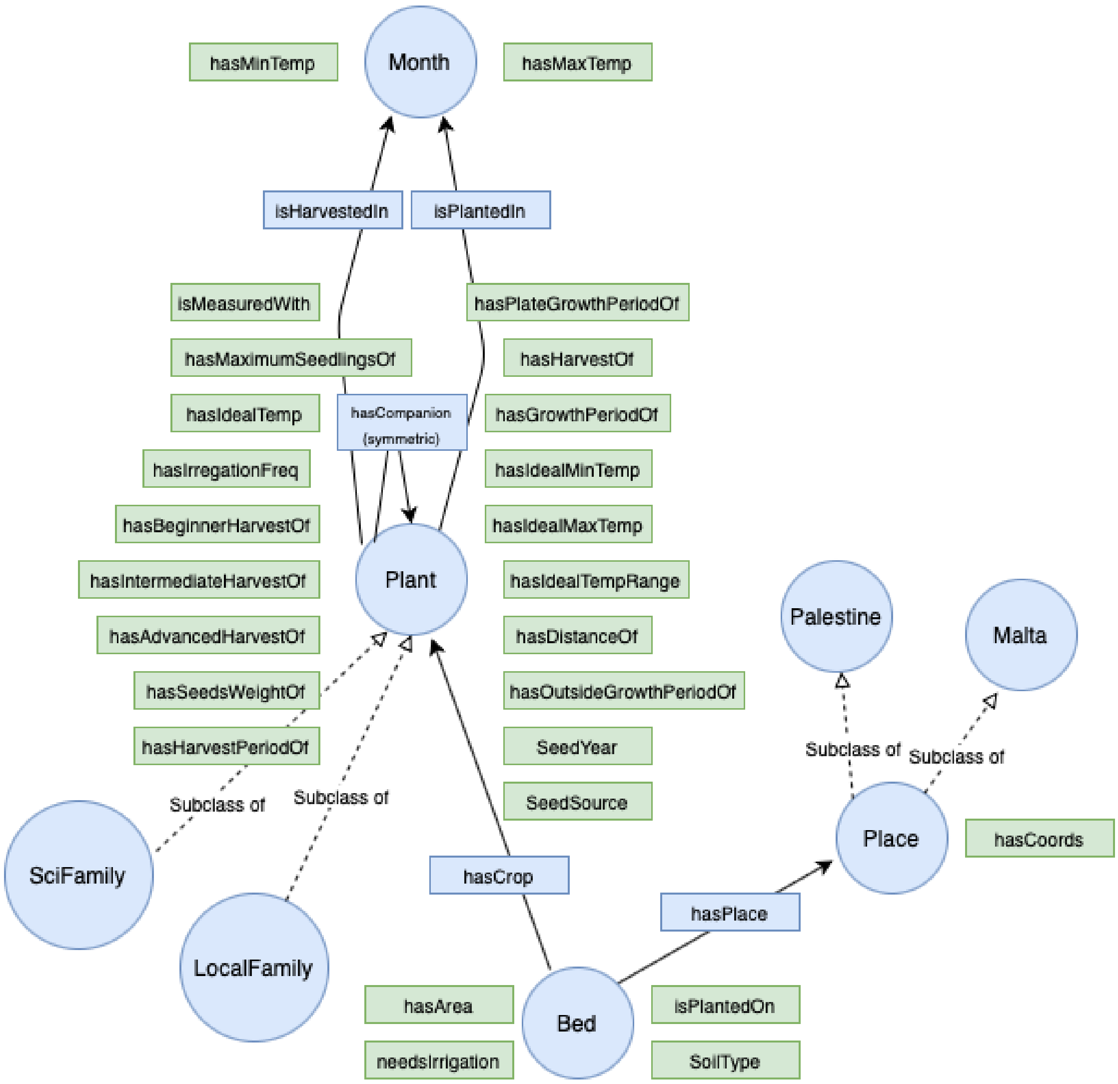

Figure 4: The full ontology is accessible on https://github.com/muslehm/Agritology/blob/main/agri.owl.

The annotations were used in the ontology to provide references that could help reuse the ontology in different contexts. It includes comments on data properties to clarify them. Furthermore, a Maltese and Arabic (Palestinian dialect) translations were provided using the *rdfs:seeAlso* annotation for all the instances created in the ontology.

5. Results

When evaluating the final ontology with the initial research questions, it can be concluded that it satisfies the initial research questions posed by this study.

An overview of how this was achieved in relation to the competency questions:

- In **RQ1**, we sought to find ways to promote and improve sustainable farming practices in Malta and Palestine. We took the approach of focusing on promoting seasonal farming through our decision support system. This is achieved in two ways, where the user can either opt to start the flow by selecting what to plant and get recommended the ideal planting season, or else, they can select when they would like to start and the application returns a list of what crops can be planted in that period.
  The ideal season is deducted from the assertion of minimum and maximum temperatures suitable for planting each crop. In contrast to asserting the month, this approach makes the ontology reusable for other applications that target different locations. We process this data compared to the location's climate data to infer knowledge about suitable seasons for each plant. The information provided can be more accurate; however, the achieved accuracy is acceptable within the time scope of this project. We compared the results inferred by the application to the season calendar retrieved from different sources. All inferences were within the acceptable range of the season.
- In **RQ2**, we focused on providing a simple and efficient support system for farming decision-making. The application relays data from the ontology in an intuitive manner. It covers the overall timeline of planting crops, from seed requirements to expected harvest amount. The app relies on commonly understood icons and terms that communicate information with less reliance on bulk text. Thus, we avoid confusions that inexperienced farmers might face. We reorganised the application to detect location automatically, and hence making the application more efficient. This functionality is based on the assumption that while looking for the relevant information, our target user will be at the actual location where they would like to plant the crops.
- In the last research question, **RQ3**, our aim was to provide information related to the preservation of the ecosystem of the soil and improvement of its quality. Our application achieves this through companions, where it suggests other crops that can be planted together with the main crop to improve the quality and nutrition of the soil. Moreover, the ontology that we have developed can be employed to implement further functionality in the dashboard application, specifically for identifying fertiliser needs for the soil and further improve its quality.

We can conclude that our work fulfills the research objectives posed by this study, as we have presented a solution which promotes sustainable farming in Malta and Palestine, while also providing a simple and efficient support for decision-making.

The dashboard application has significant potential for future work and expansion in the field. Firstly, the decision-support system could extend to include soil testing, an aspect which is already catered for through the ontology that we have built. Moreover, the ontology could be extended to enable the application to advise farmers on irrigation decision-making.