Project requirements

(Version 1.2)

LEI - 2022/2023 - 1st Semester, 2nd Year

Abstract: This document describes the requirements of the project to be developed in the context of the Integrator Project of the courses ARQCP, BDDAD, ESINF, FISIAP and LAPR3. The work consists in the development of an IT solution that supports the management of a company responsible for the management of an organic farm. This document briefly presents: the specificities of Organic Farming; a farm and its components and the key documents in the conduct of the agricultural installation, the Field Notebook and the Irrigation and Fertilisation Plan; finally, the functional and non-functional requirements of the solution to be developed are presented, as well as how to operate and technical details of the project.

1. Project

In this project, students should be able to analyse, design and implement a computer solution that supports the management of a company responsible for the management of an agricultural facility in organic production mode (OPM). This project works as proof-of-concept and encompasses a set of critical aspects in the management of a farm in OPM, namely: the management of parcels (fields), crops, irrigations, marketing of agricultural products in network, management of information collected from meteorological sensor, and dimensioning and use of agricultural warehouses in need of controlled temperatures.

An iterative and incremental development process will be used. Therefore, an Agile scrum-based methodology should be used to manage teamwork in each four-week sprint.

The solution to be developed should consist of three applications developed in, PL/SQL, Java and C/Assembly, respectively. In order to increase the maintainability of the solution and respect good software development practices, the implementation should follow a Test-Driven Development (TDD) approach.

2. Problem Description

This section describes the problem to be solved, the development of an IT solution that addresses some of the critical aspects in the operation of a farm in organic mode. In this way, organic farming and its specificities are presented, characterisation of a farm and its components inincluding irrigation systems and meteorological stations for agriculture. The most common marketing models in this form of agriculture are also presented.

1.1. Organic Farming

Organic Farming, also called Organic, is a form of food practice that is based on sustainability and agro-ecological and social responsibility. This model is advocated by the United Nations as capable of generating food for humanity in a sustainable and fair way.

Figure 1: Biologic Agriculture
source: http://www.drvplvt.mvmvot.pt/DRAPLVT/

Organic Farming makes it possible to reverse agricultural massification, with soil as the support of the entire food chain, allows farmers to promote the health of the agricultural ecosystem, since this mode of production promotes biodiversity, biological cycles and biological activity of soils. The practice of crop rotation, the use of organic fertilisers, the cultivation of indigenous varieties and their intercrop, as well as the use of biological control against pests, fosters an interaction between soil, crops, animals and people, which form thus, an ecosystem where everyone influences themselves, ensuring sustainability, as well as the preservation of soil and the environment.

As a result of the adverse consequences that the agro-industrial model has had on the environment and the social fabric (particularly in the least developed countries), in recent decades there have been multiple projects/companies that aim to work in organic farming[1].

Organic Farming is characterized by:

- Follow a polyculture logic (multiple crops in the same agricultural facility) and on a smaller scale, in multiple cycles throughout the agricultural year with the aim of keeping the system in balance and reducing the number and size of pests that can affect crops;
- Include animals in the production cycle because they are elements that in addition to and produce goods of great economic and food value such as eggs, meat and honey, play a key role in the control of weeds and pests, conducting pollination and fertilisation of crops
- Combining ancestral agricultural techniques (such as soil stuffing, green fertilization or cultural rotation) with the latest technologies that allow: monitoring plant health, soils and climatic conditions; produce energy (e.g., solar or wind electricity, solar thermal sources or composters); use water efficiently; reduce the amount of supplies to be supplied to the soil and consequently reduce the environmental impact of agricultural activity.
- Favour short consumption chains (this means that there are few or no intermediaries between producer and final consumer)
- Promote cooperation through marketing networks that aggregate multiple small operators
- Protect common resources such as water, atmosphere and soils.

1.2. Agricultural Facility

An agricultural installation, or farm, is typically a farm consisting of a set of plots and buildings. The buildings they can be: animal stables, garages for machinery and tools, warehouses for buildings, inputs (e.g., fertilisers) and animal feed, and irrigation systems including agricultural tanks.

1 For example, in Europe, according to Eurostat data for 2019, 8.5% of the agricultural area was already in Organic Production Mode (OPM), with growth of 46% compared to 2012. Countries such as Austria and Sweden already have more than a fifth of their agricultural area in OPM.

Figure 2: Aerial view of a farm

- Agricultural Plot - the sectors, also called sectors or fields, are characterized by a designation, area (ha) and crop (e.g. apple tree, pear tree, wheat, beans).
- Culture – a plant species used in agriculture for the purpose of being consumed by humans/animals (e.g. flowers, fruits, cereals, vegetables, fodder) or para produce green fertilization. A crop may be of a permanent type (e.g. fruit trees such as pear trees or apple trees) or temporary (e.g. vegetables or fodder).
- Inputs – inputs are all products that are applied to soil or plants in order to improve and nourish soil and plants, prevent diseases, correct imbalances, and combat pests and diseases. They can be classified as fertilisers, correctives or phytopharmaceutical products. A particular product is characterized by trade name, formulation (liquid, granules, powder) and data sheet (which includes, among others, a list of elements and substances in the product and their quantities).

ELEMENTOS NUTRITIVOS ORGÂNICOS	
Azoto (N) orgânico	6%
Pentóxido de fósforo (P_2O_5)	15%
Óxido de potássio (K_2O)	2%
Óxido de cálcio (CaO)	10%
Óxido de magnésio (MgO)	2%

SUSTANCIAS ORGANICAS	
Carbono de origem biológica (TOC)	35%
Matéria Orgânica	60%
Ácidos húmicos	3,5%
Ácidos fúlvicos	7,5%
Humidade	7%
pH	6,5
Peso específico	0,8 kg / L
Formulação peletizada	Ø3mm

Figure 3: Example of a fertilizer - Guanito [source: https:// www.crimolvrv.pt]

1.3. Irrigation system and weather stations

A irrigation system is a set of equipment capable of delivering water or aqueous solutions containing inputs (e.g. fertilizers) to crops. The size and complexity of these systems can vary greatly depending on multiple factors, in particular the size of the holding, the number of production plots, the quantity and quality of the water used, the variety of inputs used.

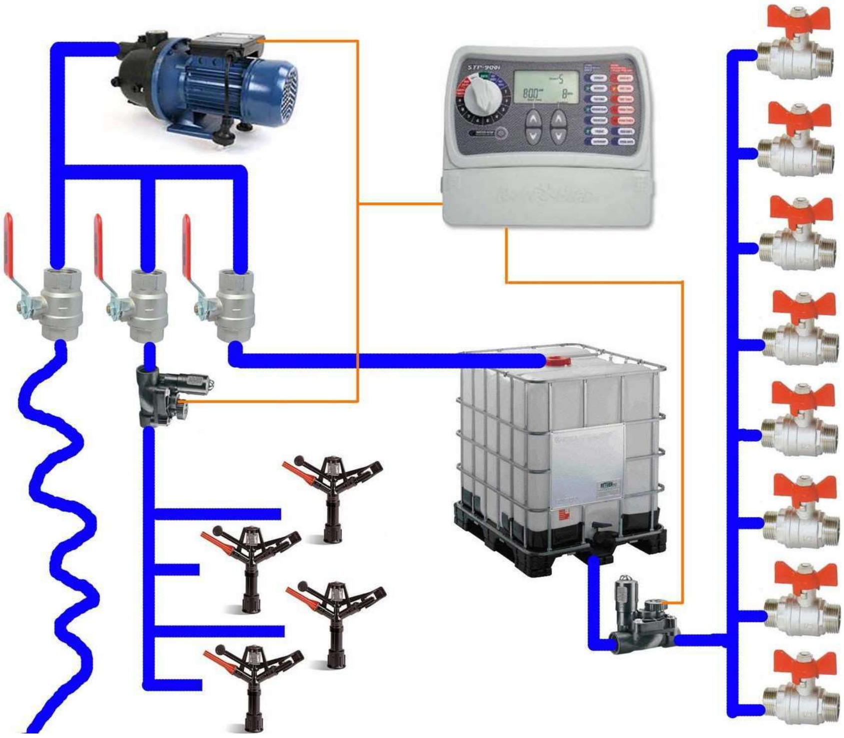

Figure *4: Simple schema of a watering system*
[source: https://forumdvcvsv.com/]

Watering can be performed by gravity, when there is a gap between the source and the crops, or pumped (through hydraulic pumps). The distribution itself can be made by spray, drip or spray, in functions of the needs of the different crops. Water is transported along the farm through a piping system (primary) and then distributed in the plots by smaller (secondary) pipes. The system also includes different filters needed to keep the pipes, sprinklers, drippers and/or sprays free of microalgae and sediments that water can carry. The controller is a fundamental element of the irrigation system because it allows, through a set of electrovalves ,to supply water or an aqueous solutions according to an irrigation plan. In this plan is defined an order with the plots to be watered, the watering times (convertible into amount of watering) and the periodicity with which the watering is carried out in each plot.

A weather station consists of a set of sensors that allow to measure atmospheric quantities such as wind, temperature, humidity, radiation and pressure. These stations are now a very important element for sustainable operation. An adequate forecast of weather conditions, such as wind, humidity and temperature, allows the amount of water required to be adjusted in the irrigation as well as to avoid the application of production factors that could be leached in the event of rain after application. This adequacy can entail very significant savings in terms of water, energy and inputs.

Figure 5: meteorological station [source: http://www.florencaagro.com.br/]

The main sensors installed in a weather station for agriculture are:

- Rainfall sensor
- Soil temperature sensor
- Soil moisture sensor
- Wind speed sensor
- Temperature, air humidity and atmospheric pressure sensor

1.4. Marketing and Distribution of Agricultural Products

In the context of Organic Farming, short and local consumer chains are privileged, ideally without intermediaries between the farmer and the consumer. The reasons for this are essentially, reduction of environmental costs associated with transport of food over long distances (called food tourism), preservation of food quality, creation of links between consumers and producers, and guarantee of a fairer economic return for the farmer.


Figura 6: Local markets[source: https://grandeconsumo.com/tvg/biologicos/]

There are multiple ways to market and distribute food produced in this form of agriculture. In addition to the simple direct sale to the consumer, on the farm or in local markets, there can be others like Consumer Groups, AMAPs[2] and also network distribution often based on Portals and computer solutions (e.g., Prove[3] or *Good Food Hub*[4]) that have the ability to aggregate multiple consumers and producers.

1.5. Field Notebook and Irrigation and Fertilization Plan

Depending on the installed crops, a (typically annual) plan of irrigation needs, mineral corrections and fertilisation throughout the agricultural season is defined. These applications can be carried out by foliar route (spraying of crops), through the irrigation system or direct application to the soil. The applications to be carried out discriminate the parcels, crops, planned dates, inputs and their quantities.

The Field Notebook is a formal document (mandatory) that allows recording all relevant agricultural operations that occurred on the holding, in particular:

- fertilisation (or application of any Permitted Production Factor) carried out by: foliar route, watering or direct application to the soil with discrimination of the factors and quantities applied, date of realization, parcel. This registers the entries of the Irrigation and Fertilisation Plan carried out as well as extra (unplanned) actions;
- Summary of data collected from weather and soil sensors
- Registration crops included product , harvested quantity, date and parcels
- Executed waterings, quantities, date of realization, parcel.

2 AMAP - Proximity Agriculture Maintenance Association - https://amap.movingcause.org/ CSA - https://communitysupportedagriculture.org.uk/

3 http://www.prove.com.pt/www/

4 https://goodfoodhubs.pt/

1.6. System users

This system can potentially be used by multiple users, namely:

- Agricultural Manager - person who manages crops in the plots , carries out the different cultural actions and registers them in the Field Notebook
- Customer - person who orders and consumes agricultural products, distributed in the form of
- Driver – person collecting the products on the farm and deposits them in the Distribution Hubs
- Distribution Manager - person who manages process of collection and transport of agricultural products between farms, Hubs and subsequent collection by customers

3 Minimum Viable Product

The purpose of this project is to develop a Minimum Viable Product in an iterative and incremental way, so the work will be divided into two Sprints:

- Sprint 1 - November 7 to December 4
- Sprint 2 - December 5th to January 8th

A description of PVM is provided for each sprint. Teams must follow the us provided and take into account their thread and their dependencies and at the end of each sprint each team must be able to meet the specified requirements. Teams should be able to add USs to the backlog, prioritize them accordingly, and distribute them to team members.

3.1 Databases (BDDAD)

In this component, a database is designed to model a farm to support the following user stories (US).

3.2.1 Sprint 1

US201 – As a project manager, I want the Team to define the naming conventions for all elements, either tables or code. Naming conventions can evolve as the database or programming objects are created. The nomenclature convention guide shall be organised in such a way as to make it easy to maintain.

Acceptance Criterion [BDDAD]

1. There are clearly defined naming conventions for creating Databases and Database objects. The minimum set includes tables, attributes, constraints, primary and foreign keys.
2. Naming conventions should be easy to understand and complete.

US202 – As a Project Manager, I want the Team to develop the necessary data model to support the required functionalities and fulfil the purposes of the PL/SQL system to be developed, that is, (A) configure the structure of the farm specifying its sectors and the characteristics of each sector; (B) manage customers and sales; (C) maintain a field notebook to record all relevant agricultural operations carried out on the property and (D) implement a basic panel to support business analysis. This data model should be designed following a systematic methodology of data modelling.

Acceptance Criterion [BDDAD]

- The result should include (1) the logical data model according to the Database technology to be used, (2) the physical data model to be implemented in the selected DBMS, (3) a data dictionary describing the relevant details of the database elements, and (4) a clear and concise justification that justify the selected Database technology.
- You can run a SQL script to create the database schema completely and consistently without errors.

- The data models generated at each of the three levels of abstraction (conceptual, logical, and physical) map only the concepts and characteristics that are significant according to the corresponding level.
- Each of the data models is consistent with the previous one, that is, the logical data model respects the conceptual data model, and the physical data model respects the logical data model.
- The conceptual data model is a valid view/representation of the UoD.
- The notation used for each of the data models is adequate, consistent , and follows specifications.

US203 – As a Project Manager, I want the Team to sketch out a SQL script to test whether the Database verifies all the data integrity constraints necessary to comply with UoD's system objectives and business constraints.

Acceptance Criterion [BDDAD]

- There is a catalogue of clearly indicated data integrity restrictions grouped by type (Domain, Identity, Referential, Application).
- For each data integrity constraint in the catalogue there is a set of SQL statements that verify/test the constraint.
- All SQL statements in the data integrity check script are accompanied by a comment that describes the expected result (Approved or Disapproved; the latter is presented with a justification).

US204 –As a Project Manager, I want the Team to create a SQL script to load the Database with a minimum set of data sufficient to perform the health check data and functional tests. This script should generate a summary report providing the number of tuples/rows that the script inserts into each interface/table.

Acceptance Criterion [BDDAD]

- The bootstrap SQL script runs and loads the database as expected without errors.
- The bootstrap report is generated.
- The bootstrap report is correct, that is, all tables are mentioned and their cardinality is correct.

US205 – As an Agricultural Manager, I want to manage my clients, companies or individuals, who buy the goods produced on my farm. A customer is characterized by an internal code, name, tax number, email, mailing address, delivery address, credit limit, number of incidents, date of the last incident, number of orders placed in the last year, total value of orders placed in the last year. The address must include the postal code that is used for sales analyses.

The credit limit is the maximum credit of the customer – customers cannot have a total amount of orders pending payment higher than their credit limit. Incidents – payments for orders that were not made on the due date, are characterized by customer, amount, date on which they occurred and date on which they were resolved and must be registered. Each customer is assigned a level (A, B, C) that characterizes their value to the business. Customers who have no reported incidents in the last 12 months and who have a total sales volume (paid orders) in the same period of more than €10,000 are level A; customers with no incidents reported in the last 12 months and who have a total sales volume (paid orders) in the same period of more than €5000 are in level B; customers who have incidents reported in the last 12 months are level C regardless of sales volume.

Acceptance Criterion [BDDAD]

- A user can insert a new Customer into the Database, with the data describing a customer, without the need to write SQL code. If the insertion is successful, the user is informed about the value of the new customer's primary key
- When the insertion process fails, the user is informed about the error that may have occurred.
- The administrator can run a procedure that updates the number and total value of orders placed in the last year by each customer
- Create a View that aggregates for each customer:
    - your level (A, B, C),

    - the date of the last incident – or the statement “No incidents to date” if there are no reported incidents
    - the total volume of sales (paid orders) in the last 12 months and
    - the total volume of orders already delivered but still pending payment.
- Implement a function that returns a customer's risk factor. A customer's risk factor is given by the ratio between the total amount of incidents observed in the last 12 months and the number of orders placed after the last incident and still pending payment. For example, a customer who has a total of €2400 in incidents and has placed 3 orders after the last incident that have not yet paid has a risk factor of €800 (2400/3)

US206 – As an Agricultural Manager, I want to keep the structure of my farm – containing a set of Sectors – up-to-date, that is, I want to specify each of the Sectors. Its characteristics, such as type of cultivation and cultivation, must be configured.

Acceptance Criterion [BDDAD]

- A user can create Sectors in an organic farm by specifying their characteristics.
- You can define new types of parameterized characteristics, such as culture type or culture among others.
- A user can list the Sectors of their farm sorted alphabetically.
- A user can list the Sectors of their farm sorted by size , in ascending or descending order.
- A user can list the Sectors of their farm ordered by type of culture and culture.

US207 – As an agricultural manager, I want to know how profitable the sectors of my farm are.

Acceptance Criterion [BDDAD]

- A user can list the Sectors of his farm ordered in descending order of the amount of production in a crop, measured in tons per hectare.
- A user can list the Sectors of his farm ordered in descending order of net production per hectare in a given crop, measured in K€ per hectare.

US208 – As an Agricultural Manager, I want to keep the production factors classified by type (fertilizer, mineral corrective, phytopharmaceutical product, etc.), including the technical data sheet – which should be stored in the database.

Acceptance Criterion [BDDAD]

- A user can configure production factors.
- It is possible to keep a technical sheet similar to the one in Fig. 3.
    - The data model includes the tables needed to persist datasheets
    - The code was created to persist a technical file (commercial name, supplier, type of production factor) and each of its elements (category, such as ORGANIC SUBSTANCES, substance, quantity and unit)

US209 – As an Agricultural Manager, I want to manage the orders made by my clients.

Acceptance Criterion [BDDAD]

- A user can register orders from a given customer (orders), requesting that delivery be made to a given address that will be the customer's delivery address (default). However, a specific address may be indicated for each order, on a given date. Check customer’s credit limit.
- A user can record the delivery of an order on a given date. It is assumed that the order is delivered in full; partial deliveries are not supported.
- A user can register the payment of an order on a certain date.
- I can list orders by status (registered, delivered, paid) – order registration date, customer, order

number, total amount and status.

3.2.2 Sprint 2

US210 – As Agricultural Manager, I want to manage the calendar and record the execution of agricultural operations on my farm. Agricultural operations can be of various types, such as irrigation and fertilizing or application of any permitted Production Factor. For each operation, it is necessary to record several details, such as the form of application (foliar, watering or soil), the products and quantities applied, the date of realization, etc. The application of production factors may be subject to certain restrictions dependent on the Sector; that is, some production factors may not be allowed in certain Sectors of a farm during a given period. These restrictions often vary depending on the geographical area and the period of application. These restrictions must be checked at the time of booking an operation and one week before applying it.

Acceptance Criterion [BDDAD]

- I can record a concrete operation to perform on a certain date and maintain a schedule of operations.
- Restrictions on the application of production factors are checked when marking an operation on the calendar.
- Restrictions on the application of inputs can be checked one week before their application.
- I can list all the restrictions of production factors that apply to a particular Sector of my farm on a given date.
- I can list all planned operations on my farm during a certain period by sector, sorted in chronological order.

US211 – As Agricultural Manager, I want to adapt/reschedule the operations planned for my farm according to the data acquired from the sensors in the field (temperature, humidity) and meteorology.

Acceptance Criterion [BDDAD]

- Any operation that has not yet been performed can be cancelled.
- Any operation not yet performed can be updated in any of its parameters (date of application, quantities, products to be applied, etc.).
- Any operation already performed cannot be cancelled or updated.

US212 – As an Agricultural Manager, I want to prepare my system so that, in the future, planned operations can be automatically adapted to weather conditions. To do so, I want to start by persisting in my database the values recorded by the sensors that are available in a table that is updated with the following information:

- sensor identifier (string with 5 characters),
- sensor type (two-character string),
- read value (integer between 0 and 100 for any sensor),
- reference value (integer, is useful for each sensor)
- instant of reading (date, time, minute in HH:MM format).
- the sensor type is characterized as follows:
  - HS - Soil moisture sensor
  - Pl - Rainfall sensor
  - TS - Ground Temperature Sensor
  - VV - Wind Speed Sensor
  - TA - Atmospheric temperature sensor
  - HA - Air Humidity Sensor

    - PA - Atmospheric pressure sensor

The table in which these readings are recorded has the following schema `input_sensor(input_string VARCHAR(25))`.

Acceptance Criterion [BDDAD]

- There is a function that returns the nth element of each tuple of input_sensor
- It is possible to transfer sensor readings to a set of tables in 3NF. Successfully transferred input_sensor records are removed from that table.
- Only input_sensor records validated according to the specifications are transferred.
- If the input_sensor table has records with formatting errors, these are identified and are not transferred to the tables in 3NF. The input_sensor table is processed in its entirety, but only records without errors are introduced into the set of tables to be created for this purpose.
- Each sensor data reading process is registered by inserting the following data: date and time of execution of the process, number of read registers, number of inserted registers (without errors) and the number of registers not inserted due to errors of formatting.
- With regard to records not inserted due to formatting errors, it is also necessary to persist the sensor identifier and the number of identified errors caused by each sensor.
- As soon as a file reading process is completed, a summary of the process is displayed, showing: the total number of records read, the number of records transferred (without errors) and the number of records not transferred due to formatting errors .

US213 – As agricultural manager, I want to have access to audit clues of agricultural operations planned or carried out in a particular sector of my farm, that is, I want to have access to a list of all changes made to the database, in chronological order. For each change I want to know: the user/login that made it, the date and time the change was made, and the type of change (INSERT, UPDATE, DELETE).

Acceptance Criterion [BDDAD]

- There is a table for recording audit clues, i.e. for the recording of all writing operations in the database involving a particular sector of my farm.
- The appropriate mechanisms for recording write operations (INSERT, UPDATE, DELETE) are implemented.
- A simple and effective audit trail consultation process is implemented.

US214 – As an Agricultural Manager, I intend to develop a data model to build a Data Warehouse for production and sales analysis. The facts to be analysed are "production in tons" and "sales in thousands of euros". The dimensions to consider are Time, Sector, Product and Customer. The Time dimension has a hierarchy with the following levels: Year, Month. The Product dimension is subject to the following hierarchy: Culture type, Culture. An estimate of the superior cardinality of the tables of dimensions and facts should be indicated and justified/commented.

Acceptance Criterion [BDDAD]

- The fact tables are properly identified and described.
- The dimension tables are properly identified and described.
- The Star or Snowflake model is consistent with the purpose of the data warehouse, as well as with the fact and dimension tables identified earlier.
- The estimation of cardinalities is consistent with the data model and duly justified .
- A SQL script to load the Star/Snowflake schema with enough data to support a proof of concept is available and runs without errors.
- A SQL script to query the data warehouse and support a proof of concept is available and runs without errors. This script answers the following questions:
    - What is the evolution of the production of a given crop in a given sector over the last five years?

- Compare one year's sales with another?
- Analyze the evolution ofmonthly sales by crop type?

3.2 Non-functional requirements

This section describes some of the non-functional requirements that should be considered when implementing the project.

- The validation of business rules that must be respected when recording and updating data.
- The Database will be the main repository of system information and should reflect the necessary data integrity. The information should be persisted in a remote DBMS.

4 Technical Details

4.1 Integrated Project

Updated version of this statement and additional information on the moodle page of the Integrated Project.

(https://moodle.isep.ipp.pt/course/view.php?id=4119)

Each group must create a repository in the *bitbucket* with the name:

- sem3pi2022_23_gXXX xxx being replaced by the group number. Read permissions should be granted to teachers.