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Trabajo Fin de Grado

DESIGN AND IMPLEMENTATION OF A WEB SERVICE FOR OLIVE GROVE MANAGEMENT

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Dedications

My sincere gratitude and warmest greetings go to my grandmother "Saida" to whom I dedicate this work, who inspired me to be strong despite many obstacles in life and supported me with her prayers.

I also dedicate this work

-To my beloved parents Hiba and Moez, they did not stop believing in me, and in my ability to dare to take a stand and make a difference in my life.

Thank you mom and dad for your understanding, your moral and financial support and for your Eternal Love.

-To my dearest sister "Dina" who teases me all day long. You made my world better, you are irreplaceable. To my little brother Omar who supports me despite his young age.

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I would never forget to express my warmest thanks to my relatives who shared with me the moments of joy and difficulties and especially for being always understanding throughout this project.

SUMMARY

List of Figures

List of Tables

List of Abbreviations

APIs: Application Programming Interfaces

ARVI: Atmospherically Resistant Vegetation Index

CDM: Conceptual Model Data

CSS: Cascading Style Sheets

DEM: Digital Elevation Model

DTM: Digital Terrain Model

EPSG: European Petroleum Survey Group

ETRS: European Terrestrial Reference System

GCP: Ground Control Point

GNDVI: Green Normalized Difference Vegetation Index

GNSS: Global Navigation Satellite Systems

GPS: Global Positioning System

HTML: HyperText Markup Language

HTTP: Hypertext Transfer Protocol

Kg: kilogram

NDRE: Normalized Difference Red Edge index

NDVI: Normalized Difference Vegetation Index (NDVI)

NIR: Near-Infrared

NTRIP: Network Transport RTCM via Internet Protocol

PA: Precision Agriculture

PF: Precision Farming

PHP: Hypertext Preprocessor

Qgis: Quantum Geographic Information System

RGB: Red-Green-Blue (colors used in television transmission)

RPAS: Remotely Piloted Aerial Systems

RTK: Real-Time Kinematic

SQL: Structured Query Language

SRS: Supported Reference Systems

UAV: Unmanned Aerial Vehicles

UML: Unified Modeling Language

URL: Uniform Resource Locator

USA: United States of America

UTM: Universal Transverse Mercator coordinate system

VHR: Very High Resolution

VRA: Variable Rate Application

VRT: Variable Rate Technology.

ABSTRACT / RESUMEN :

- In this study, Geographic Information Systems (GIS) were used to analyze, evaluate and create maps from images obtained with UAV of a farm in the study area of the province of Jaen using multiple indexes such as NDVI, SAVI, and others that have good resolution for a vegetation area. This farm is characterised by rainfed olive groves with traditional tillage where a Design and implementation of a web application was made to integrate spatial information and other variables, in order to jointly evaluate the values obtained through representative maps and advanced queries, wich will allow the farmer to access useful information about his farm at different levels of detail.

- En este estudio se utilizaron Sistemas de Información Geográfica (SIG) para analizar, evaluar y elaborar mapas a partir de imágenes obtenidas con UAV de una finca agrícola en la zona de estudio de la provincia de Jaén utilizando múltiples índices como el NDVI, SAVI, y otros que tienen un buen resultado para una zona de vegetación. Esta finca se caracteriza por ser de olivar de secano con labranza tradicional donde se realizó un Diseño e implementación de una aplicación web para integrar la información espacial y otras variables, con el fin de evaluar conjuntamente los valores obtenidos a través de mapas representativos y consultas avanzadas, para permitir al agricultor acceder a información útil sobre su finca a diferentes niveles de detalle.

I. INTRODUCTION

The culture of agriculture is complicated and requires a lot of attention from the farmers, especially when it comes to farming olive trees, which is a very important topic in Spain, since it’s the world's leading olive oil producer, although the highest concentration is in Andalusia. In this topic particularly, many geomatics tools usefully provide optimised solutions helping for a better management of the farms, so every farmer can deal easily with his own land. Those tools can shows many details and coordinates that can be discovered for each tree, which is part of the study of our subject.

The processing, analysis of information and generation of map products from images obtained by Unmanned Aerial Vehicles related to a farm are extremely useful in the decision making on how to improve production and avoid harmful agricultural practices. The use of high spatial and temporal resolution data of an area, facilitates a comprehensive analysis of the farm at different scales.

An analysis was conducted by combining geomatic tools, spacial analysis and web mapping with development of a website to characterize and identify the vegetation in the study area. The processed maps were used to make our results wich are accessible in a website that presents a web mapping page showing all the analysed data, allowing the farmer to access and see all of the information related to his own farm.

I.1 University of Jaén

I.1.1 Presentation

The Institution of Jaén (Universidad de Jaén in Spanish) is a public research university in Jaén, Andalusia, Spain as its shown in the Figure 1.

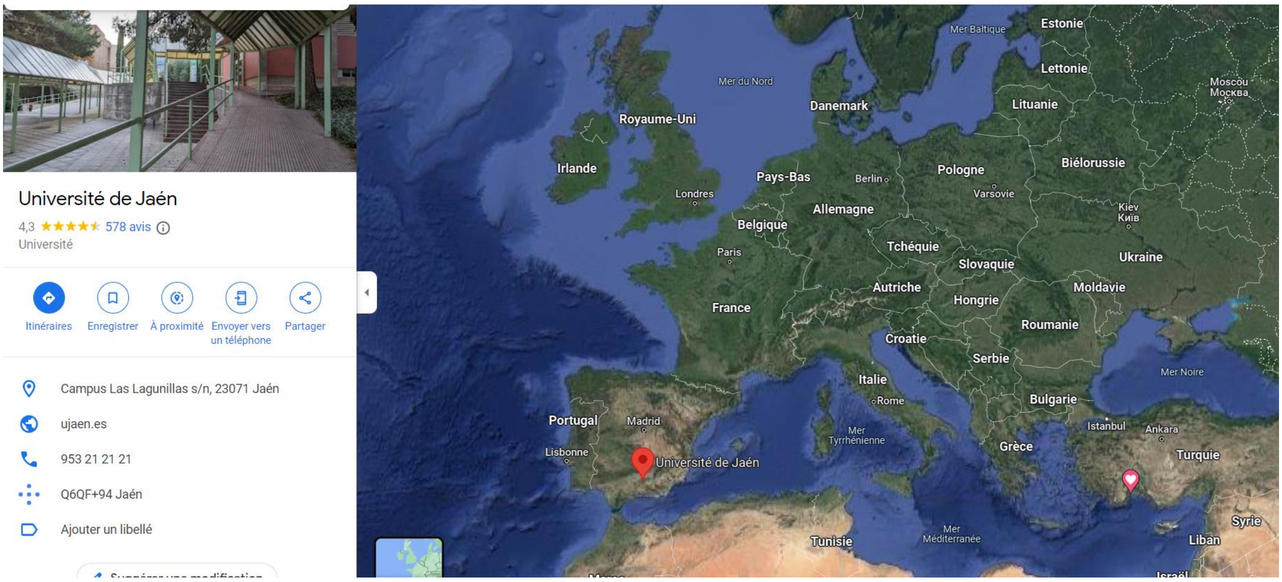


Figure 1 : The location of the university of jaén

Source : Taken from 'Google Map' Website

According to Reuters Higher Education Effect Rankings published in 2021, the university is still ranked among the top 100 universities in the world for adhering to the United Nations' Development Goals, which emphasize research, stewardship, communication, and education.

The Lagunillas Campus is located in the city of Jaéns northwestern outskirts, between major thoroughfares such as Madrid Road, Bailen-Motril A-road, Torrequebradilla Road, and Ben Saprut Avenue. That's where the majority of the University of Jaéns courses take place, as well as the main administrative offices.

The campus is composed into several structures, the most important being :

A-1 : Centre for Animal Experimentation and Animal Facilities

A-2 : Teaching labs and Technical research services

A-3 : Department of Engineering and Technology Building.

…

I.1.2 History of the University

The Jaén University Campus Technical & Academic Committee was established in May 1992, which helped to lay the ground for the University of Jaén (UJA) to be formally established on July 1, 1993, in accordance with Law 5/1993 from the Andalusian Parliament. On September 7, 1993, a management committee was established, and their their job was to build the University of Jaén from the ground up. But the University of Jaéns' origins can be found in both the modern era and the

University of Baeza, as well as in the 17th century, when the Santa Catalina Convent School briefly became a Pontifical University. Since then, the University of Jaén has solidified more and more, changing its surroundings as it fits in. It's a thriving, contemporary institution that values students above all else, is eager to take on new challenges, and has a strong connection to society and the local community.

I.1.3 Why do my final thesis here

I had the great opportunity to make my final project in Spain's, University of Jaen in the A3 Building of Engineering and Technology.

In such projects, the use of drones are the most appropriate solution since it is the fastest and most accurate technology in terms of the results it provides, and because it is not available and its use is prohibited in Tunisia, Therefore I saw fit that doing my project at the University of Jaén, Spain was the most appropriate option.

Since in this university almost all modern technologies are available for students to do their research, such as the diversity of drones and the availability of many types of sensors that are important in our studies.

I.2 Project justification

This project is about an olive farm, and we're going to help the owner run his farm more efficiently by combining information and cartographic data from geomatic sensors with information from an expert, in this instance the farmer.

As a result, this project is to bring together the knowledge gained during the years of study in geomatics and topography, particularly those related to drone planning and data collection, database structuring, the creation of a geographic map viewer, and the use of GIS analysis and processing tools (GIS).

I.3 Object of the project

Our goal is to establish a work methodology that is appropriate for managing an olive grove. Various geomatic tools will be used for this, during both the data collecting and processing phases and throughout the information utilization phase. In this study, the most appropriate methodology is defined as the one that is capable of integrating the geomatic data and information from geomatic sensors with information from an expert, in this case, an agriculturalist.

In order to carry out the goul of our project we have to work with all of the data we have from images taken by an unmanned aerial vehicle or from other sources, which represent important olive tree specifications, in order to create a flexible and effective website that allows the farmer to obtain relevant agricultural information at multiple levels for each tree on his farm, the idea is to provide an agile and effective tool that allows farmers to get useful information about their operations at various levels of detail such as knowing if the land needs watering based on available rainfall information.

I.4 Specific project objectives

This project has a number of goals in order to achieve the desired outcome. The major goal is to develop an acceptable operating technique for managing an olive farm. To reach this goal, several geomatics tools will be employed, during both the data collecting and processing phases as well as during the information exploitation phase. In this study, the most appropriate methodology is one that is able to incorporate concepts of agricultural resource optimization, and is defined as one that is capable of integrating information and cartographic data from geomatic sensors with information from experts, as well as an approximation of prior knowledge of farm yield levels.

And, for a more precise definition of our goals, we may consider the following secondary objectives :

- Collection of data from an orchard using photogrammetry with drones equipped with various types of sensors.
- Analysis, and production of cartographic products.
- At the request of the farm manager, design a system for collecting information and data related to agricultural production, agronomic and meteorological ones
- Incorporation of geographical data, from which the obtained values may be analyzed using both representative maps and advanced queries.
- Creation of a spatial data base based on the type of the collected and generated variables.
- Examining the obtained results.
- Design and implementation of a web application to integrate geographical data and other factors, allowing for simultaneous evaluation of values obtained via representative maps and advanced queries.

In other words, these goals, will be met through the use of geomatic applications based on photogrammetric techniques, as well as in the context of a spatial data infrastructure that is integrated and used to better olive farming management.

I.5 Structure of the project

This work is divided into four major sections. The steps of the project presented in this work may be seen more clearly in the organization chart below (Figure 2).

The first part « Introduction » explains the project's justification and goals, or what it hopes to accomplish, as well as the main steps that will be followed.

The second part « Background » is a collection of theoretical content and supplementary material that are directly related to the developed project and will be critical to its comprehension.

The third part « Methodology and results » describes the whole method used in this project, including a description of the work area, the software and materials, and the steps used in image processing until the final products are obtained.

The fourth and last part « Conclusions » summarizes the findings of the methodology employed, Cards and related information will be annexed to the report.

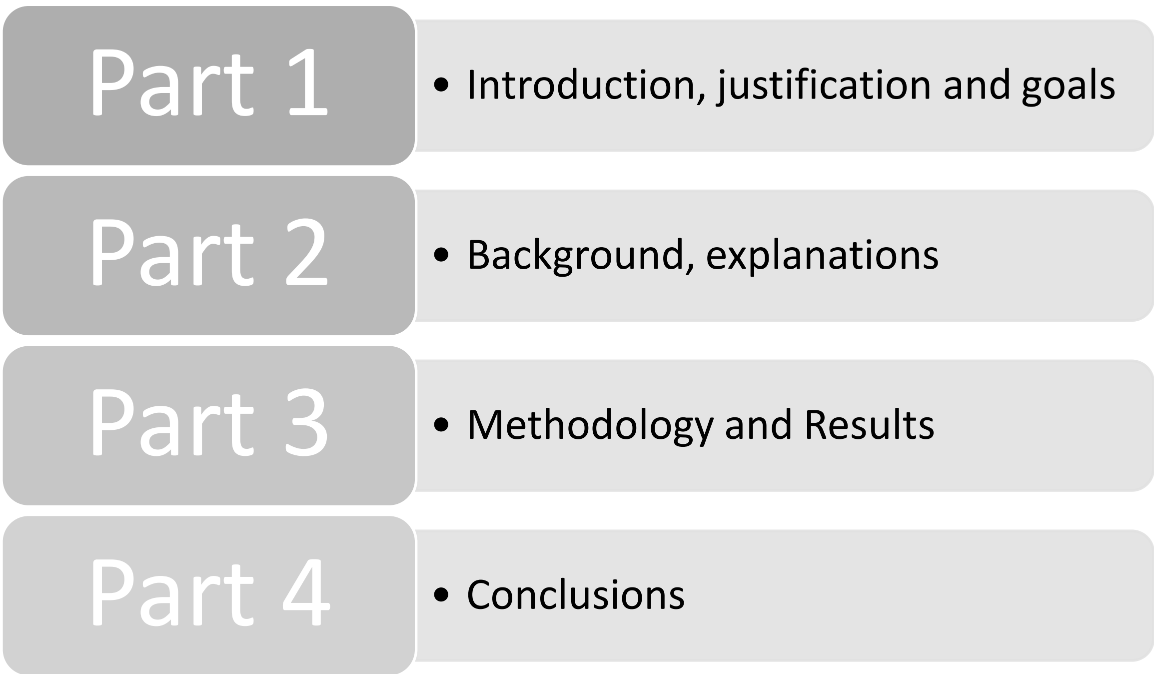


Figure 2 : Structure of the project

Source : Own elaboration

II. BACKGROUND

This introductory background's goal is to place this work in a larger perspective, allowing for a better understanding of the study. The first half is devoted to providing a presentation of the topics on which the project is based, while the other half explains the effectiveness of the techniques that were used to accomplish this work.

II.1 The Definition and Significance of Olives in Spain

Raising olive trees and producing olive oil has resulted in the creation of a multitude of behaviours, customs, rituals, and traditions since the Antiquity in nearly every aspect of life in countries all around Mediterranean area. Throughout history, every population living in this area have provided their own technologies and culture, making the olive a widely used product as well as a main trading commodity.
According to the Ministry of Education, Culture and Sports, (2017), Olive groves can be found virtually everywhere in Spain, although the largest concentration is in Andalusia, a region in the south of the Iberian Peninsula. Olive grove areas (as well as production and exports) have gone through several phases of expansion and contraction that are often tied to market conditions, culminating in the vast increase of olive grove areas in Spain in the twentieth century (when olive trees went from occupying 1.1 million hectares in 1888 to 2.5 million hectares). Over the last few years, yjere has been a tremendous increase in the southern part of the country (Andalusia, Castilla-La Mancha, and Extremadura), where olive trees have historically grown and accounted for 70% of the total area by the end of the nineteenth century. This percentage has now risen to above 85%. On a provincial scale, the province of Jaén is a classic example, with olive trees covering just over 190,000 hectares in 1888 and about 600,000 hectares nowadays.

The Olea Europeae is the olive tree cultivar that grows in orderly rows over Andalusia today. It is significant enough that the Junta de Andalusia (Regional Government) has decided to track every commerce tree. In fact, each has its own GPS coordinates, which are closely watched by regional officials to guarantee that EU subsidies are paid correctly.

Figure 3 : Olive trees land

Source : Taken from Offset Website

II.2 Olive precision farming

The culture of extra virgin olive oil predates the turn of the century. The policies of protection of the "designation of origin" and quality controls have been reinforced during the last part of the 20^{th} century and the beginning of the 21^{st} century.

According to Roma, E., & Catania, P. (2022), there's been a growth in the agricultural area dedicated to olive growing as well as the use of extra virgin olive oil (EVOO). The constant evolution of growing techniques offers new problems to ensure environmental and economic sustainability. Precision oliviculture (PO) is gaining scientific interest having a greater influence on the sector in this setting. Its implementation is dependent on various technological developments, including sensors for local and remote crop monitoring, global navigation satellite systems (GNSS), equipment and machinery to perform site-specific management via variable rate application (VRA), geographic information system (GIS) implementation, and systems for analysis, interpretation, and decision support (DSS).

Precision farming (PF) is a management strategy that tries to analyze an agroecosystem's spatial and temporal variability in order to carry out site-specific treatments using various technologies and methodologies.

Many processes are now being done in this regard at the olive grove, The analysis of spatial variability, employing various types of sensors capable of capturing raster or vector data, is the first stage in precision agriculture. Monitoring Technologies also acquires the maximum amount of georeferenced information within the olive grove. A variety of sensors may be employed to monitor the many factors that define the plant development condition.

Soil, climate, and crop are the three agronomic factors that must be evaluated in order to successfully implement precision farming. Also taking into account their potential impact on agricultural activities. The most significant scientific development has been made in the analysis of results from biophysical parameters, trade data, and crop spectrum responses. The major way of study and control of the vegetative-productive variability discovered is the use of vegetation indicators or temporal data strongly connected to the productivity of the olive grove (such as the production map).

The techniques available for monitoring system of olive groves are diverse and allow for increasingly precise monitoring. These are distant image acquisitions at various resolution scales that can describe the olive grove by detecting and recording reflected sunlight or wavelengths radiated from the surface of objects. Remote sensing tools rapidly offer a description of the form, size, vigor, water condition, diet quality, stress level, and variability within the olive grove. Satellites, airplanes, and unmanned aerial vehicles UAV (or remotely-piloted aerial systems RPAS) are the three primary platforms utilized in remote sensing.

Due to the rapid population increase, its consumption is knowing the same fate, while climate change complicates the ability of maintaining food security in a sustainable manner.

As a result, new techniques of agriculture and farm management, like we can see in Figure 4, are being developed to ensure enough food supply for the people while minimizing environmental damage. Precision olive growing is now a farm management strategy that delivers clear benefits to the industry, particularly to the its farmers, from all perspectives : productive, qualitative, and environmental. Indeed, precision olive farming entails the use of several technologies to optimize the use of various agricultural inputs. The use of remote sensing technology for precision olive cultivation has grown considerably in recent years.

Figure 4 : precision farming

Source : Taken from Elaisian Website

The unexpected presence of high-resolution (spatial, spectral, and temporal) satellite imagery has encouraged the use of remote sensing in a wide range of PA applications, such as crop management, irrigation methods, nutrient management, infection control, pesticide application, and yield forecasting.

II.3 Geomatic tools for olive precision farming

Sahoo, R. N. (2012) affirms that several technical advances in the twentieth century, particularly in geomatics, contributed to the creation of the notion of precision agriculture. The precision agriculture system's success is dependent on the integration of various technologies into a unified system that can be managed at the farm level with minimal effort.

Latest geomatic techniques can give adequate coverage with sufficient precision. So, the development of technology enabled throughout time the monitoring of an olive grove, both at the plot and single olive levels, constitutes a significant advancement in agricultural practice.

Precision farming's key goals are to enhance crop yields, improve product quality, save energy, and preserve physical environment from pollution. Because of the advantages of high-resolution and cost-effective imaging, UAVs are now commonly used in agriculture, primarily for monitoring. It can provide oil olive growers with more accurate information, and that was the most recommended technique for precision farming compared to piloted aircraft and satellite imagery.

The data gleaned may be layered, grouped, and styled in a simple and practical way through the production of a web page mapping, needing no understanding of databases or GIS software. Thus the usage of this approach can assist farmers to have a better view of their land and crops. The use of spatial data in agriculture may also assist farmers having a better understanding of their agricultural land and gives them the information needed into better decision making.

II.3.1 Remote sensing and UAV

II.3.1.1 Remote sensing

According to P. Srestasathiern and P. Rakwatin (2014), A trustworthy and precise instrument for remote detection and processing of picture data has emerged in the form of remote sensing, with recent developments in the area of image processing and the accessibility of Very High Resolution (VHR). The automatic detection of olive trees has been achieved using a variety of methods and algorithms.

Sensors are the most commonly used technics in remote sensing of olive trees and precision farming. In general, these sensors are cameras that can capture pictures (raster data) in several multispectral bands. Their application varies depending on the geographical, spectral, radiometric, and temporal resolution they provide.

Sensors that may be utilized remotely are classified according to their operation, method of acquisition, number of acquisition bands (multispectral and hyperspectral), and other factors. RGB, hyperspectral, and multispectral pictures are common sources of spectral information in remote sensing. We can find several qualities of Remote Sensed Imagery as we can see in the Figure 5. However, because those convey various information, it is vital to comprehend their true potential. Multispectral pictures are the most often utilized spectral information in precision olive growth.

As a result, maps showing crop and soil variability obtained from distant sensing pictures taken by sensors mounted on satellites, drones, or ground-based equipment have become a crucial component of variable-rate technology (VRT).

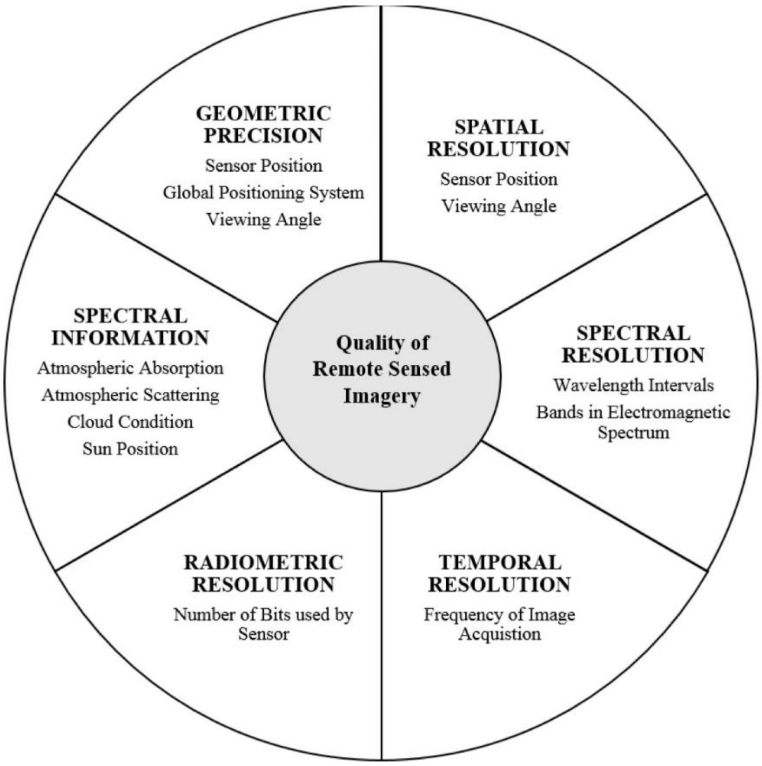


Figure 5 : Quality of Remote Sensed Imagery

Source : Taken from Ohioline Website

Remote sensing is the most cost effective method for large scale monitoring and analysis in agriculture.

II.3.1.2 Unmanned aerial vehicles

Remote sensing technology based on photographs taken by unmanned aerial vehicles (UAVs) might be an excellent tool to speed up data collecting and, as a result, reducing the time and expenses of field operations.

Unmanned aerial vehicles, also known as drones and referred to as Remote Pilot Aircraft by the International Civil Aviation Organization, wich is an aircraft that do not require a human pilot on board, as shown in Figure 6. On-board computers or the remote control of a pilot on the ground or in another aircraft that controls their flight in a autonomousway. The function of an automated process or an external ground operator is used to launch and recover an unmanned aircraft.

Figure 6 : Unmanned aerial vehicules

Source: Taken from Fundacion Aquae Website

On the report of Ram Gopal Lakshmi Narayanan, Oliver C. Ibe, (2015), UAVs are employed for strategic skills and observation. This technology is now accessible to aid crew members in the emergency response field. UAVs are categorised according to their altitude range, endurance, and weight, they can be used for both military and commercial purposes. Ground-control stations containing laptops and other equipments small enough to be transported with the aircraft in small vehicles, on boats, or even in backpacks are frequently used with the smallest categories of UAVs. Those equipped with high-resolution cameras may cruise above the disaster scene, take images, and provide image and structural analysis to the crew.

Benefits :

- Possibility of use in high-risk or hard-to-reach areas.
- It does not require the performance of pilots in the combat zone.
- It favors the industrial sector by being able to be used in productive processes.

Disadvantages :

They can be classified as follows

- Techniques
- Ethics
- Economic

According to an article on gim-international website, Drones can be used to improve crop management through analysis of plant growth stage, photosynthesis activity, study of heat or cold stress, early detection of pests, or the application of variable ratios (such as simulants, fertilizers, or pesticides) with a corresponding economic benefit for the harvest. This was made possible by incorporating drones with multispectral, hyperspectral, and thermal sensors.

II.3.2 Web Mapping

As stated by MILLOGO, (2013) A geographic information system (GIS) makes localized and cartographic information available to the general population, whether they're professional or not, and the technology in this field are ever evolving. When combined with the GIS tool, the Internet has become a powerful tool for communication and dissemination of geographic data.

This GIS-Internet connection is known as webmapping, and it has became a rapidly growing field in recent years. This growth has been accelerated by the rise of web 2.0, and particularly the appearance of mapping portals such as Google Maps, Bing Maps, OpenStreetMap, and others. Online cartography, on the other hand, has become more accessible by the availability of APIs (Application Programming Interfaces) that makes it easier to integrate and process geographic maps, as well as a variety of free tools.

For a better explanation of the functioning of this technology, we find a discussion to explain Web mapping and Web servers functioning.

II.3.2.1 Web development and Web servers

The advancement and recent technological advances have enabled the creation of many web sites that are gaining traction on the market and have become an essential tool for the development of new services.

In this section, we'll go over some general information about websites and discuss website development strategies.

Websites are becoming increasingly significant in our daily lives since the features they provide greatly simplify our lives.

II.3.2.1.1 Definition of Web development

Web development is defined as the creation and maintenance of an internet-based website. Web design, web publishing, web development, and database management are all included.

It's the coding or programming that allows a website to function according to the owner's requirements. It mostly deals with the non-conceptual aspects of website development, such as coding and balisage writing.

Web developers employ a range of code languages in order to do this. The developer's choice of language is determined by the type of job or task at hand.

A web designer simply uses HTML and CSS to create the website's interface. A web developer can create a website and write web scripts in a programming language. For example, PHP JavaScript. In addition, as cited before web developer creates, maintains, and updates websites.

II.3.2.1.2 Definition of Web servers

A "web server" can refer to development tools (computer), hardware elements or software and hardware components that function collectively, giving an answer to the customer's needs through the World Wide Web using HTTP (Hypertext Transfer Protocol) and some other protocols. A web server's primary responsibility is to present content by saving, processing, and transmitting webpages to customers.

- Hardware side :

A web server is a computer who holds web server software and website component files on the technical elements side (for example, HTML documents, images, CSS stylesheets, and JavaScript files). A web server connects to the Network and facilitates the transfer of physical data with other web-connected devices.

- Software side :

A web server has many software components that determine how web users access hosted files. That's an HTTP server at a bare minimum. An HTTP server is a technology that can comprehend URLs (web addresses) and HTTP requests (the protocol the browser uses to view webpages). An HTTP server is usually accessed by the web addresses of the websites it hosts, and it transmits the content of these websites to the user's device.

II.3.2.1.3 Web site advantages and disadvantages

<u>What are the advantages of having an online presence ?</u>

There are numerous advantages to using an internet site :

- A dedicated and personalized location to communicate about brand
- Possibility of increasing the visibility and attracting new customers
- The ability to sell online without wasting time

- The ability to receive payments directly through the internet without involvement.
- For prospects, a platform that is available 7 days a week and 24 hours a day is available.
- Easy to personalize and modify (compared to paper documents).
- Develop client trust and your ability to provide after-sales service.
- Automate specific tasks for you, such as inventory management or meeting scheduling on your calendar.

What are the drawbacks of having an online presence ?

However, there are some drawbacks to using the internet, and it is vital to list them :

- A dedicated and personalized location to communicate about brand
- A good internet site costs money; to give site a professional appearance, must at least pay for hosting and a domain name for the year.
- A good website is more than just a pretty face; it's the entire management of the elements it contains to allow for a quick download or a good search engine ranking!
- Your website should be updated on a regular basis and have maintenance available in the event of a problem.
- There are several rules and laws to follow, such as the RGPD, which require a little forward.

However, rather than viewing these expenses as losses, they can be viewed as an investment that will pay off in the long run.

II.3.2.2 Web mapping architecture

The architecture of a Web mapping system is based primarily on four fundamental elements, as shown in Figure 7 :

• Data is the most important component of the system ;

• Web cartography software is a server-side program that can generate a dynamic map (simple image) from data based on the client's request.

• The Web application's interaction tools: allows the user to manipulate and explore the map (zoom forward and backward, panoramique), as well as retrieve textual information.

• The Web Navigator : enables the user (client) to launch a Web application and to explore the map.

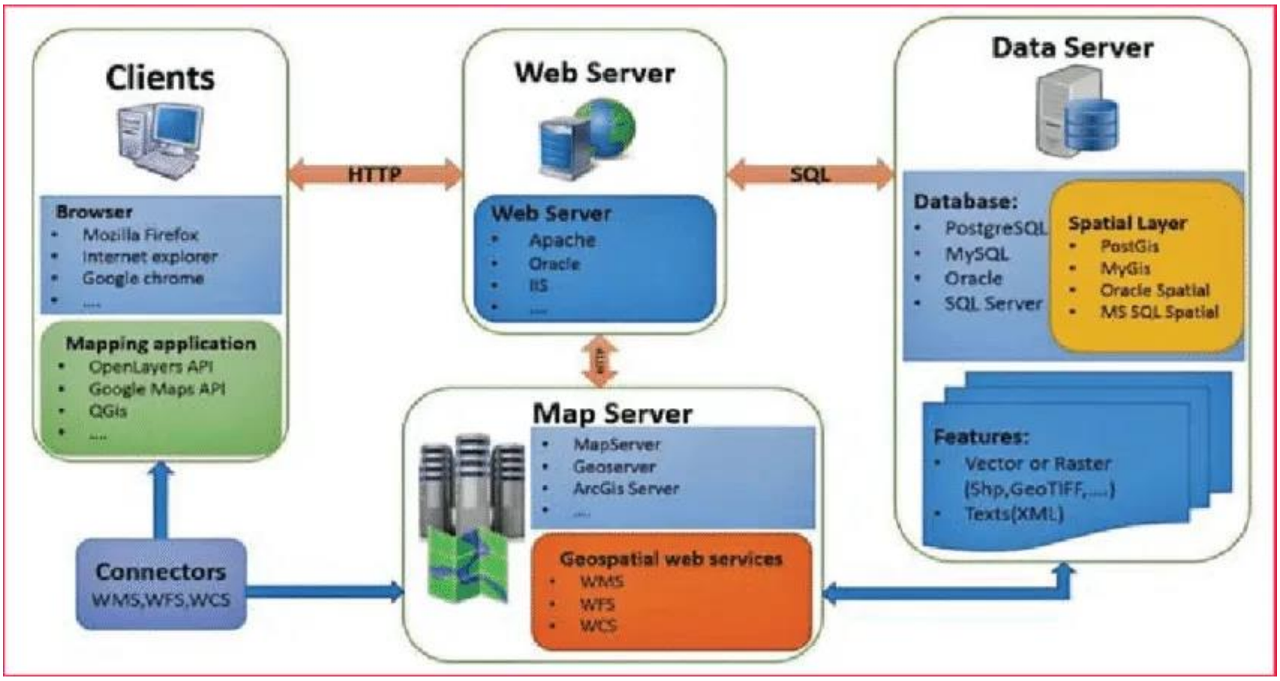


Figure 7 : Webmapping application architecture

Source : Taken from MILLOGO, F, Thesis

II.3.2.3 Webmapping application domains

Web mapping has quickly gained traction in a variety of industries and fields. This is a technology that has completely transformed the application world.

Web mapping's application : Web mapping can be used to distribute maps through the internet in almost any field ; here are few examples :

- Governments : agricultural, environment, municipalities, natural resources, health, and transportation.
- Industry : forestry, mining, and transportation.
- Defence : military purposes
- Business environment : insurance, etc.
- Academic : universities, schools, research.

Web Mapping System is one of the systems that assists in land or area mapping, the effectiveness of expenditures incurred will be improved using online mapping for agricultural land. Furthermore, it helps with land management and provides prediction methods for agricultural land management and makes it easier for the farmers.

II.4 The most well-known sites in precision farming

II.4.1 ArcGIS Online

Esri has a death grip on the GIS industry. As we can see in Figure 8 it's not only GIS desktop software, but it's now mapping in the cloud. ArcGIS Online (AGOL) is Esri's cloud's service with loads of functionalities. It's ideal for large organizations because it's easy to integrate. And the best part of all – it's targeted towards non-programmers.

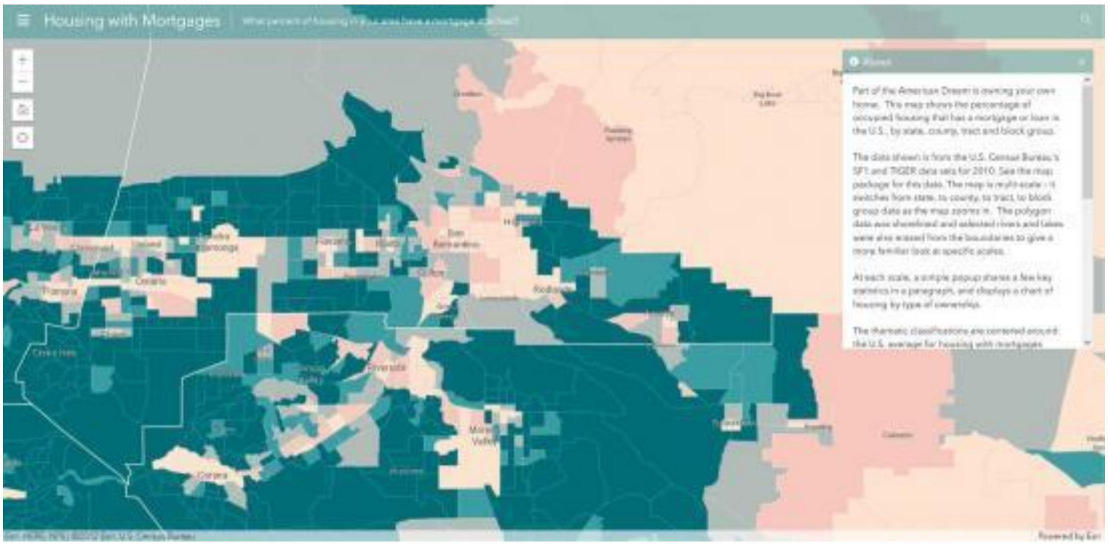


Figure 8 : ArcGIS Online

Source : Taken from Gisgeography website

II.4.2 Exemples of commercial products

AGRIVI

The AGRIVI is an approach to solve the global food problem through the digitalization of agriculture, that is, by switching the farmer's decision-making which is reliant on traditional practices and historical knowledge to the new data-driven and fact-based decision-making empowered by best-growing practices and real-time agronomic insights available using technology.

AGRIVI

AGRIVI Website offer as main functionalities :

- 360-degree farm management solutions, AGRIVI digital agriculture products offer an overview of farm agronomy and business processes from season planning, field operations management, resource and finance management to agronomic decision-making based on real-time insights from fields.

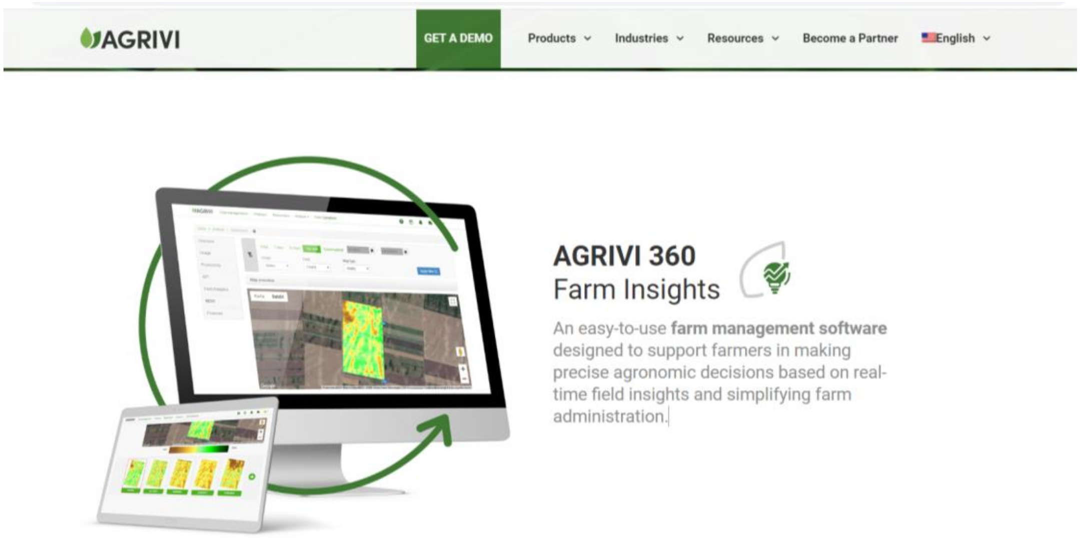


Figure 9 : Page of 360-degree farm management solutions

Source : Taken from AGRIVI website

- Enterprise farming holdings, the software enables enterprise farming holdings to have complete control over all agronomic operations, gain deep insights into all processes, optimize costs and improve yields with powerful analytics.
- Farmer cooperative management, AGRIVI digital agriculture products offer a 360-degree farmer cooperative management, from farmer contracting to data-driven agronomic advisory, traceability and crop marketing support.
- Solutions for integrated supply chains, Powerful agriculture supply chain management platform for food and beverage companies, enabling them to manage their responsible food sourcing processes and direct farmer contracting activities while securing quality, food safety, sustainability and traceability.
- Digitalization of agricultural financing, Turnkey platform for agribusiness banks that supports their farmers in making precise agronomic decisions based on real-time field insights and simplifying farm administration, while empowering big-data and farm performance analysis for agribusiness banks.
- Turnkey farm management software, Proven and global leading digital agriculture platform for seed, agrochemical, and agricultural machinery

manufacturers that empowers the process of creating digital relationships with farmers all over the world based on trusted and data-driven agronomic advice.

- Actionable agronomic advice, Empower your agronomic advisory services and become a trusted advisor by providing data-driven recommendations based on real-time field insights and digital collaboration with farmers.

As we can see AGRIVI is a big commercial website that provides many services for the farmers, but it does not highlight the small details of farm management such as the organization of used agricultural trucks and information about the workers of the farm, And that is exactly what we will offer in our website will offer.

Farmers Edge

Farmers Edge website is committed to driving the next agricultural revolution by creating data-driven tools that assists farmers in operating profitable businesses while increasing food production for a fast expanding global population.

Farmers Edge website offers as main functionalities :

- Smart solutions, is dedicated to developing the best smart farming solutions to sustainably guarantee productive farming at an affordable price. Combining on-farm hardware, easy-to-use software, digital agronomy, AI-driven analytics and unbeatable support.
- Farm Command, vertically integrated and driven by full-farm connectivity. The platform provides a unified, 360-degree stakeholder view to enhance how growers, agricultural professionals and agri-businesses interact with data.
- Variable Rate Technology, provides a premium precision fertility program to help growers optimize inputs, produce high-yielding, low-carbon grain and generate high-quality carbon offsets. Customizable and tailored to each farm's unique goals.
- Carbon, the website helps farmers grow more, using less through smart farming practices powered by robust, real-time datasets and the most comprehensive on-farm digital infrastructure. Their solutions results are verifiable, low-carbon grain production and high-quality carbon offsets.

- Satellite Imagery, offers high-resolution, high-frequency satellite imagery as we can see in Figure 10.

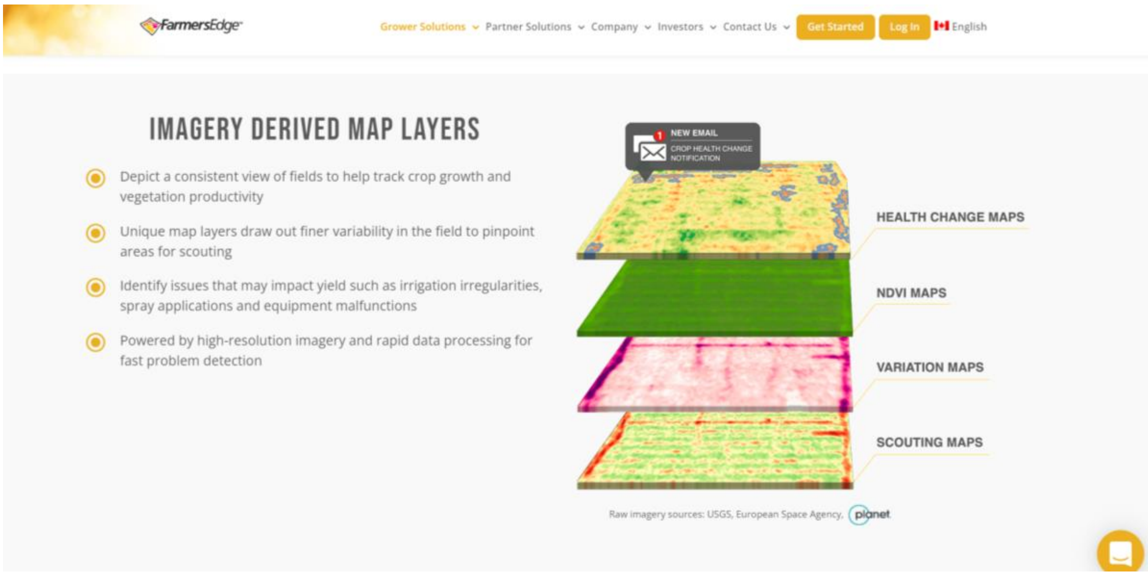


Figure 10 : Page of Satellite Imagery

Source : Taken from Gisgeography website

- Laboratory, Farmers Edge Laboratories provide soil, manure and tissue analysis for growers, retailers and crop consultants across Western Canada and USA.

As we already mentioned in AGRIVI website Farmers Edge is also an importing website that offers many significant functionalities, but small details of farm management are missing.

As a further explanation, like i have already mentioned above, these huge sites are mainly focused on the management of a large agricultural enterprise, As we find a lack in terms of providing small details, such as providing daily weather values, detailed detailed annual meteorological values for each location, as well as almost a lack of giving the farmer a capacity to manage and store information about his farm, this section is very important for the small farmer, so in our work we have tried to offer him a proper management of his farm, in addition to the details of the climate that we have provided and the layers that present the data extracted from the images of the drones with a pop-up window that displays the information, the farmer also has the opportunity to add important information related to his product and his needs for production such as expenses, in addition to including the details of his workers and the necessary machinery and their needs, which can make a difference and facilitate the way to manage his farm yearly.

III. METHODOLOGY AND RESULTS

This part first consists in presenting the study area in order to better understand the characteristics of the region. The following section will present the instruments and software used during the implementation of this project, indicating the techniques used. Finally, a description of the various steps developed regarding the processing of acquired images and the methodology adopted to extract the vegetation indices, by representing the analyzes and the results obtained.

III.1 Description of the working area

This section identifies and describes the geographical area where the project will be carried out,

Our research area is located in Lahiguera, a Spanish municipality in the province of Jaén, in Andalousia, as seen in the maps below Figure 11, shows exactly the study area of the farmer land on which we are going to work on. This area is dedicated to olive cultivation.

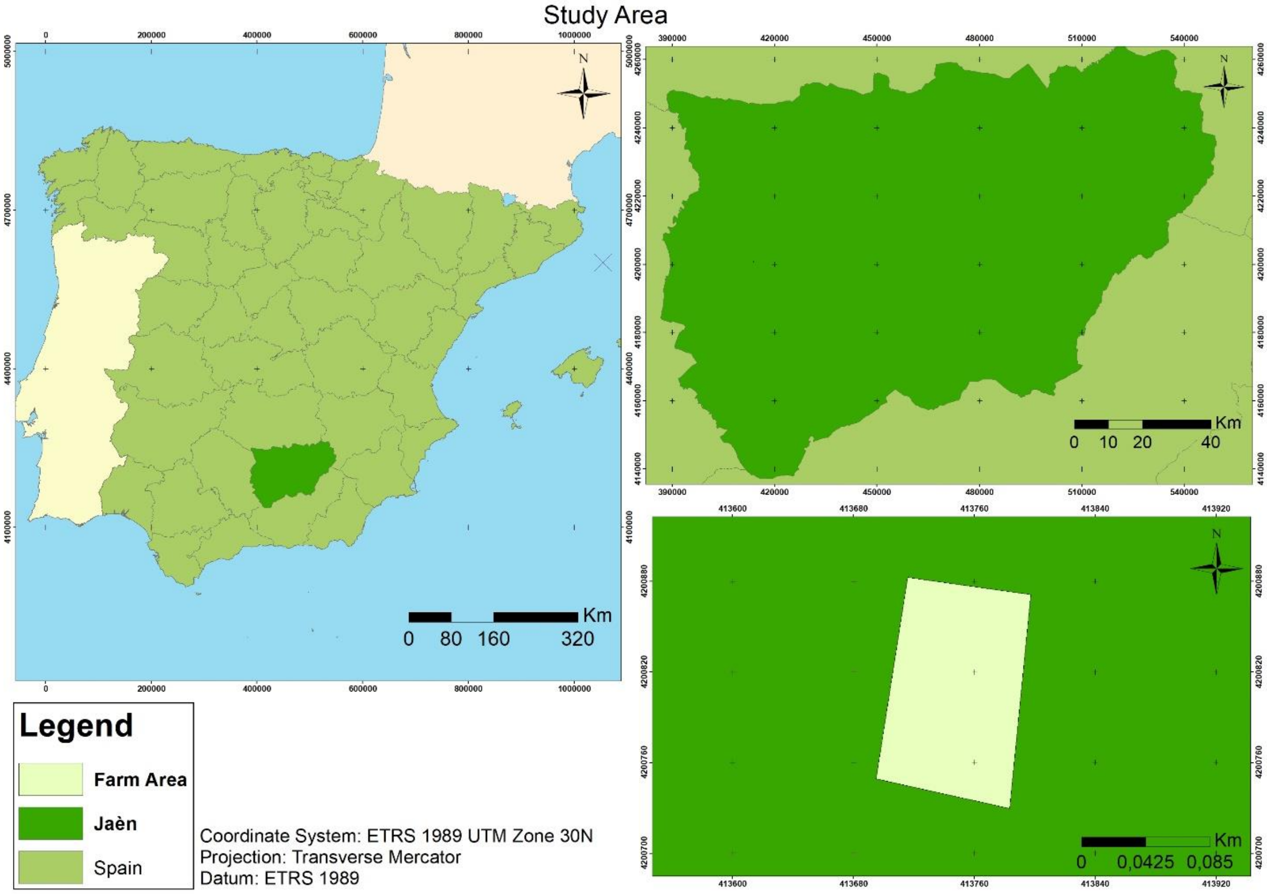


Figure 11 : Study Area

Source : Own elaboration

Through the Junta de Andalucia website, we were able to obtain information about the whole land of our farmer as shown in Figure 12, which we will work on, an area of only 11958,715m2 of the entire land.

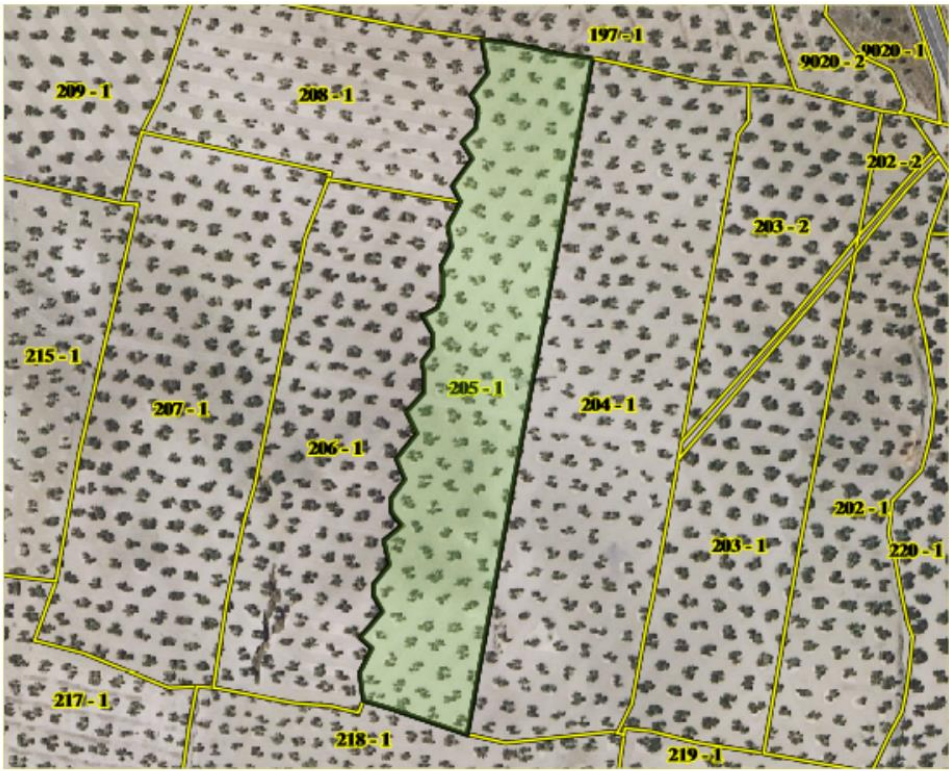


Figure 12 : Study Area

Source : Taken from Junta de Andalucia (sigpac) website

For more details on our study area we have presented the identification data with a SigPac reference in table 1 below.

Table 1 : The SigPac reference

Source : Taken from Junta de Andalucia (sigpac) website

SigPac Parcel Reference				Cadastral Reference
Province	Municipality	Polygon	Parcel	
23-Jaén	40-Lahiguera	5	205	23040A00500205HD

III.2 Instrumentation used

III.2.1 Drone

We worked with DJI MATRICE 300 RTK model drone in this project as shown in the Figure 13. It is known to be capable of carrying out difficult tasks more effectively, intelligently, and reliably. These tasks include fighting fires, searching for and recovering missing persons, providing protection, and inspecting high-tension lines, gas pipelines, and petroleum storage tanks. Inspired by the most advanced aviation systems, it incorporates the most recent advancements in artificial intelligence, along with a new integrated management system, it sets a new standard for the industrial drone industry.

A significant capacity for adaptability, the RTK M300 platform supports up to three sensors at once and has a useful load capacity of 2.77 kg. Depending on needs, one may mount one stabilizer at the bottom, two stabilizers, or add another stabilizer at the top.

Its main technical characteristics are many, and here are some of them :

Protection index : IP45

Maximum transmission distance : 15 kilometers

Detection range : up to 40 meters

Flight Time : 55 Minutes

Figure 13 : Drone DJI Matrice 300

Source : Own elaboration

III.2.2 Sensors

The choice of the sensors to use is entirely up to the the infography and geomatics research group (TIC-144) at the University of Jaén. Additionally, since the data collected by its sensors will only be used for agricultural purposes and vegetation indexes will undoubtedly be produced. The first sensor required is the multispectral one, represented by the Micasense Red Edge-MX. The second one that was used is a thermographic and RGB sensor, represented by the Zenmuse H20T. These cameras are essential in all types of precision agriculture work.

III.2.2.1 Camera Micasense Red Edge-MX

Micasense camera leading manufacturer of agricultural drone sensors, RedEdgetMX, offers the most advanced Micasense technology, a new aluminum housing for increased durability and heat resistance, equipped with a calibration panel as we can see in Figure 14.

It integrates easily into any drone, captures up to five spectral bands, and creates color photos and vegetation index in a single flight.

And it's also designed to operate in the most challenging environments, even in hot weather (up to 60 degrees), and calibrated to take precise measurements that may be repeated if necessary.

Figure 14 : Camera Micasense Red Edge-MX

Source : Own elaboration

The RedEdge-MX full-spectrum camera allows to capture NDVI, and advanced NDVI of vegetation measurements without any distortions in a single flight.
Multispectral sensor for precision agriculture,

- Easy to install on a multitude of aircrafts
- More accurate and durable
- Generates vegetation indexes and color images in a single flight
- Improves the profitability of your farm

III.2.2.2 Camera Zenmuse H20T

This multi-capture tool turns what we think of as operational effectiveness into missions. With its integrated design and distinctive intelligence as shown Figure 15, it offers previously unheard-of imaging possibilities for a range of professional applications. All the necessary capture devices are combined into one. Captures everything, up close and far away, in real colors or thermal images. Use the integrated laser distance meter to measure distances up to 1200 meters from an object (LRS).

This potent integrated useful charge frees up advanced intelligent capabilities for DJI's industrial drone platforms.

Figure 15 : Camera Zenmuse H20T

Source : Own elaboration

- Camera with a 20 MP zoom
- 12 MP large-angle camera
- Laser distance meter with a maximum range of 1200 meters
- Thermal radiometric camera, 640x512 pixels

III.2.3 GNSS Receptor and Leica Geo Office

The following supplies were utilized to create the ground control points, a multi-frequency GNSS receiver aimed for the surveying industry is the GR-5 receiver and it's presented in Figure 16. Using a full wave antenna, the GR-5 can pick up and decipher a wide variety of signal types. Additionally featured are GNSS tracking, dual-frequency RTK, and other features.

Figure 16 : Topcon GR-5 Integrated GNSS Receiver

Source : Taken from Universal Marine Surveying Center website

Software called Leica Geo Office enables you to import and uses data that has been acquired, including points that can be captured using a total station, a GPS, a laser scanner, or a drone.

To obtain the coordinates of the ground control points we did use Leica in this project.

III.3 Software used

A wide range of softwares are used to achieve the objectives of this project and to generate the required cartographic products, which will be outlined in this part.

III.3.1 QGis

A group of developers created the "open source" geographic information system (GIS) known as QGIS with the goal of processing geographic data. Its processing tools were used to build shapefiles, change attribute tables, do spatial analysis, and perform additional processing that will be illustrated in the next sections.

QGIS

It is included to be used to integrate and visualize the created cartographic data.

III.3.2 Visual Paradigm

It's a software used to create diagrams within the framework of a programming. It is used to model the relational database. This tool has a good working environment, which facilitates the visualization and manipulation of the modeling project.

III.3.3 PostgreSQL + PostGis + PgAdmin

PostgreSQL is a sophisticated, enterprise-class open source relational database. With more than 20 years of community work behind it, it is a very reliable database management system with excellent levels of resilience, integrity, and accuracy. Many online, mobile, geospatial, and analytics applications utilize PostgreSQL as their primary data storage or data warehouse.

PostGIS is a spatial database extension for PostgreSQL's object-relational database. Location queries may now be executed in SQL's Structured Query Language thanks to the addition of support for geographic objects.

They are the tools employed for the storage of the geographic products produced by a geographic data base.

PgAdmin is the most widely used and comprehensive Open Source administration and development platform for PostgreSQL, the most cutting-edge Open Source database that exists.

PgAdmin is helpful for accessing, managing, and using the created geospatial data base.

III.3.4 Visual Studio Code (VS Code)

Is a free open source code editor for development and debugging modern cloud and web applications which is available for free on Linux.

Supports more than 30 different programming, markup and database languages, some of which are JavaScript, C#, C++, PHP, Java, HTML, R, CSS, SQL, Markdown, TypeScript, Less, Sass, JSON, XML and Python.

III.3.5 Geoserver

GeoServer is an open source server used to share geographical data. It excels at publishing any significant geographical data source using open standards since it is built for interoperability. It excels at handling very huge datasets, both raster and vector, with the right data preparation.

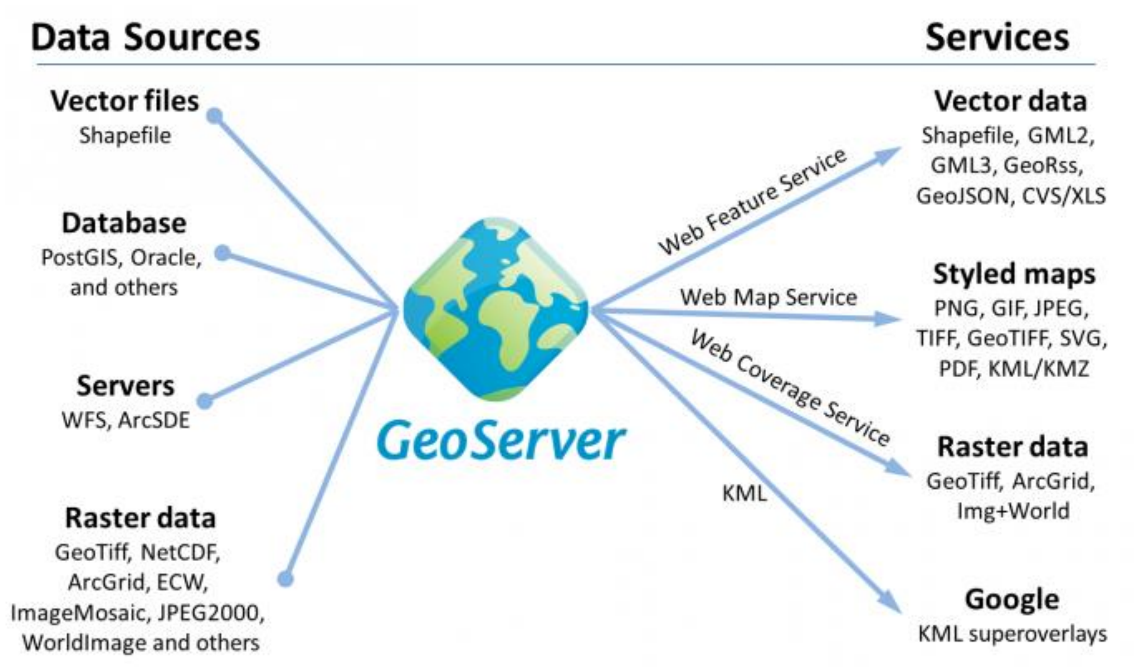


Figure 17 : GeoServer function types

Source : Taken from Eatlas website

III.3.6 OpenLayers

To promote the usage of all types of geographic information, OpenLayers was created. A dynamic map may be easily added to any web page using OpenLayers' JavaScript, which is absolutely free. Map tiles, vector data, and markers loaded from any source may all be shown.

It was utilised in this project to produce the map-based online viewer. On the OpenLayers website, there are several examples that served

III.4 Data capture

In this part we are going to talk and describe all the data that we will produce and use to insert it as information in our web mapping page for the project.

Reference System :

According to the website of Ministry of Agriculture, Fisheries and Food, in our project we did use as a Supported Reference Systems (SRS) a EPSG (European Petroleum Survey Group) code EPSG 25830, and a native reference system of the data is ETRS89, EPSG : 25830, ETRS89 / UTM zone 30N

III.4.1 Drone

Here is a display of the drone-taken photographs along with a discussion of how we used vegetation indexes to extract the necessary data from the images.

All the images here were taken by the DJI MATRICE 300 RTK model Drone with a treatment on them by Mehdi choura (2022), to have the final RGB, multispectral and thermographic images.

- RGB Image :

The data obtained with the RGB sensor of the Zenmuse H20T camera were used to generate an orthomosaic RGB (Figure 18), an DEM (Figure 19) and a DTM (Figure 20), presented below.

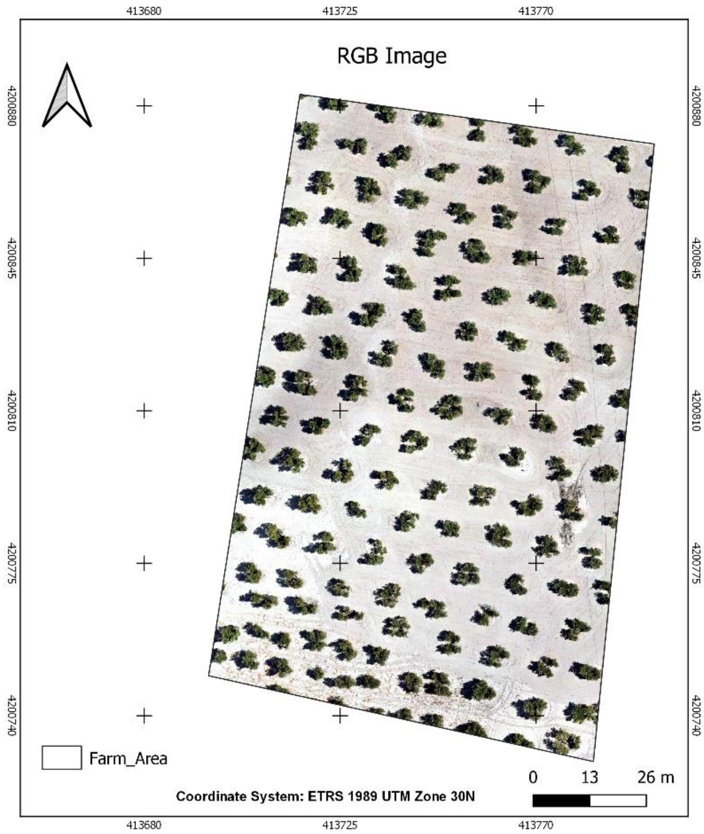


Figure 18 : RGB Orthoimage

Source : Image taken from Mahdi choura (2022)

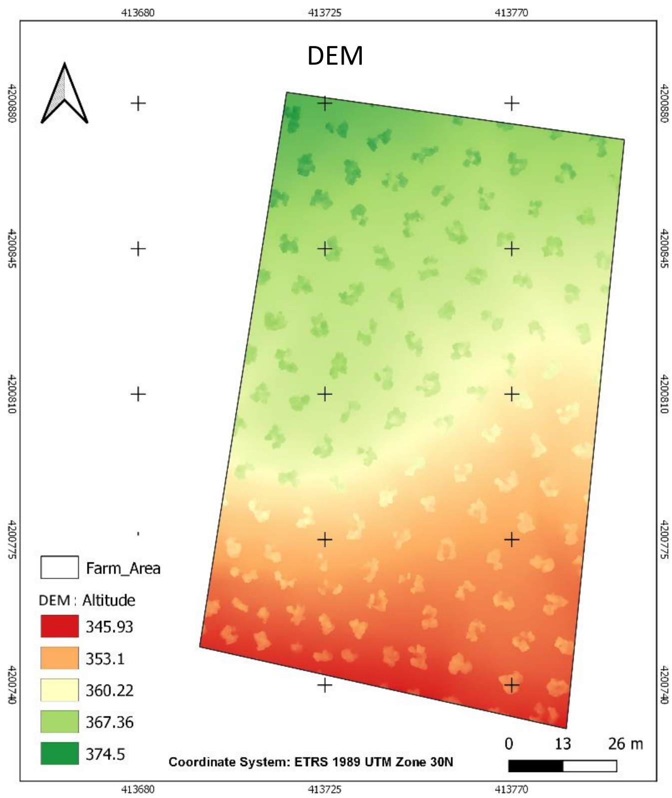


Figure 19 : DEM

Source : Image taken from Mahdi choura (2022)

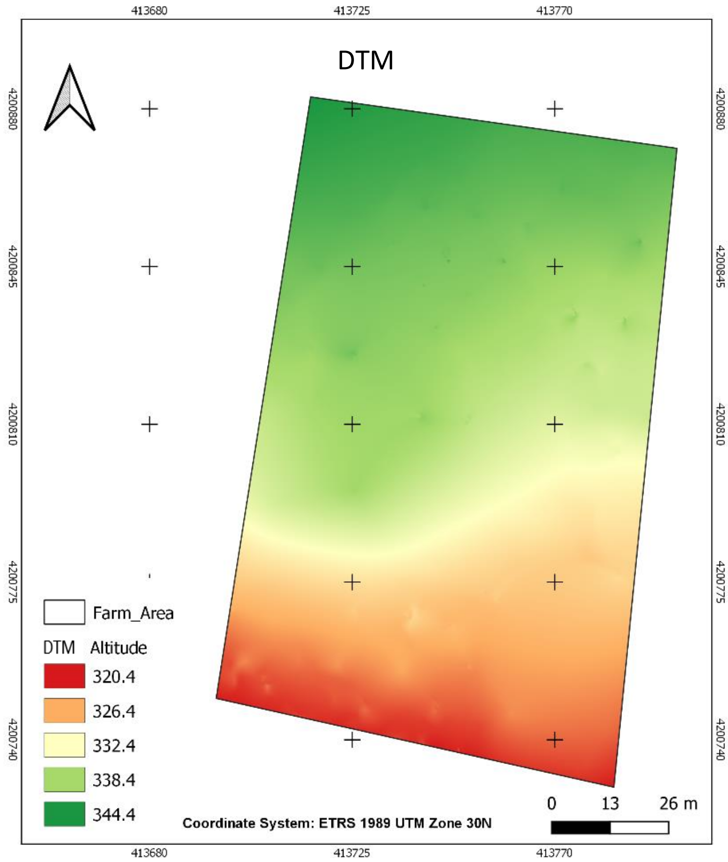


Figure 20 : DTM

Source : Image taken from Mahdi choura (2022)

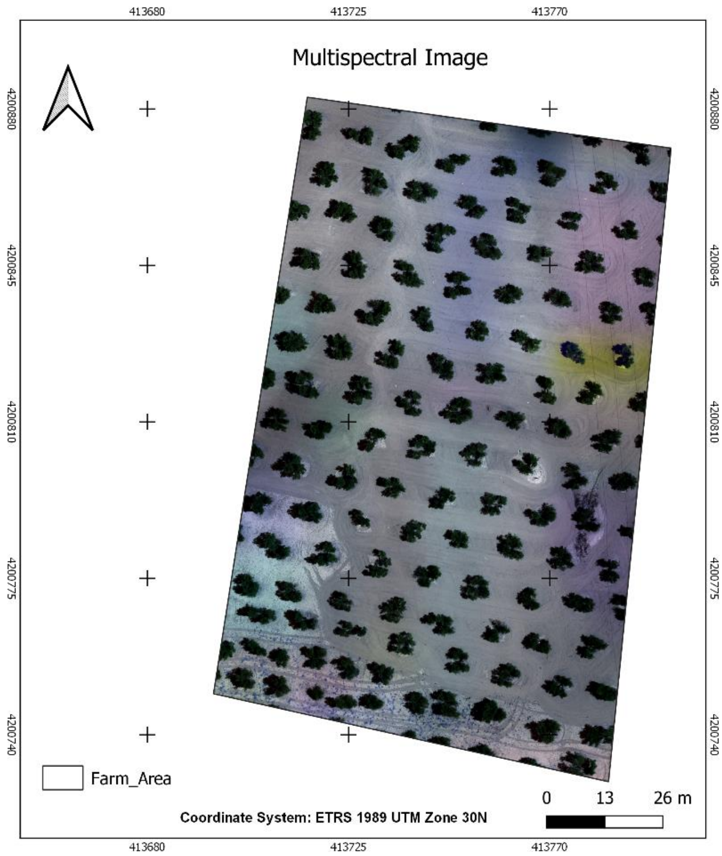


Figure 21 : Multispectral orthoimage

Source : Image taken from Mahdi choura (2022)

III.4.1.1 Vegetation indexes Maps

When we talk about indexes, we're referring to a collection of algebraic operations carried out using two or more bands belonging to the same scene on the pixel values. An indicator of vegetation may be described as a parameter that is particularly sensitive to the vegetated surfaces and is calculated using reflectance values at various axis longitudes (Gilabert et al, 1997).

Additionally, it is a number that may be generated by a certain arrangement of spectral bands and may be related to how much vegetation is present in a given pxel. These indicators are used to improve the distinction between soil and vegetation while lessening the impact of relief on the spectral characterization of the various coverings.

- Index Processing :

There are many different types of vegetation indexes, therefore after conducting research, we chose to select the most generally used ones. Five of them were generated in our study, NDVI is the most well-known one and used in academic and professional circles,. GNDVI, NDRE, SAVI, and ARVI

The calculation of the index will be done with the raster calculator function of QGIS as we can see in the Figure 22 below which shows the example of NDVI with :

B1 Blue band, B2 Green band, B3 Red band, B4 Red Edge band and B5 Near Infra Red

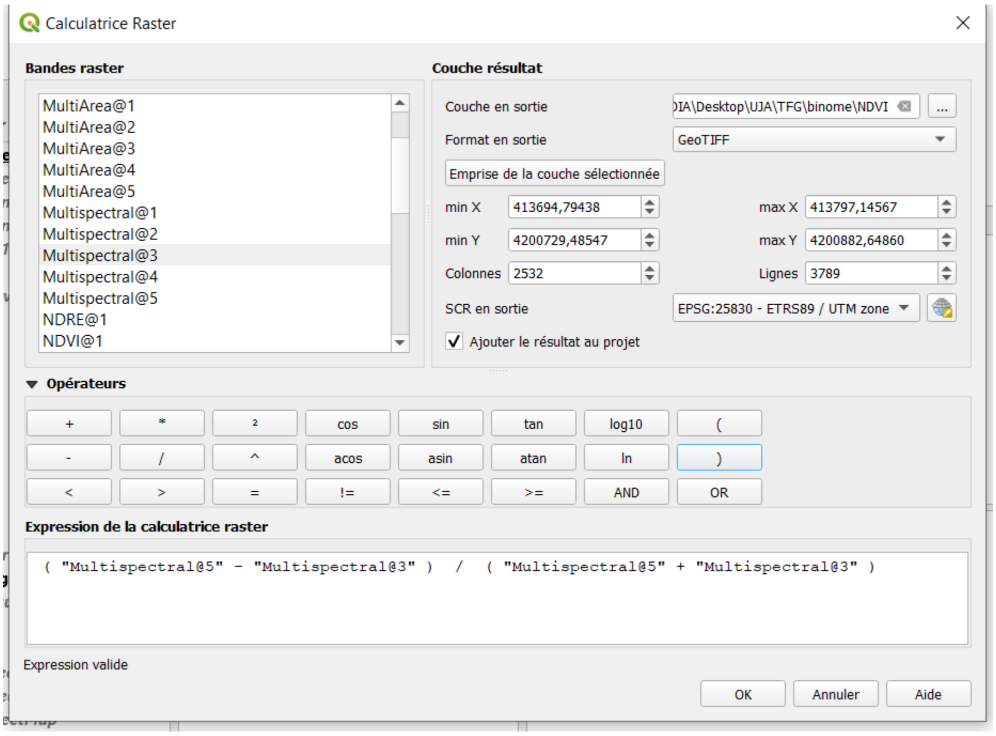


Figure 22 : Raster calculator Qgis

Source : Own elaboration

III.4.1.1.1 Normalized Difference Vegetation Index (NDVI)

Due to its straightforward computation, simple interpretation, and ability to partially offset the effects of atmosphere and geometry, NDVI is an extensively used vegetation index.

Rouse et al. (1973) apply the Normalized Difference Vegetation Index for the first time, The NDVI is a measure of the vegetation's strength.

And By measuring the reflectance of NIR and red bands, which are both frequently used to show the greenness of actively developing leaves, it provides information on the health of crops (such as poor growth or agricultural illnesses).

NDVI is calculated as :

$$\mathrm{NDVI} = \frac{(\mathrm{NIR} - \mathrm{RED})}{(\mathrm{NIR} + \mathrm{RED})}$$

Where the spectral values :

NIR = Near Infra Red band

RED = Red band

It is an excellent predictor of vegetation, agricultural productivity, forest cover, and crop season variations. The range of the NDVI is from -1 to +1.

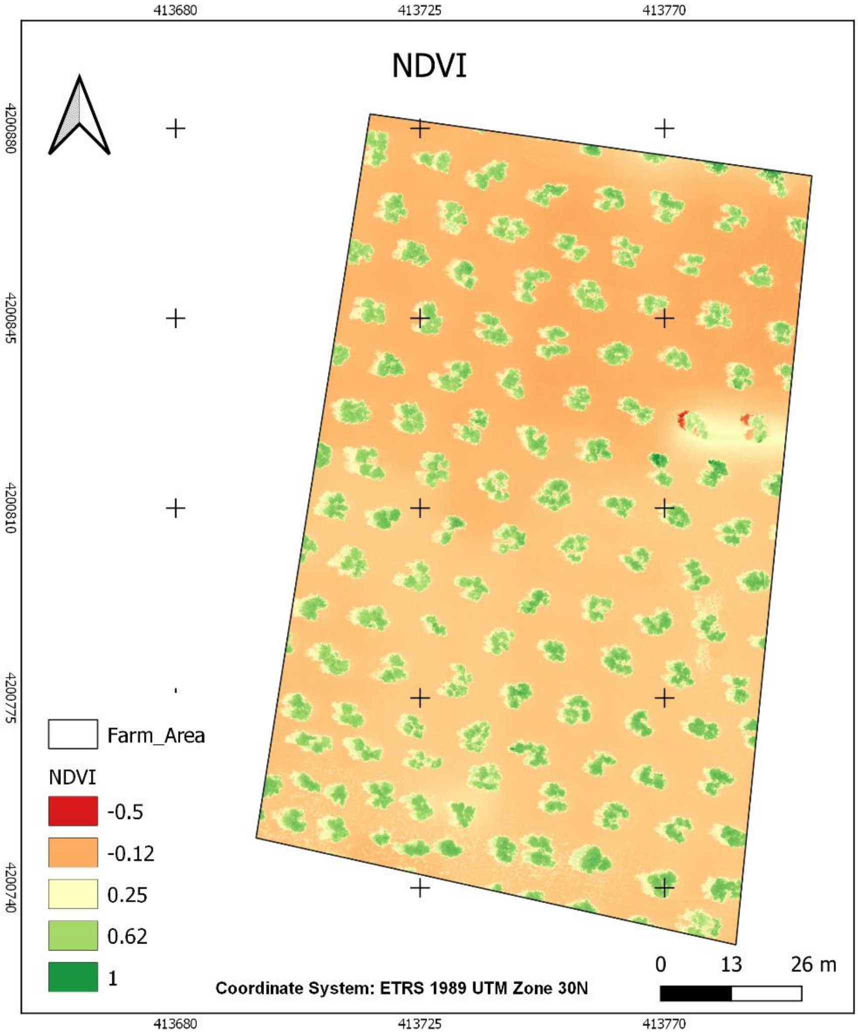


Figure 23 : NDVI
Source : Own elaboration

To make our result which appears in the Figure 23 above more clearer, the closer the vegetation is to 1, the more vigorous it will be considered, while values below 0 correlate to areas devoid of vegetation, such as, for instance, water, The typical range for vegetation is between 0.2 and 0.9, with trees and crops falling between 0.2 and 0.3 and forests and culture falling between 0.4 and 0.9 (Pettorelli, 2005), The values between 0 and 0.1 are considered to be nude soils.

III.4.1.1.2 Green Normalised Difference Vegetation Index (GNDVI)

In the green normalised difference vegetation index (GNDVI), The red band is replaced by a green band, which has the same format as the NDVI (Gitelson, Kaufman, & Merzlyak, 1996). Hunt, Hively, Daugtry, and McCarty (2008) shown that it correlates with biomass and LAI and follows the ratio of photosynthetically absorbed radiation. As a result, the GNDVI is more sensitive to the amount of chlorophyll than the NDVI (Candiago et al. 2015).

GNDVI is calculated as :

$$\mathrm{GNDVI} = \frac{(\mathrm{NIR} - \mathrm{GREEN})}{(\mathrm{NIR} + \mathrm{GREEN})}$$

Where the spectral values :

NIR = Near Infra Red band

GREEN = Green band

This index, is like NDVI index, vary from -1 to 1, with values between -1 and 0 indicating the presence of water or nude soils, respectively. It is therefore often used to assess the nitrogen status in crops and water absorption, which helps to optimize irrigation.

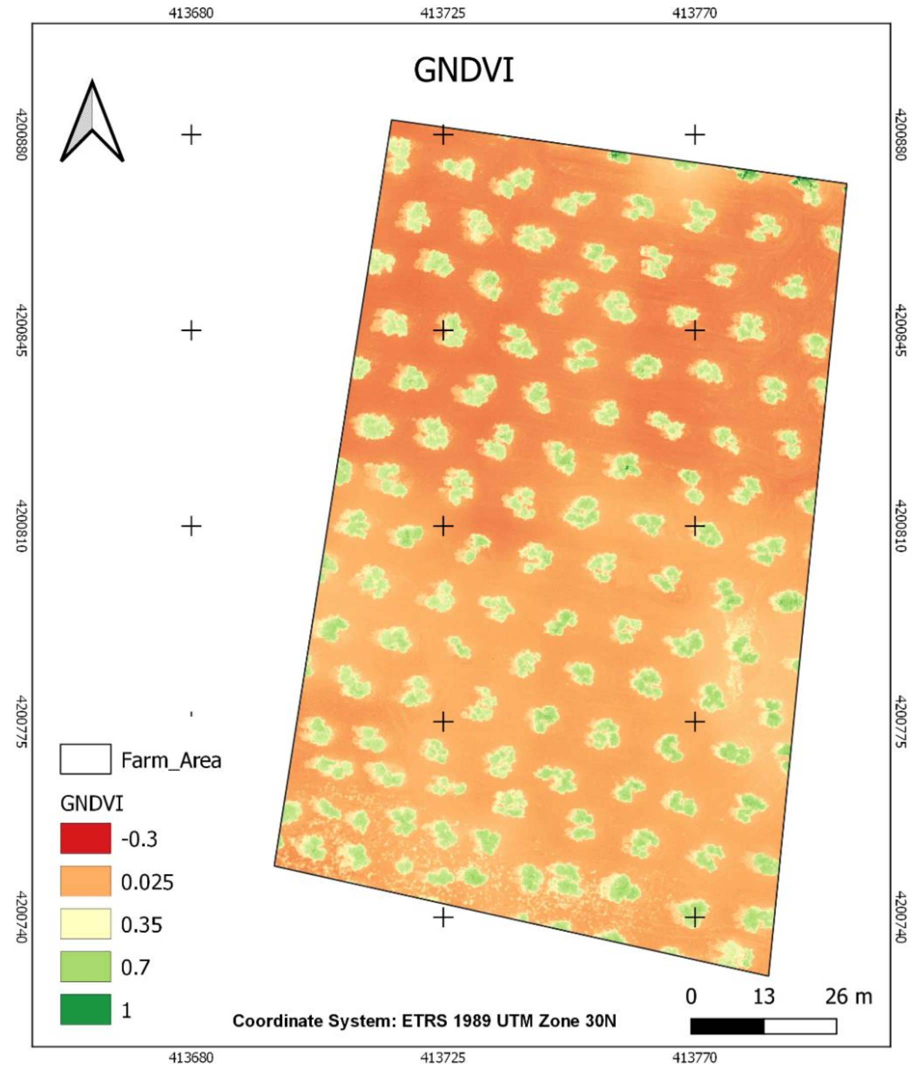


Figure 24 : GNDVI

Source : Own elaboration

According to the Figure 24 above, we can say also that with the equation of GNDVI index we have an acceptable result of vegetation, However, a higher result is obtained with exposed soil.

III.4.1.1.3 Normalized Difference Red Edge (NDRE)

NDRE has the same ratio as that of NDVI, but with the red band replaced by REDGE, Tucker (1979)

NDRE index implementations comprise PA, forest monitoring, and identification of vegetation stress (Cammarano et al., 2014; Fitzgerald, 2010; Hunt et al., 2012; Siegmann et al., 2012).

NDRE is calculated as :

$$\mathrm{NDRE} = \frac{(\mathrm{NIR} - \mathrm{REDGE})}{(\mathrm{NIR} + \mathrm{REDGE})}$$

Where the spectral values :

NIR = Near Infra Red band

REDGE = Red Edge band

NDRE has values varying from -1 to 1, it is using wavelengths along the Red-Edge Region (RE). It takes use of the RE vegetation's sensitivity to subtle changes in canopy leaf content, canopy coverage, and senescence.

As shown in the Figure 25 below, the index result is quite low compared to the other vegetation results, but the bare soil result is more accurate.

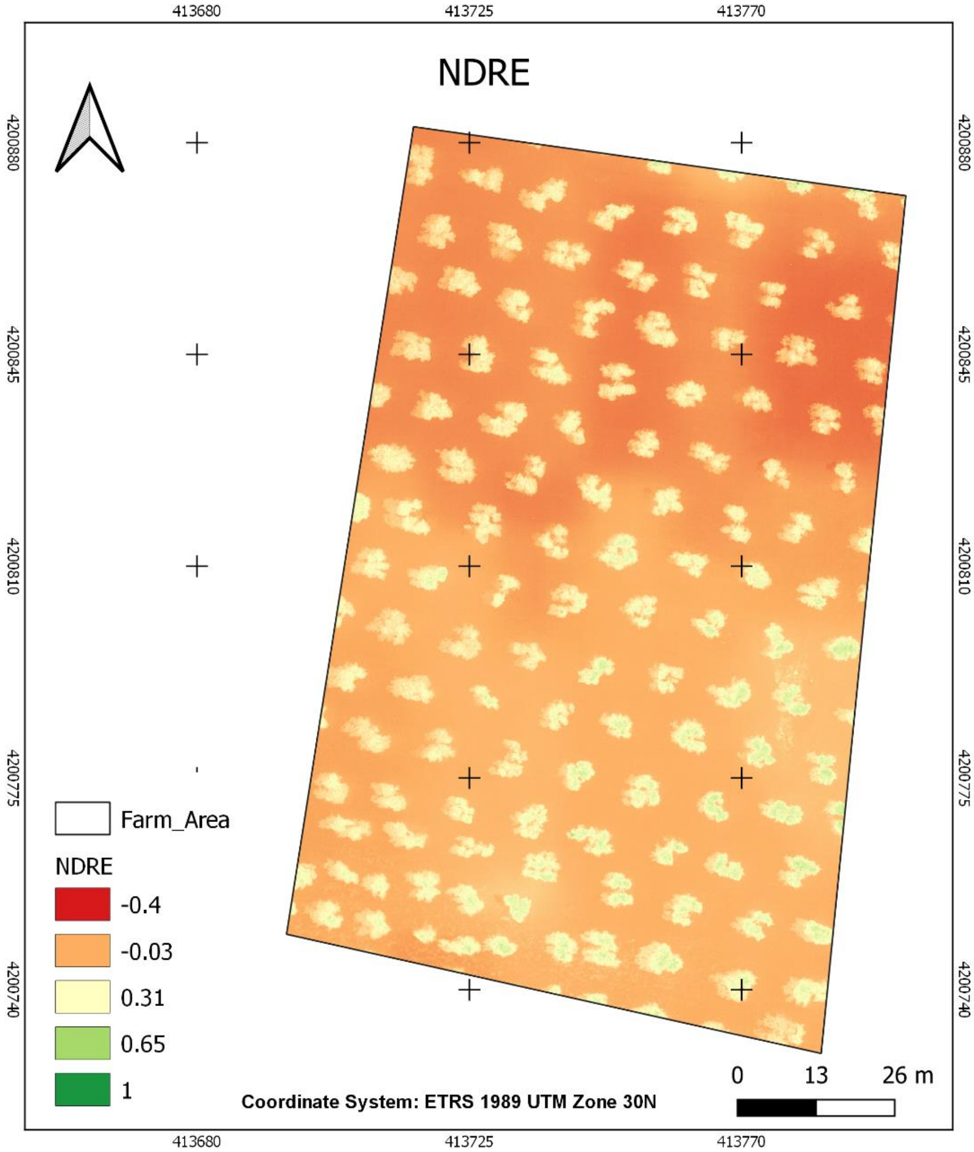


Figure 25 : NDRE

Source : Own elaboration

III.4.1.1.4 Soil-Adjusted Vegetation Index (SAVI)

The SAVI, a vegetation index that is used to quantify the presence of green vegetation while minimizing the impact of the soil introduced by Huete (1988).

SAVI is calculated as :

$$\mathrm{SAVI} = \frac{(\mathrm{NIR} - \mathrm{RED})}{(\mathrm{NIR} + \mathrm{RED} + \mathrm{L})} * (\mathrm{L} + 1)$$

Where the spectral values :

NIR = Near Infra Red band

RED = Red band

L = Adjustment factor

SAVI index might range from -1 to 1. According to AGROgestor, negative values correlate to artificial surfaces or clouds, between zero and 0,1 corresponds to a barren landscape, 0,2 and 0,3 to a sparse vegetated area, and 0,4 to 0,8 indicates a growing vegetative stage.

Regarding the values of the factor L, they can also range from -1 to 1, but inversely proportional to how much vegetation is present in the scene. It is advised to set it to a value of 0 when the area has a high level of vegetative cover, 0,5 for a medium level of vegetative cover, and close to 1 for a low level of vegetative cover. L was used with a value of 0.5.

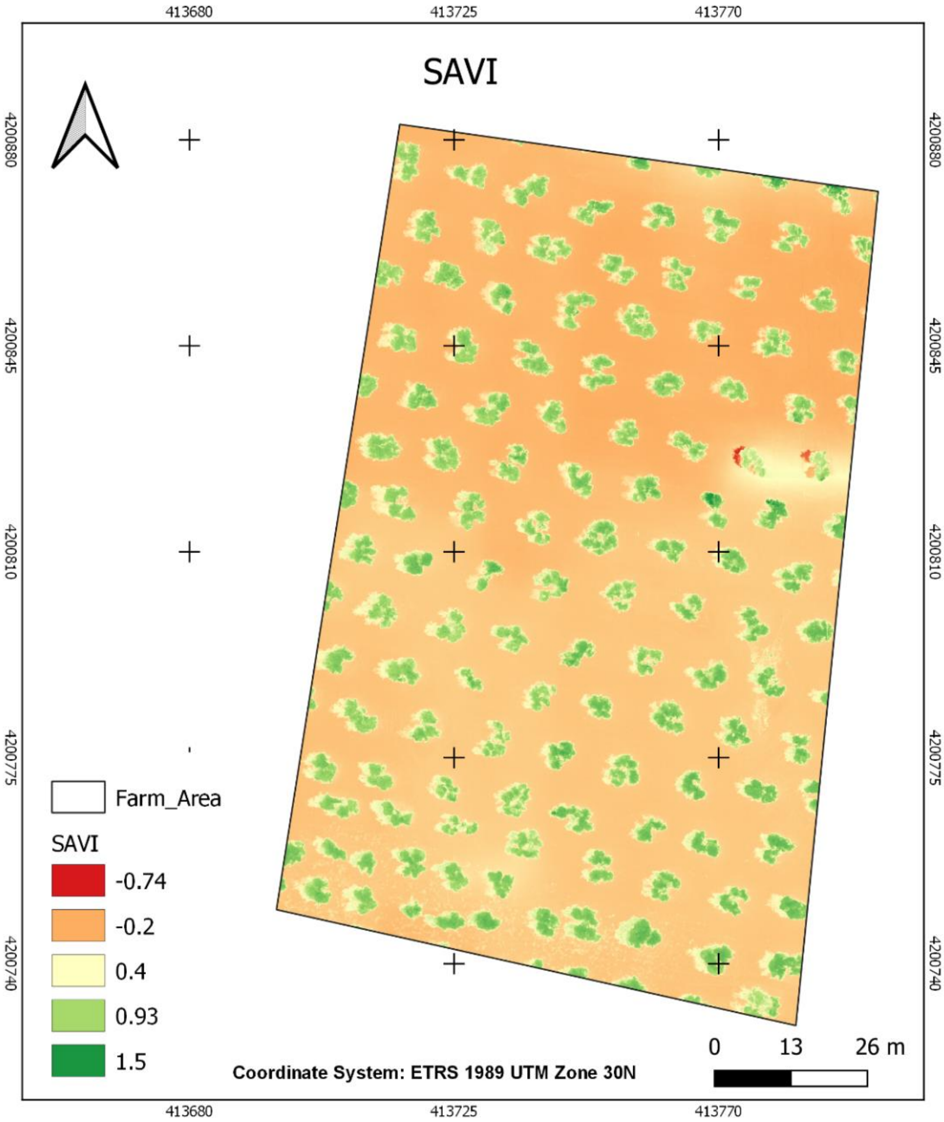


Figure 26 : SAVI

Source : Own elaboration

Due to the degree of quality of vegetation and soil, it seems closest to the result of the NDVI index, we can notice the precision of values on the map of Figure 26 above.

III.4.1.1.5 Atmospherically Resistant Vegetation Index (ARVI)

L'ARVI was created to reduce atmospheric effects in the sensor's output by replacing the length of the red wave sensitive to aerosols utilized in NDVI with a mixture of the red and blue wavelengths, according to Kaufman & Tanré, 1992, Consequently, the blue band is included in the algorithm to account for atmospheric impacts.

ARVI is calculated as :

$$\mathrm{ARVI} = \frac{(\mathrm{NIR} - (2 * \mathrm{RED}) + \mathrm{BLUE})}{(\mathrm{NIR} + (2 * \mathrm{RED}) + \mathrm{BLUE})}$$

Where the spectral values :

NIR = Near Infra Red band

RED = Red band

BLUE = Blue band

The range for an ARVI is -1 to 1 where green vegetation generally falls between values of 0.20 to 0.80 as we can see in the Figure 27.

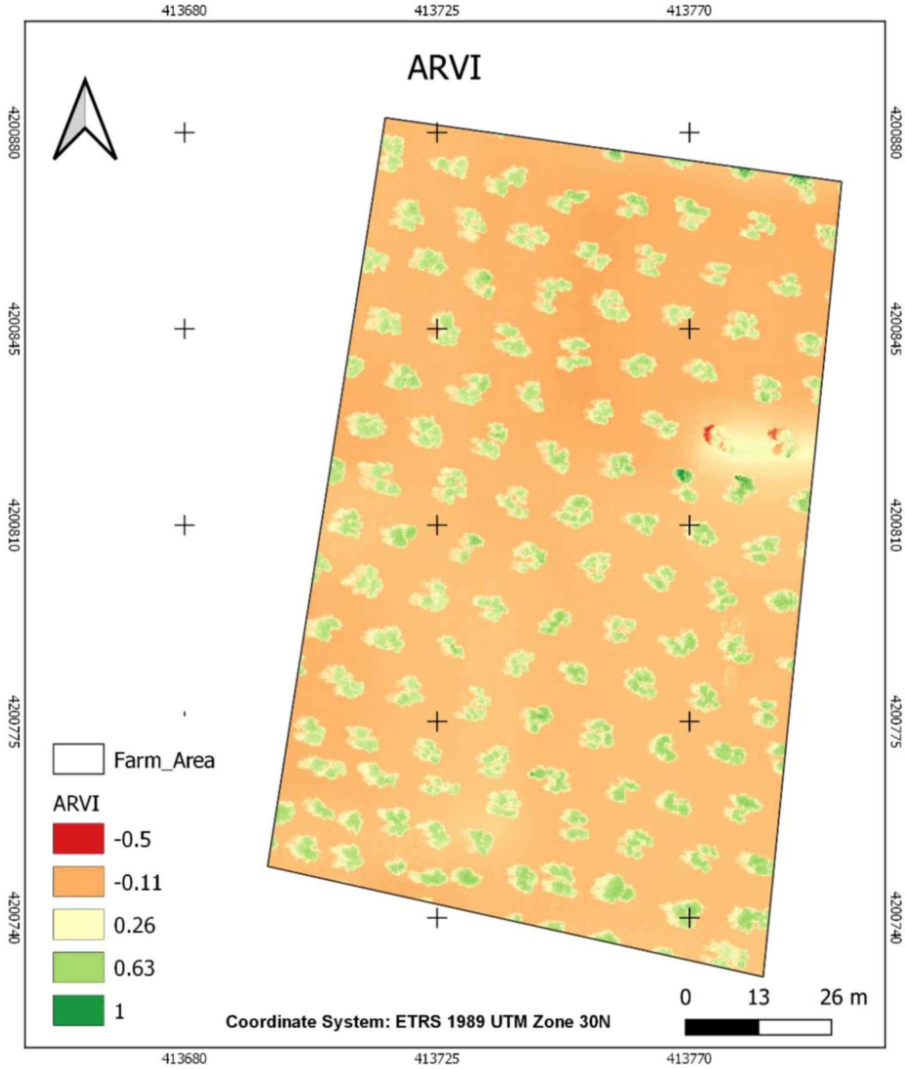


Figure 27 : ARVI

Source : Own elaboration

III.4.1.2 Data maps extracted

The data gathered allowed for the development of several secondary data that are helpful for the analysis of the farm; this data, as well as how they were produced, are discussed in the following sections.

III.4.1.2.1The area of each olive tree

To calculate the area of the canopy, we created a vector layer (shapefile) of the canopy of each olive grove, that allows a better visual representation of the data obtained wich also facilitates the spatial analysis.

Therefore, to achieve this goal, the orthoimage generated from the NDVI, which represents best the vegetation, was used. Then, using the QGis raster calculator, a threshold was established to facilitate this differentiation and thus a second binarized image was created. That is, as shown in Figure 28 below, for values above 0.4 and below 1, the pixel was transformed to 0 and for values outside of this threshold, the pixel was transformed to 1. This threshold was set by trial and error, that is, until the trees were well identified.

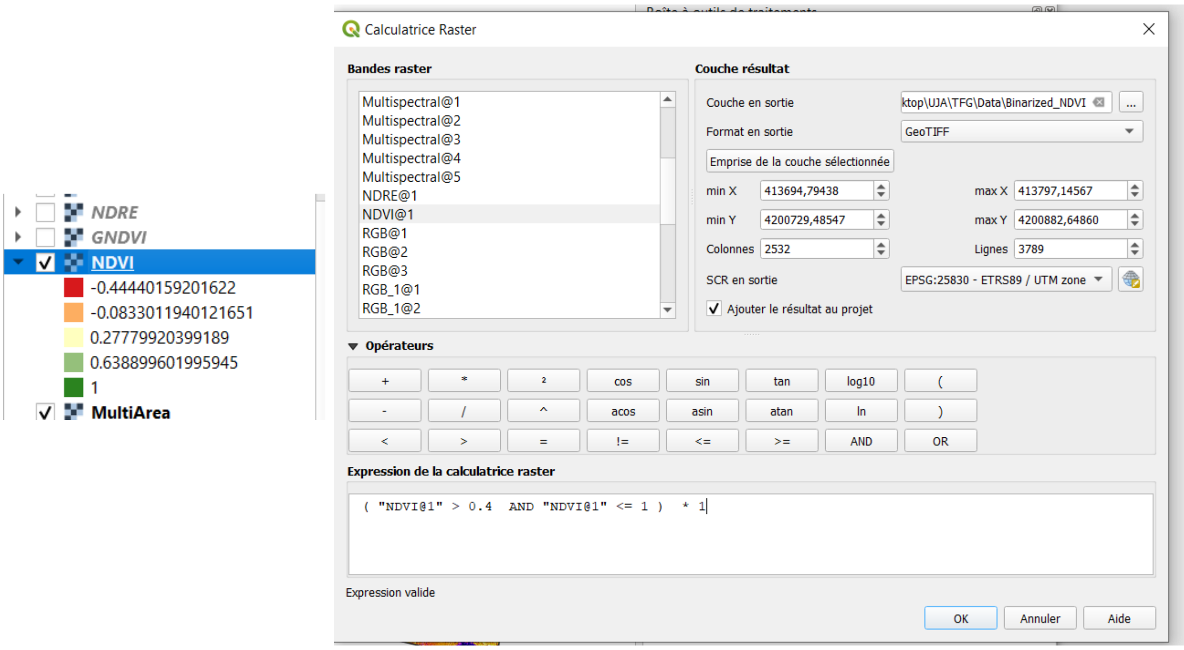


Figure 28 : Raster calculator Qgis

Source : Own elaboration

Based on the previous steps, the Figure 29 below shows the result that identifies bare soil and vegetation

Figure 29 : Binarized orthoimaging

Source : Own elaboration

Once the image was classified, it was a matter of using the Polygonize processing tool which transformed the raster into a vector as shown in Figure 30 below, with setting the parameters necessary.

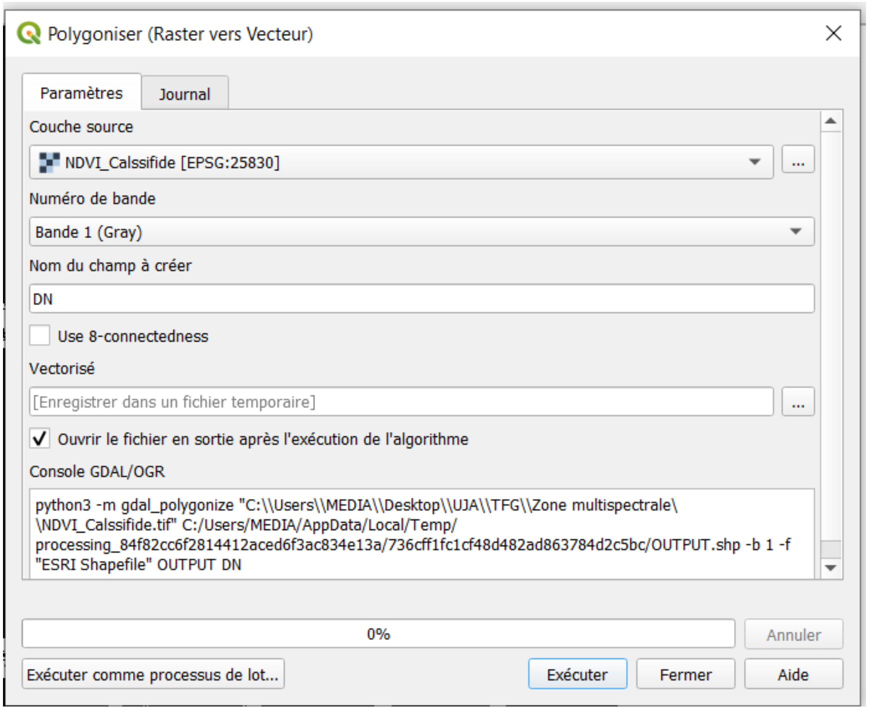


Figure 30 : Raster to vector tool Qgis

Source : Own elaboration

By using this technique, it was feasible to automatically digitize the olivier covers.
At this point, one may distinguish a minor error caused by the shadow using the NDVI and many small polygons were created during the automatic scan and these had to be deleted, which calls for additional processing for improved data visualization as seen in Figure 31 following.

Figure 31 : Olive trees polygons

Source : Own elaboration

After processing and correcting the data, the area of each polygon present in the layer was calculated. Additionally, it was verified that only the outline of the trees of interest remained. The Qgis field calculator was used to calculate the area, as can be seen in Figure 32 below.

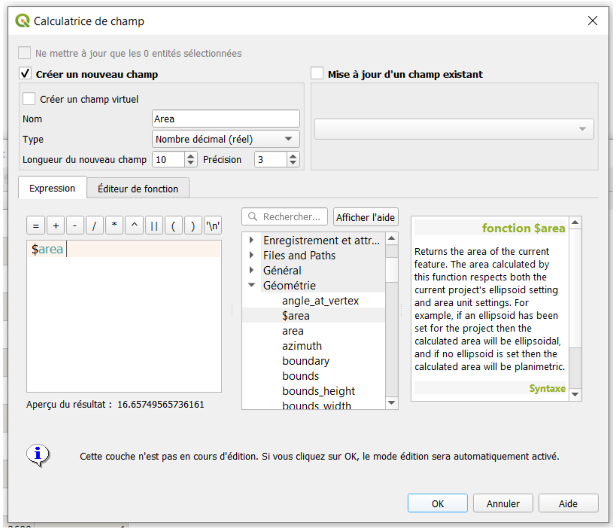


Figure 32 : Field calculator Qgis

Source : Own elaboration

The attribute table of the olive tree shapefile is shown in Figure 33.

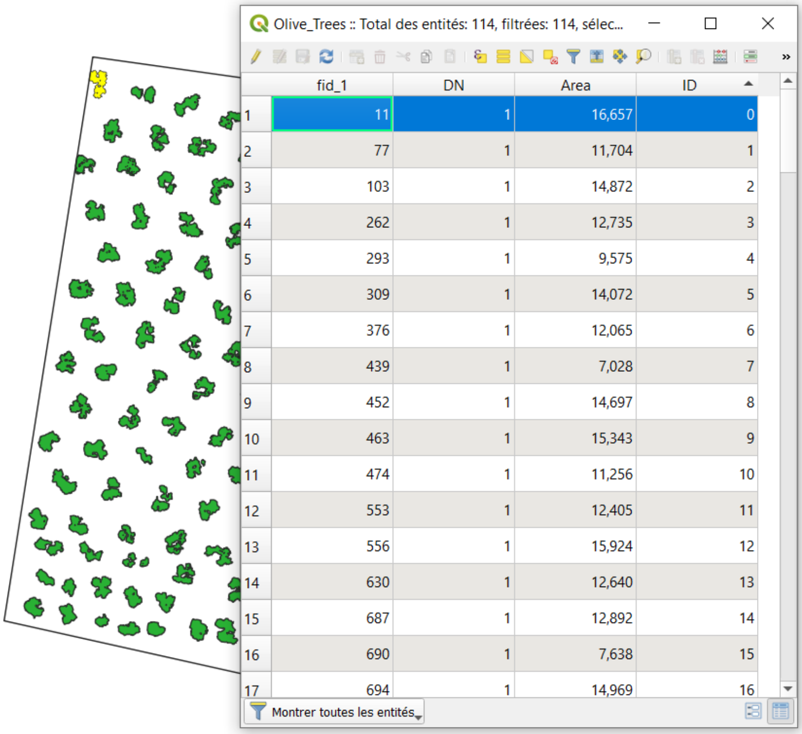


Figure 33 : Attribute table Qgis

Source : Own elaboration

In brief overview, this is a very intriguing technique that combines a variety of prior geomatics knowledge, starting with the idea of the relationship between NDVI and vegetation, then the benefit of having a binarized raster, and finally the advantages of using a SIG for polygonization, surface computation, and categorical information visualization.

As another extracted data, it is possible to obtain an approximate calculation of the volume of each olive tree by combining the surface data with the height data that can be extracted from the DEM.

III.4.1.2.2Level curve

Using the produced DTM and a QGis contour tool capable of extracting the contour lines from this type of raster, we will create the contour lines of the farm in this phase, Figure 34 shows the tool that was employed and Figure 35 below shows the outcome.

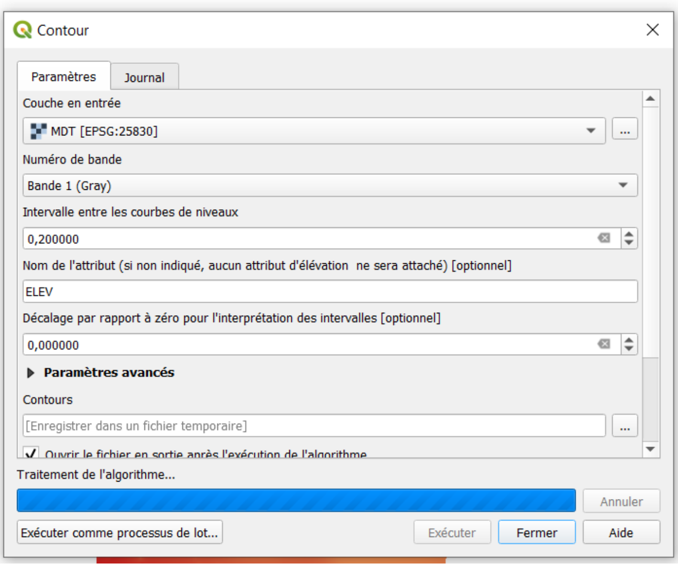


Figure 34 : Contour tool Qgis

Source : Own elaboration

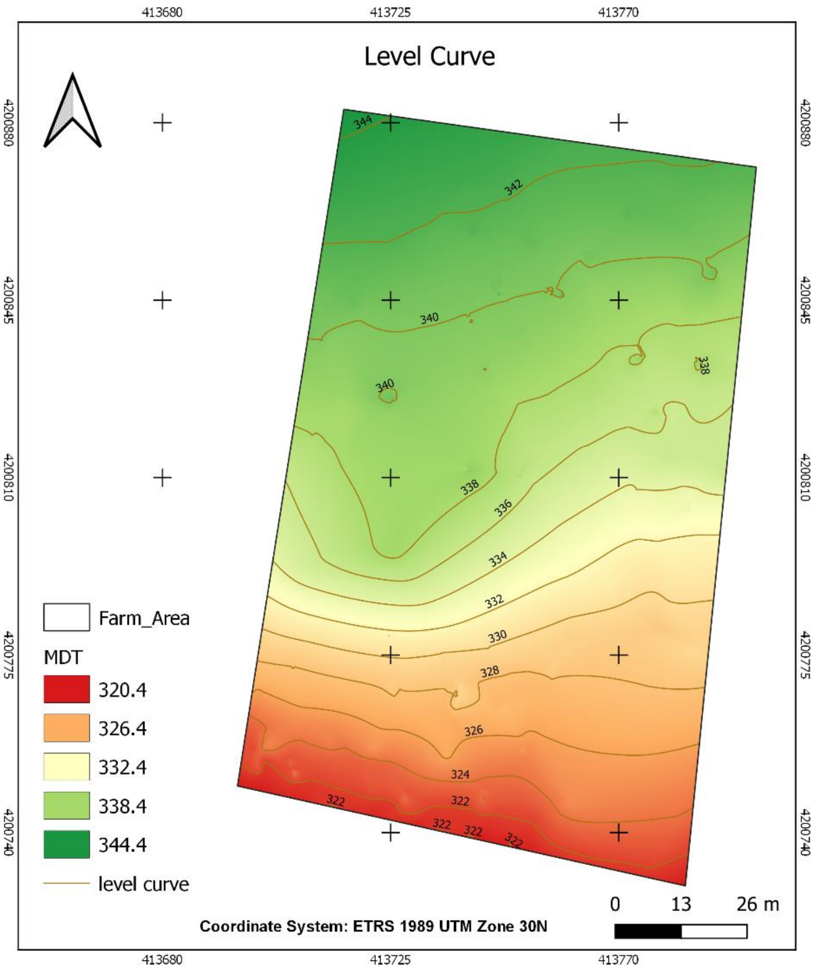


Figure 35 : Level curve

Source : Own elaboration

III.4.1.3 Ground control point

Ground control points can significantly increase the overall accuracy of your drone map when used properly. In other words, they ensure that any place on your map's latitude and longitude precisely match the GPS coordinates.

Control points are actual search area landmarks that can be recognized in photogrammetric flight images.

The first stage was to evenly distribute control points around the study area, these points were clearly specified. In this exercise, we attempted to place control points in the study area's center using white plates covered in aluminum with a screw inserted in the middle.

In a second step, the drone flies and capture the GCP targets in our images, which are then used to increase the accuracy of our map, and of course the GNSS equipment was connected to the Andalusian Positioning Network RAP (Red Andaluza de Posicionamiento) to perform the RTK.

According to the website Junta de Andalucia, The real-time differential corrections of the RAP network stations are broadcast over the Internet using the NTRIP protocol (Network Transport RTCM via Internet Protocol), so red connection in RTCM3.x format was used, the Andalusian Positioning Network (RAP) was created with the main objective of solving the problem of positioning in Andalusia

In addition to the RTK (Real Time Kinematic) method installed on the drone, we will use our field survey Topcon receiver GR-5 to identify the precise coordinates for the control points.

Leica Geo Office's software generated a total of 10 points above the base, but in my situation, I just used 9 points for my study space, which are listed in Figure 36 along with their precision.

	A	B	C	D	E
1	Header>> D	Lon(East)%	Lat(North)	Ht(G)%10	Codes%10
2	100	413756,710	4200884,456	318,554	PLAT1
3	101	413748,795	4200860,179	316,337	PLAT-B1
4	102	413776,174	4200856,771	315,101	PLAT2
5	103	413742,176	4200838,244	314,233	PLAT3
6	104	413760,472	4200829,641	312,223	PLAT-B2
7	105	413763,197	4200811,266	309,028	PLAT4
8	106	413733,747	4200815,104	313,426	PLAT-B3
9	107	413731,946	4200783,516	307,563	PLAT5
10	108	413753,544	4200776,644	303,232	PLAT-B4
11	109	413752,783	4200748,905	298,668	PLAT6
12					

Figure 36 : The control points coordinates and their corresponding precisions

Source : Own elaboration

To import the ground control point into Qgis, we used the data source management tool by changing the parameters (field, datum), as we can see in Figure 37. Consequently, as shown in the map in Figure 38.

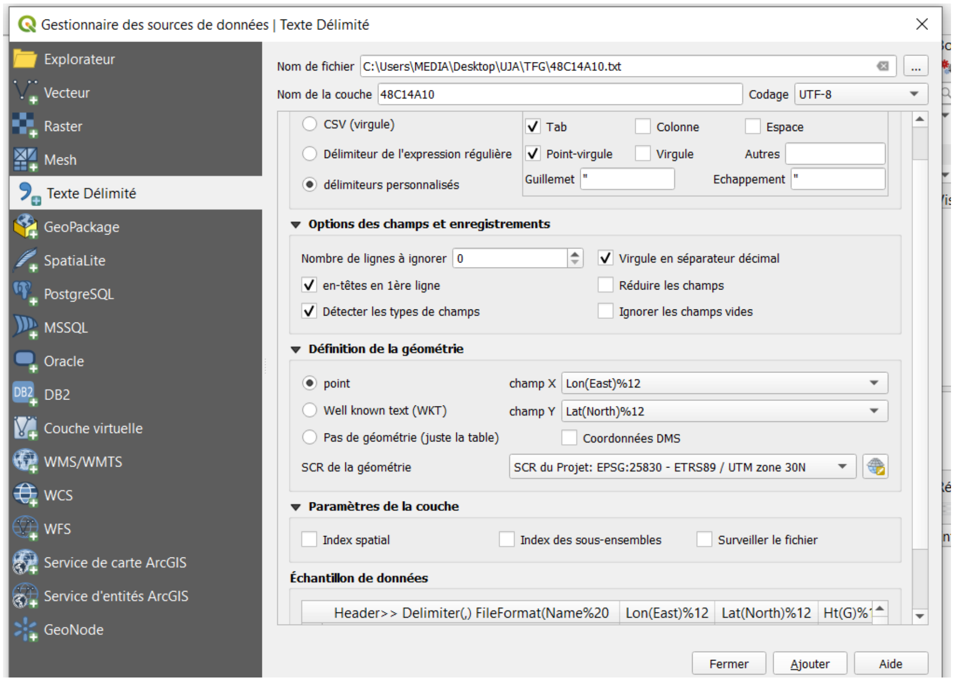


Figure 37 : Data source management Qgis

Source : Own elaboration

Figure 38 : Ground control point

Source : Own elaboration

III.4.2 Web services

To increase the value of data presented in the project our goal was to collect more useful information from the open source websites, such as specifically meteorological details for our study area, so in case of that, after a research we did found that the official site of the Junta de Andalucia, the Andalusian Institute of Research and Training on Agriculture, Fisheries, Food, and Organic Production (Instituto Andaluz de Investigación y Formación Agraria, Pesquera, Alimentaria, y de la Producción Ecológica), provides detailed information about all affiliated provinces.

We consulted the site to find the information needed for the project, As it existed in the section of agriculture fishing water and rural development, so we defined our station to be more specific 'Meteorological Station of La Higuera de Arjona'

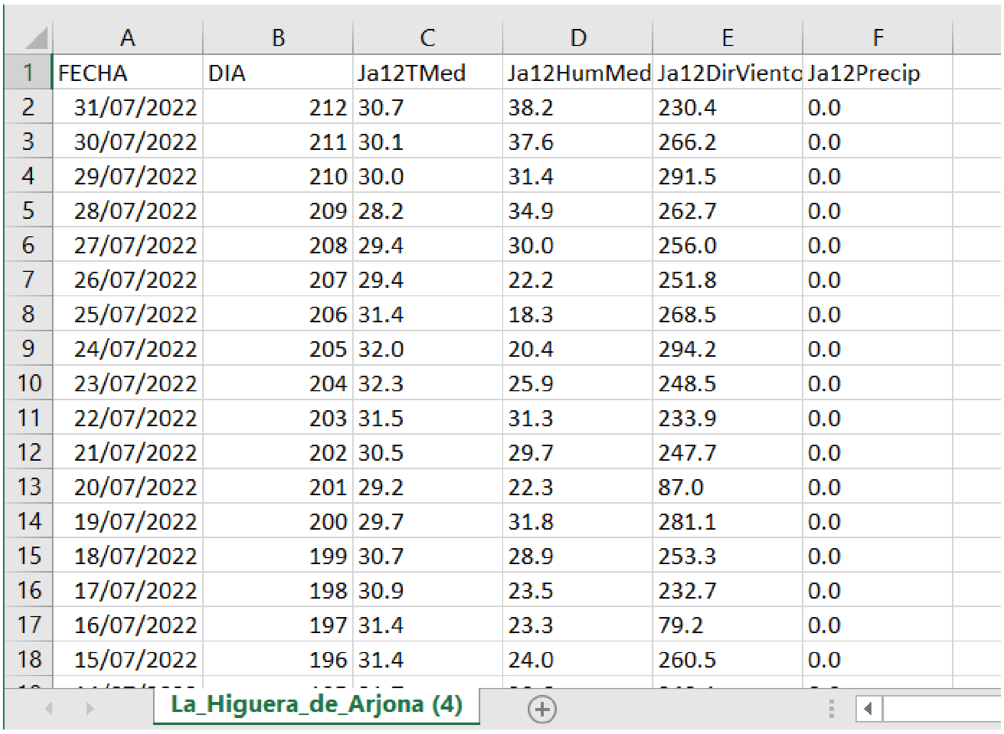
As we can see in the capture presented in the figure 39 billow we find three options, you can read the last data recorded 'Last Recorded Data', the option to download a file of data wanted 'File Download' and as a final option a historical data 'Historical facts'.

In this case the filtering of data that we did is that we did choose the Medium Temperature, Medium Humidity, Direction of the wind and the Precipitation values for the 2022 year.

Figure 39 : Meteorological Station of La Higuera de Arjona page

Source : Taken from Andalusian Institute of Research website

We downloaded the excel file from the page as shown in Figure 40 below because it contained the exact data from the meteorological station of La Higuera de Arjona.



	A	B	C	D	E	F
1	FECHA	DIA	Ja12TMed	Ja12HumMed	Ja12DirViento	Ja12Precip
2	31/07/2022	212	30.7	38.2	230.4	0.0
3	30/07/2022	211	30.1	37.6	266.2	0.0
4	29/07/2022	210	30.0	31.4	291.5	0.0
5	28/07/2022	209	28.2	34.9	262.7	0.0
6	27/07/2022	208	29.4	30.0	256.0	0.0
7	26/07/2022	207	29.4	22.2	251.8	0.0
8	25/07/2022	206	31.4	18.3	268.5	0.0
9	24/07/2022	205	32.0	20.4	294.2	0.0
10	23/07/2022	204	32.3	25.9	248.5	0.0
11	22/07/2022	203	31.5	31.3	233.9	0.0
12	21/07/2022	202	30.5	29.7	247.7	0.0
13	20/07/2022	201	29.2	22.3	87.0	0.0
14	19/07/2022	200	29.7	31.8	281.1	0.0
15	18/07/2022	199	30.7	28.9	253.3	0.0
16	17/07/2022	198	30.9	23.5	232.7	0.0
17	16/07/2022	197	31.4	23.3	79.2	0.0
18	15/07/2022	196	31.4	24.0	260.5	0.0

Figure 40 : Excel file of data

Source : Taken from Andalusian Institute of Research website

Those data will appear as curves in our web mapping page.

III.4.3 Farmer

In our project, to make it more useful for the farmer, we made forms to fill in the web mapping page that enables him to add all the information that interests him about his farm, in that way he can insert the most important data that characterize his olive trees only known by him.

In our case, we provided three forms, first, the farm data form, which has the following information :

- Year
- The yearly production (Kg)
- Water requirement per tree (liters)
- Tree watering times (per year)
- Phytosanitary products requirement per tree (liters)
- The number needed of workers

We can add also as an important economic data, that the farmer want to insert

- Expenditure on plant protection products.
- Expenditure on tillage.
- Expenditure on machinery repairs.

Second, the workers form which allows the farmer to add informations about his new workers, the form contains :

- First name
- Name
- Age
- Date of start
- Date of end

Third, the truck form which allows the farmer to add details of the trucks used in the farm, the form holds :

- Registration number
- Type of truck

- Next check date
- Remarks

III.5 End-to-end project solution

III.5.1 Designing the Spatial Database

The creation of a spatial database may well be thought of as a process whose objective is to create a detailed data model to describe a reality. It is necessary to carry out an accurate storage of all of the data in this project in a separate database. The importance of storing data in a database is primarily to ensure their security while also allowing for data sharing with other systems.

What is a spatial data database ?

- Allows to store and manipulate spatial objects just like any other database object.
- The benefit of the data model's coherence and the structure of the database into themes.
- Data centralization for geographical data.
- Interpolation of spatial data with attribute data is available when using SQL queries.
- Numerous spatial functions.

First of all, we must define all the data that will be saved, to effetively create our database, and after that we will present, firstly relational entity model secondly the Conceptual model data design and finally, Logical design.

III.5.1.1 Data Structure

The resulting information has a vector and raster structure, , and of course the economic data that gonna be inserted by the farmer in a value type and other data in a text type.

A vector is a type of data structure that is used to store spatial data. In vector mode, the position of each object is defined by a single coordinate value on a spatial medium organized by a referenced coordinate system. Points, lines and polygons are used to show irregularities in the geographical distribution of features such as buildings, roads and rivers, among others.

In addition the raster structure describes its location, shape, size and orientation.

Due to the addition of spatial extensions like PostGIS, current technology now makes it possible to store these two types of data in the same database, which is a significant advancement.

Some of these data will change over time, showing temporal characteristics. It was considered in the analysis but won't be used for this project because the data only pertains to one campaign.

In order to generate the database, some of the data needs to be described.

At the beginning we specify the reference system that will be used for all data, in our case we are using the ETRS89 / UTM HUSO 30N system.

In conclusion, the data that will be included in the data base have been classified according to their raster or vector nature. The complete classification of the data for this project is shown in Table 2.

Table 2 : Classification of the data

Source : Own elaboration

	Type	
Data	Raster	Vector
RGB	Grid	
Multispectral	Grid	
DEM	Grid	
DTM	Grid	
NDVI	Grid	
GNDVI	Grid	
NDRE	Grid	
SAVI	Grid	
ARVI	Grid	
Farm_Area		Polygon
GPS_Points		Points
Olive_Trees		Polygon
Level_curve		Polylines

All that is left to do is to characterize each one and examine their interrelationships. This will serve as the foundation for the presentation of our database's entity-relationship model's schema represented in Figure 41.

The following entities are involved in this project :

- Orthoimages : This entity houses the information for each orthoimage that was processed for the project, including the RGB, Multispectral, Vegetation Indexes, DTM, and DEM orthoimages.
- Farm_Area : The study farm is defined by this object.
- GPS_Points : A collection of GPS measurements that were made in the field, with geographic coordinates.
- Olive_Trees : Specifies the boundaries of the canopy of each olive tree on the property.
- Level_curve : An object that describes the contours drawn from the study farm's digital terrain model.
- Meteorological : This one present the data imported from the web services.
- Economic_Data : Present the data inserted by the farmer.

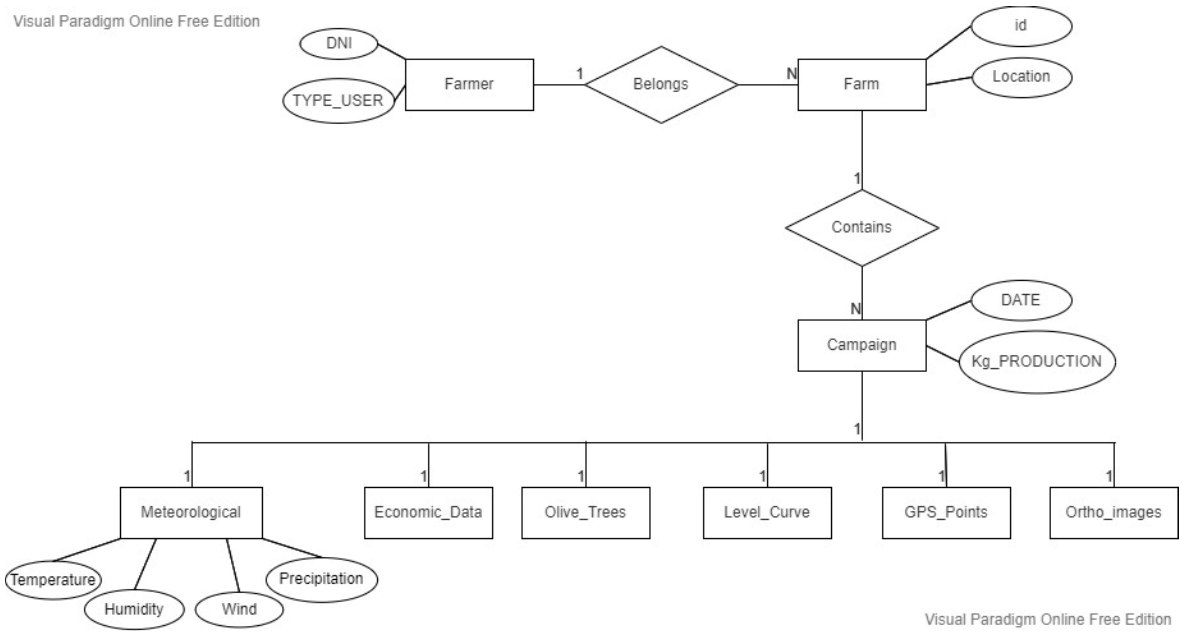


Figure 41 : Relational entity model

Source : Own elaboration

III.5.1.2 Conceptual data model design

Due to its accessibility and simplicity, the conceptual data model is one of the foundational elements in female modeling that is currently most commonly employed in the MERISE model, in order to develop this model, we utilized the program Visual Paradigm.

The study of data led to the creation of the following conceptual data model in Figure 42.

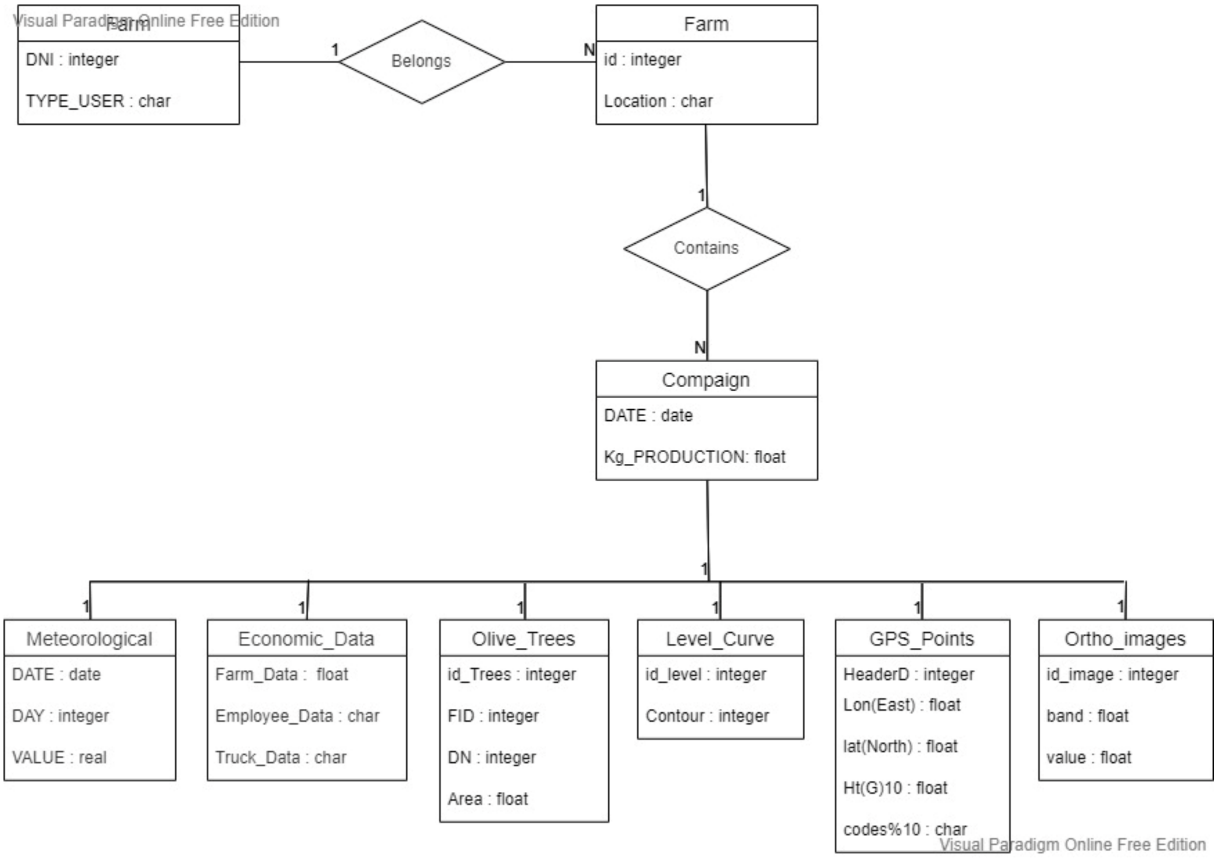


Figure 42 : CDM
Source : Own elaboration

The CMD contains 4 classes, it represents the data of our study area such as Olive Trees, Level Curve, GPS points and in order to obtain a total cartography of agriculture of our area of study, each entity present her attributes:

- Olive_Trees entity: id_Trees, FID, DN and Area.
- GPS_Points entity: Header, Lon(East), lat(North), HT(G)10 and codes%10.
- Level_Curve entity: id_level and Contour.
- Ortho_images entity: id_image, band and value
- Meteorologie: Date, Day and VALUE
- Economic_Data: Farm_Data, Employee_Data and Truck_Data

III.5.1.3 Logical data model design

We passed to the second level, the logical model of the data, in which the entities are progressively defined as well as the relations which would exist between them, by taking well into account the objectives to be reached with the tool.

The Logical Data Model (LDM) is the logical modeling of the data which takes into account the organizational level of the data. It is a logical view in terms of the organization of the necessary data (GALLO, F, 2000).

The LDM then takes again the contents of the preceding CDM, but specifies the organization of the data such as they could be implemented at this stage, as demonstrated in picture 43 downwards.

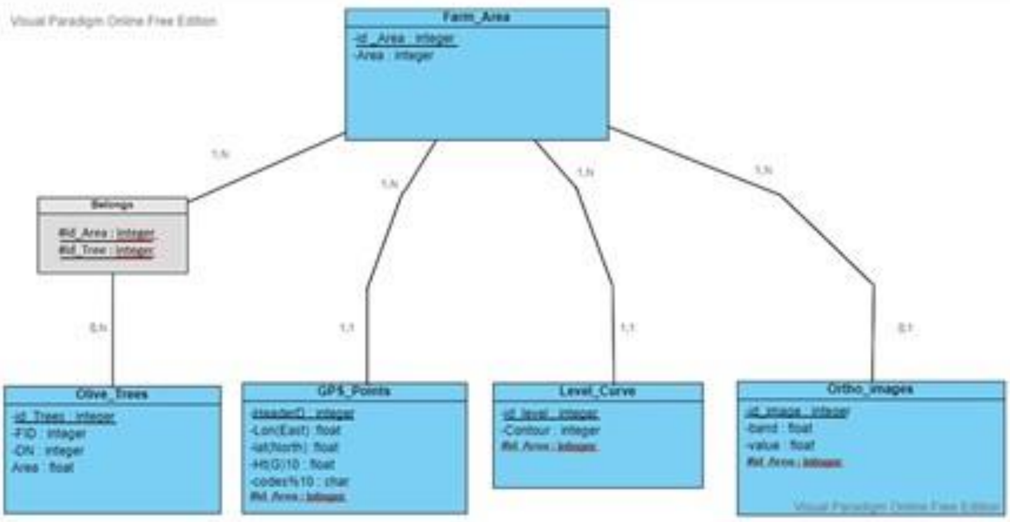


Figure 43 : LDM

Source : Own elaboration

III.5.2 Storage of the information in a database

Following the step-by-step installation procedure makes installation easier after downloading the PostgreSQL installation file for Windows.

For our application, we created the database farm_db, by clicking on Create database as we can see in the Figure 44 bellow,

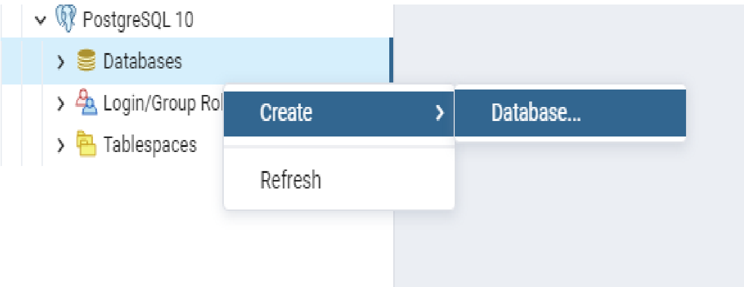


Figure 44 : Create database tool

Source : Own elaboration

The Database dialog organizes the development of a database through the following dialog tabs, general, definition, security, and parameters as illustrated in picture 45.

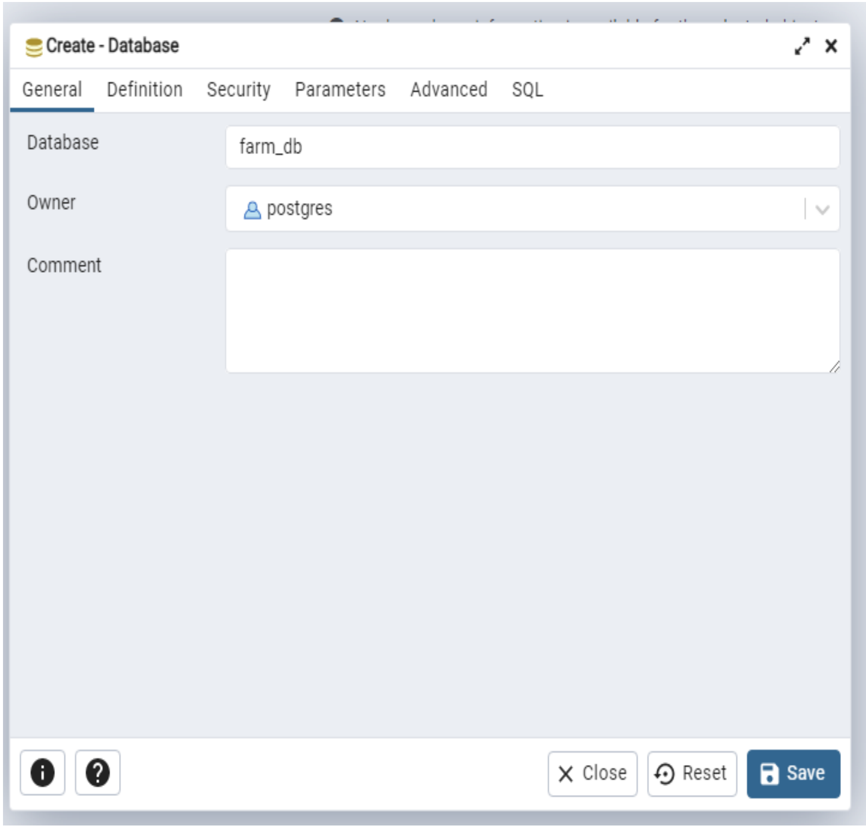


Figure 45 : Create database dialogue

Source : Own elaboration

Then we add the postgis extension to the Postgres database (Figure 46).

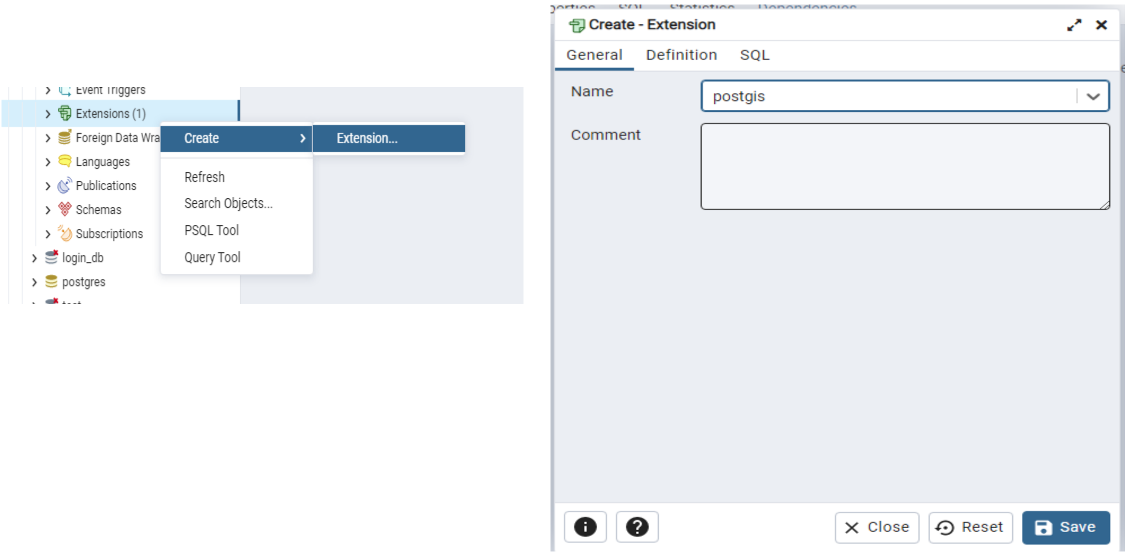


Figure 46 : Create postgis extension dialogue

Source : Own elaboration

The next step is the PostGis connection, so when the base is defined, we have imported all the layers that we will use through Postgis. And for these imports, it is shown in the Figure 49. But first, the Postgis tool requires a connection check between the database and the extension to ensure the transfer (Figure 47).

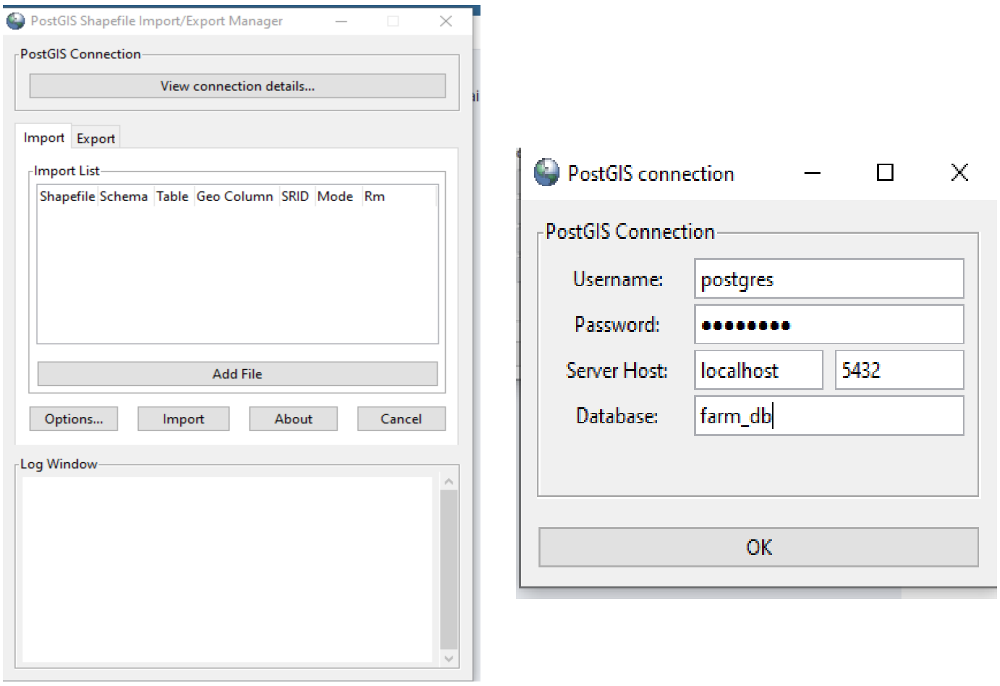


Figure 47 : Postgis connection check

Source : Own elaboration

We have a Succesful connection :

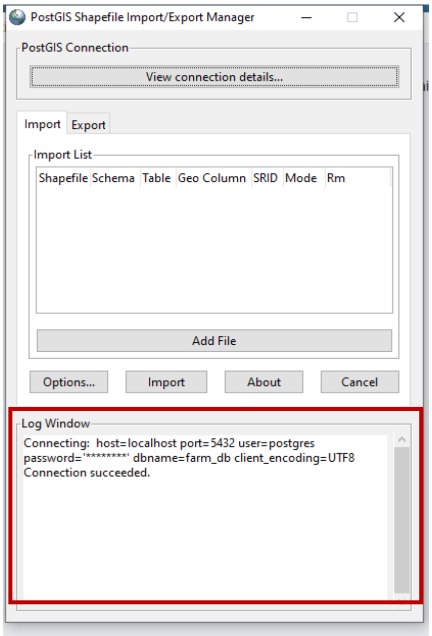


Figure 48 : Succesful connection

Source : Own elaboration

To import all the layers that we will use through Postgis as we already said, we open the shape file browser and select the different shapefiles.

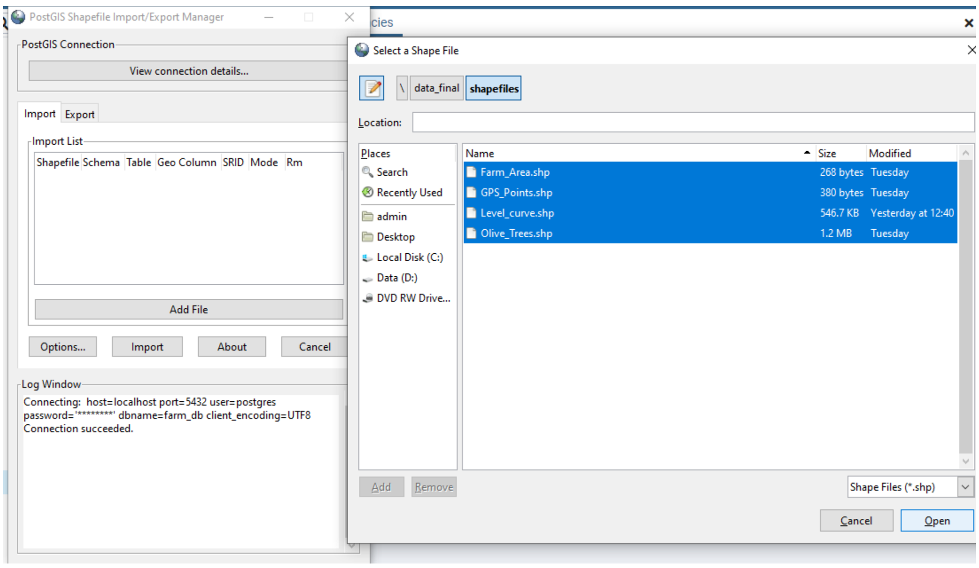


Figure 49 : Importing the shapefiles process

Source : Own elaboration

Then we chould change SRID to the reference system that we are working on it EPSG:25830 - ETRS89 / UTM zone 30N, Finally, click on the Import button and the import will run as illustrated in the Figure 50.

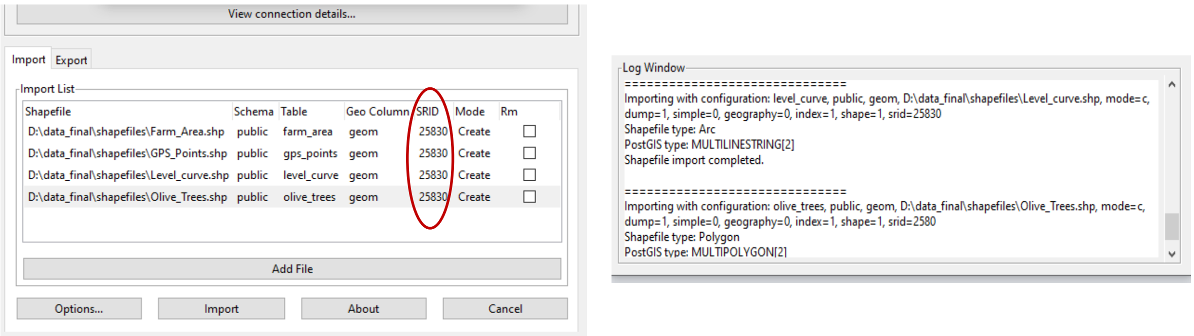


Figure 50 : Importing of the shapefiles succeeded

Source : Own elaboration

Finally we can check our tables in pgAdmin shown in Figure 51 and a capture of one table.

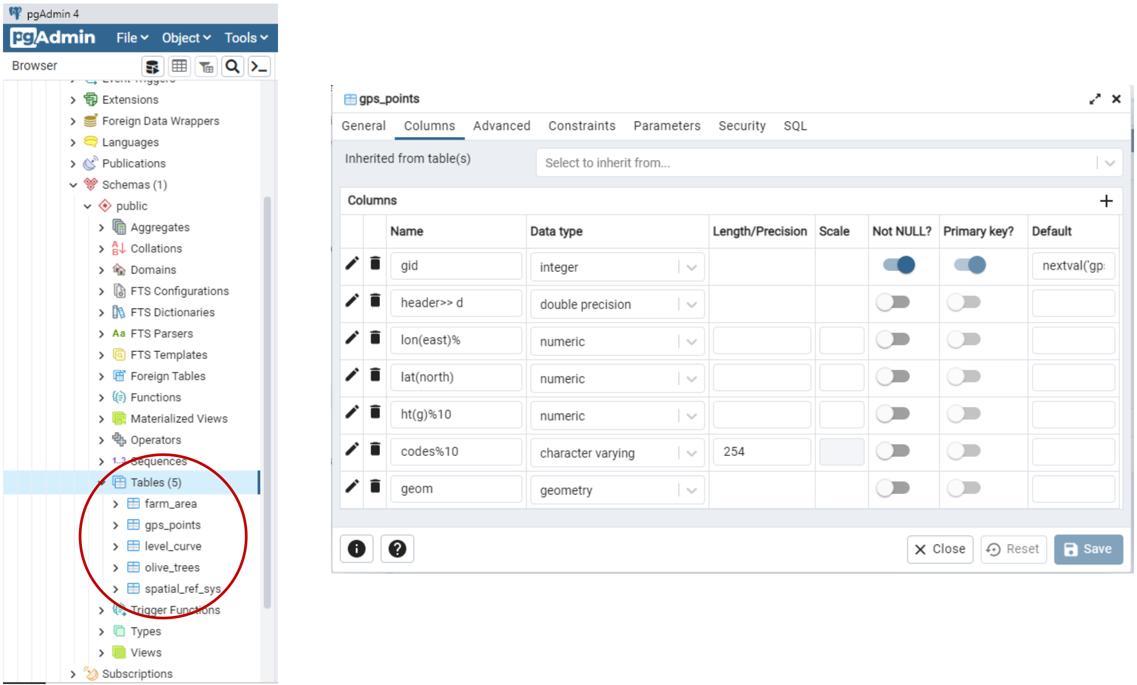


Figure 51 : GPS point table

Source : Own elaboration

III.5.3 Creation of new tables in our database

As the next step in the creation of the database, we will create new tables that present the forms of the actors in the web page realized as the user, agricultural data, employee and truck, we will provide the steps in this section.

Right click to tables→ create→Table (Figure 52), to create each table

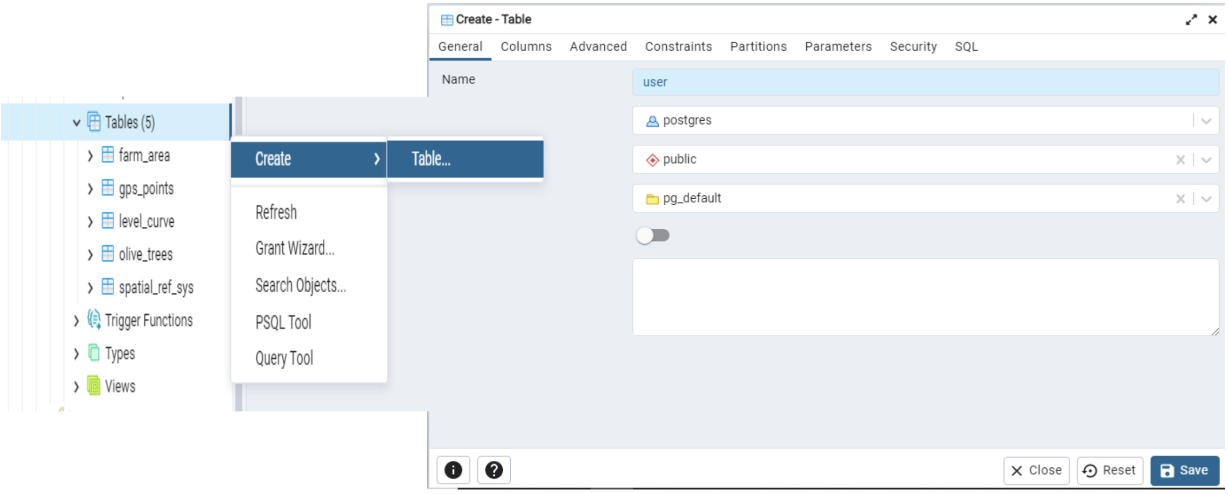


Figure 52 : Create new table

Source : Own elaboration

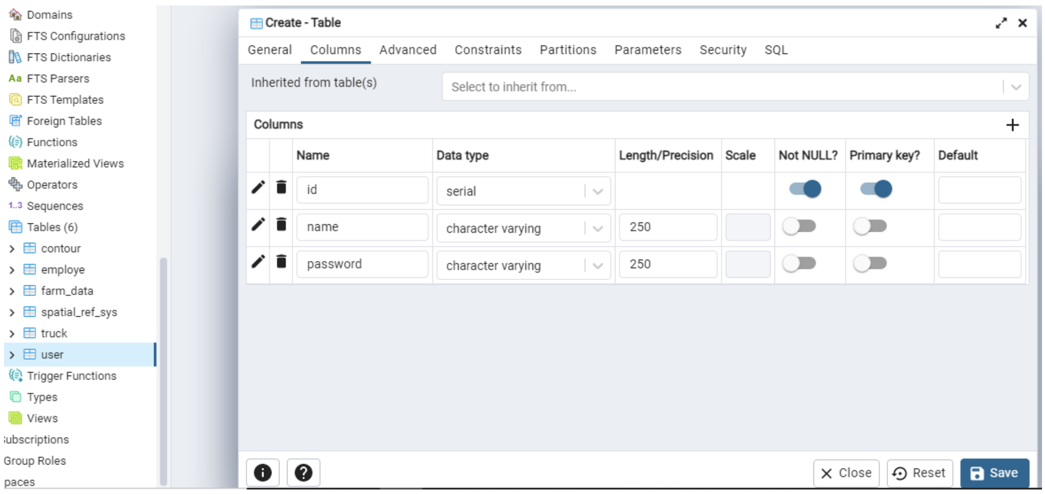


Figure 53 : User table

Source : Own elaboration

We save and do the same to other tables

We have now specified the tables name, column names, column types and a simple constraint.

we can use the SQL tab for review, to see the result of our work, we can go to the SQL query editor and expand the "user" table, (see an example in Figure 54 below).

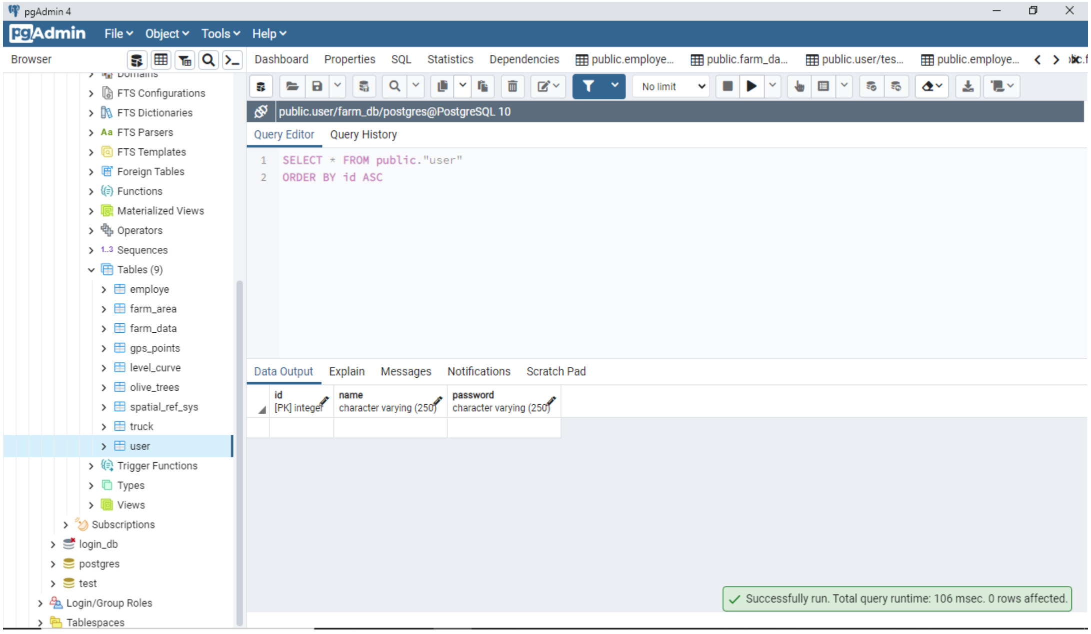


Figure 54 : SQL tab

Source : Own elaboration

III.5.4 Importing the data into Geoserver

Creating a workspace :

The first step is to create a workspace for the data. The workspace is a container used to group similar layers together.

We create a new workspace that we call "Farm", illustrated in the Figure 55.

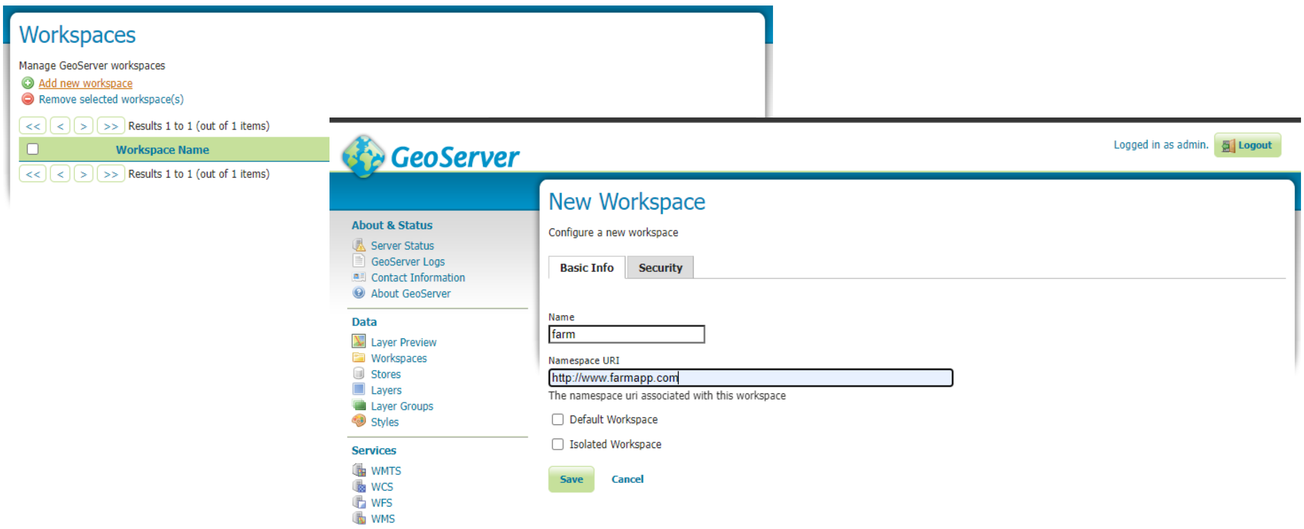


Figure 55 : New workspace

Source : Own elaboration

Adding GeoTIFF (Raster Data) in GeoServer :

After the creation of the workspace we go to the addition of a Raster DATA SOURCES « GeoTIFF » (Figure 56).

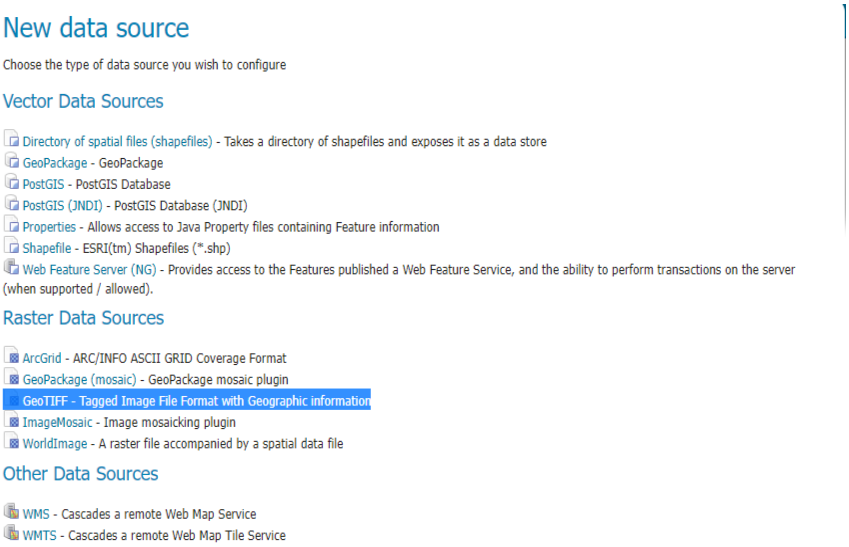


Figure 56 : New data source

Source : Own elaboration

On the add raster data source page we start by configuring the Database Information. Select the workspace "Farm" from the drop-down list and enter the name.

In the Connection settings section define the location of the data source, as demonstrated in Figure 57 following.

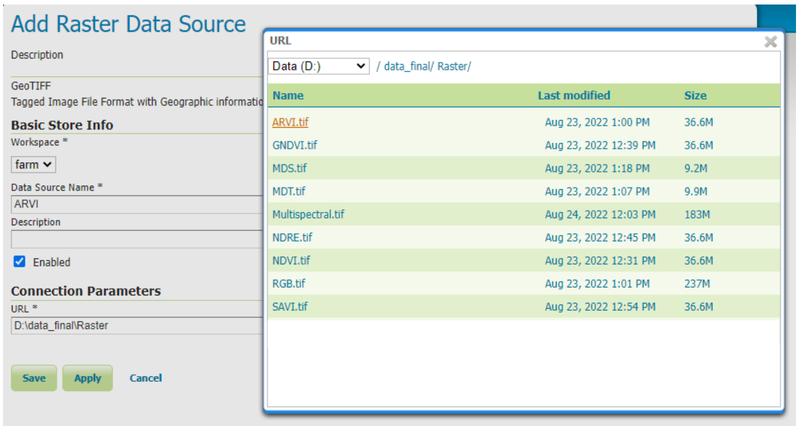


Figure 57 : Add raster data source

Source : Own elaboration

III.5.4.1 Connection of the database with Geoserver

Adding PostGIS Database (Vector Data) in GeoServer :

To add the raster data, in the new data source window select the PostGIS - PostGIS Database option (Figure 58).

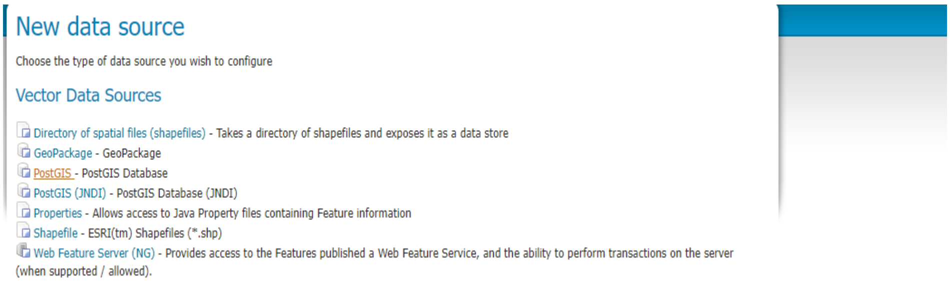


Figure 58 : Add vector data source

Source : Own elaboration

In the appeared new vector data source window, fill in the following fields, This indicated in Figure 59 beneath.

- Basic Store Info :

Select the Farm Workspace from the drop-down list.

Enter the Data Source Name (for example, farm_vector).

Using the same work space “farm” created when uploading raster layers.

- PostGIS database Connection Parameters :

Host : database host can be taken from the Info button.

Database : name of the database you’ve created with PostGIS extension (in our case, farm_db).

User and passwd : credentials to the PostgreSQL you’ve received while creating the environment.

Other fields are filled by default, you can leave the initial values.

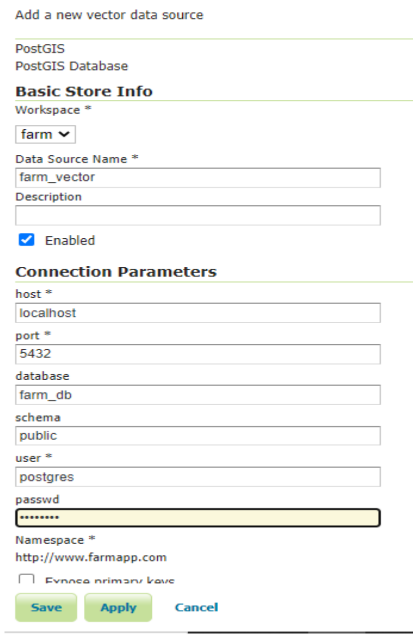


Figure 59 : New vector window

Source : Own elaboration

After apply and save, go to Layers → add new layer (Figure 60).

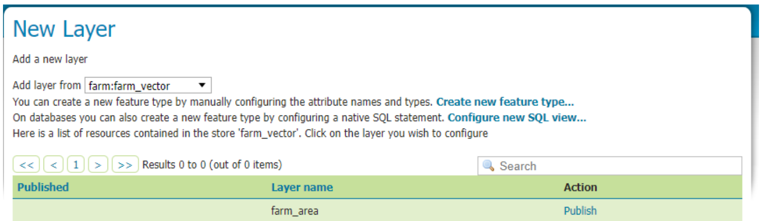


Figure 60 : Add new layer

Source : Own elaboration

We published layer by layer and selected the appropriate style downloaded earlier, as we will describe in the next section.

III.5.4.2 Defining layer styles in GeoServer

III.5.4.2.1 Styles of vector data

In this step, adding all the styles we will check the parameters of our data.

So when publishing be sure that Bounding Boxes (Figure 61) :

Native Bounding Box : Compute from data.

Lat/Lon Bounding Box : Compute from native bounds.

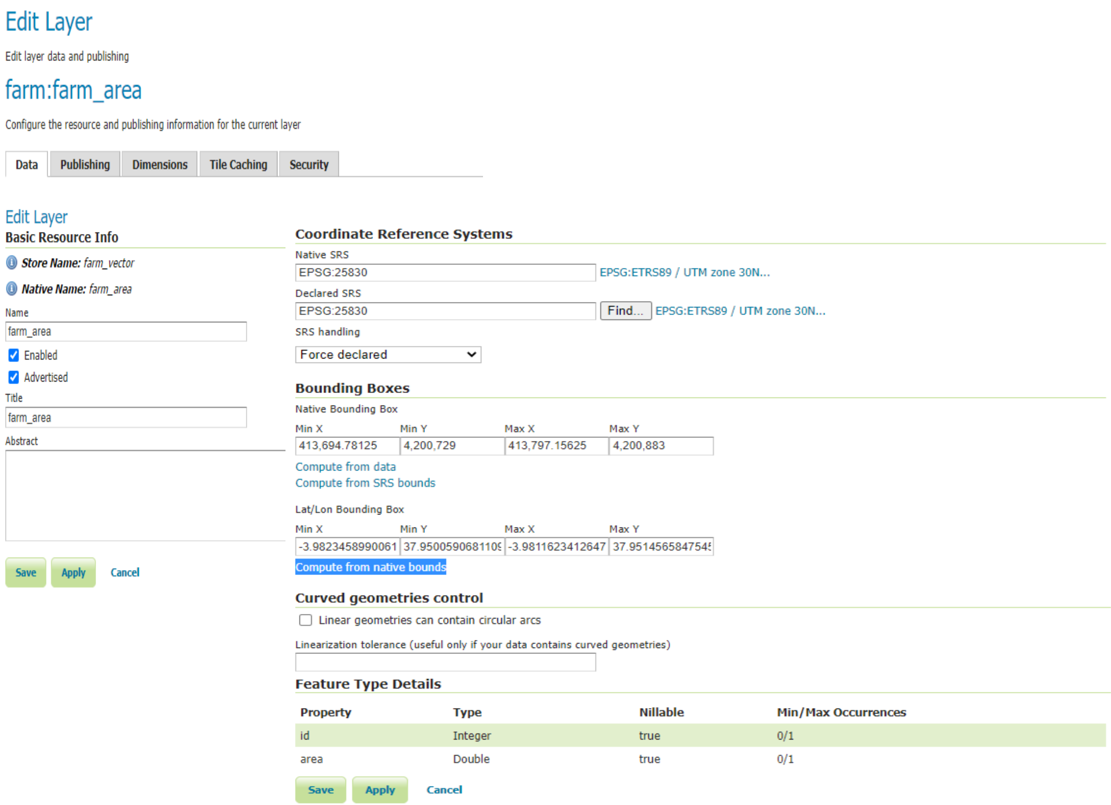


Figure 61 : Edit layer

Source : Own elaboration

For the styles in the WMS parameters (layer parameters) we choose the style, Like seen in Figure 62 following.

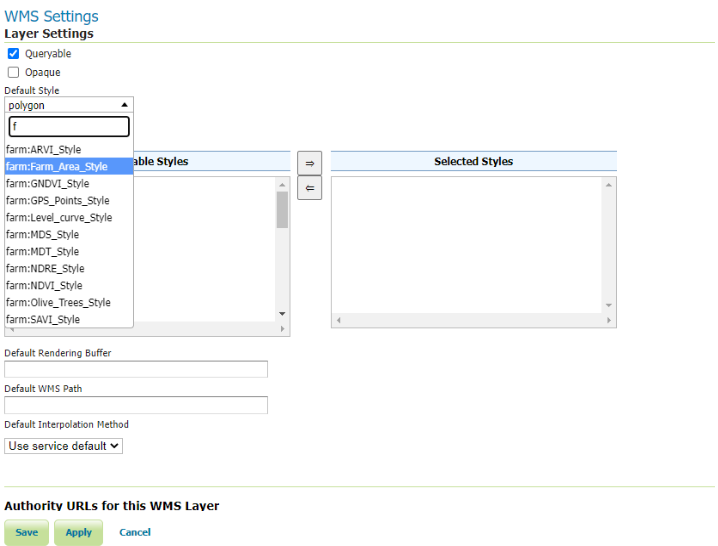


Figure 62 : Layer parameters

Source : Own elaboration

When we finish publishing layers in the same way, we can check our work in the layer preview (Figure 63).

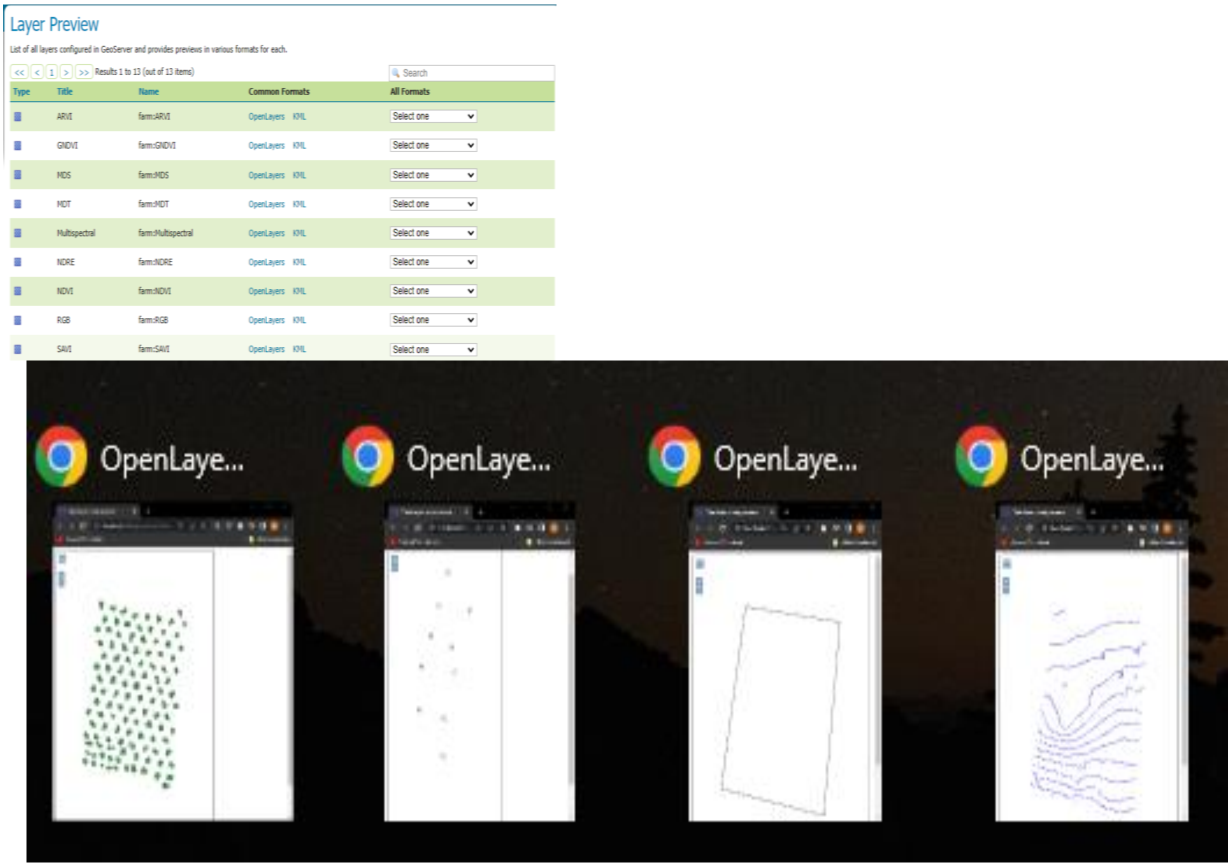


Figure 63 : Layer preview

Source : Own elaboration

III.5.4.2.1 Styles of raster data

After adding all the raster data, we start selecting the style for each of them in the styles window as depicted in Figure 64 down.

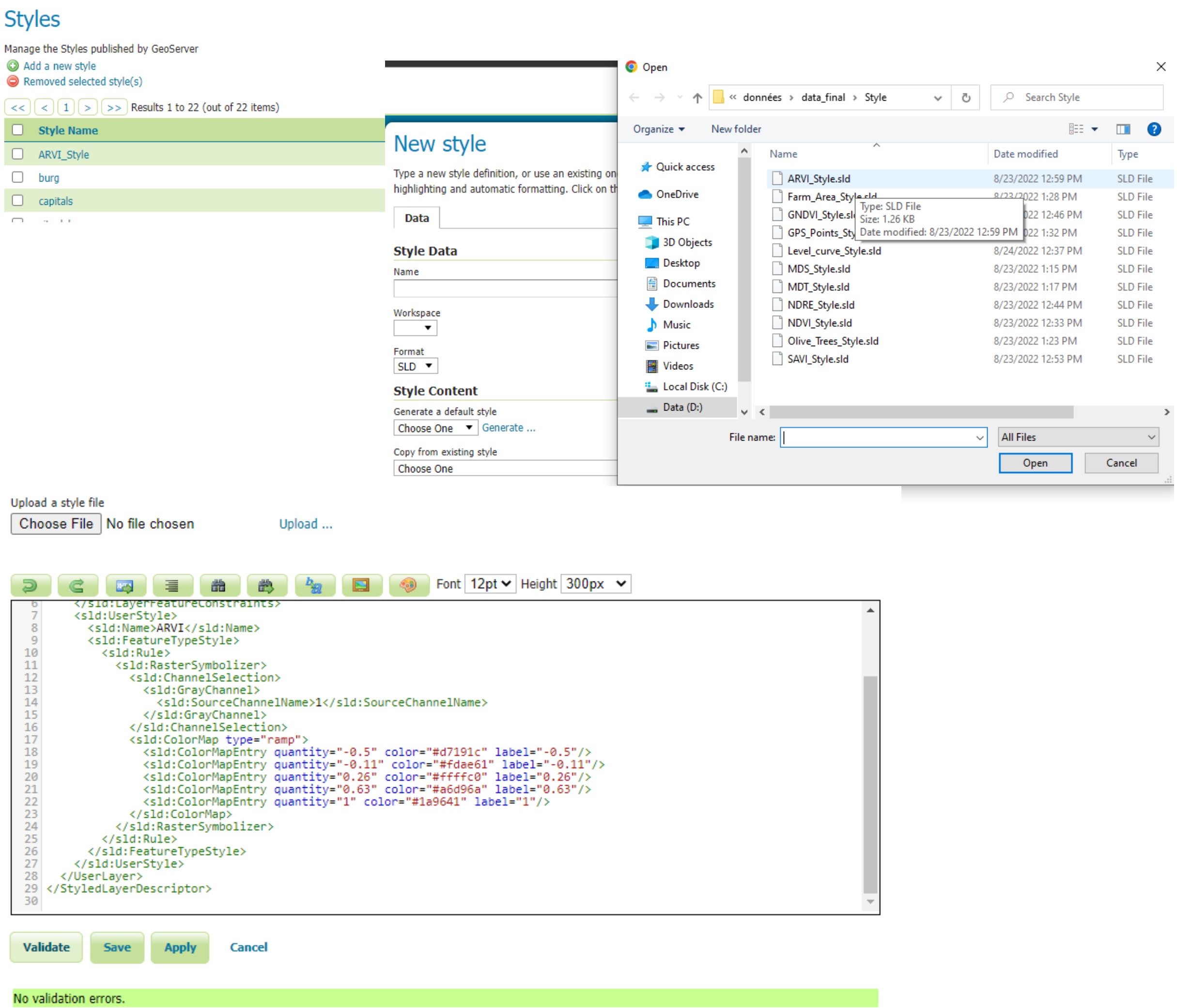


Figure 64 : Importing .sld files into GeoServer

Source : Own elaboration

In this level we enter the new layer window and select our first layer that we will specify its style, here we will also check the parameters of the Coordinate Reference Systems (Figure 65), then in the layer edition window (Figure 66) we import the style prepared for this layer, we finish the configuration of the data and their publication by scrolling down to the bottom of the page and clicking on save.

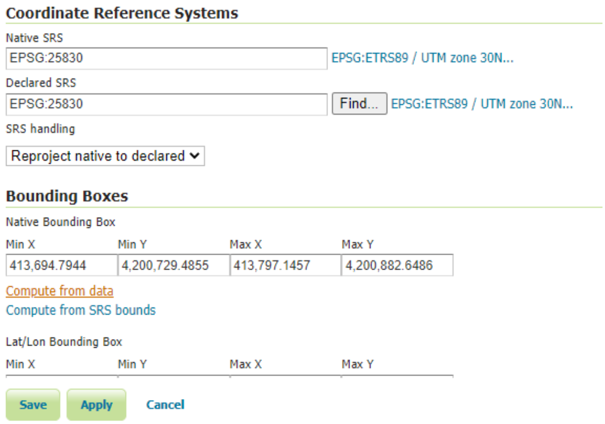


Figure 65 : Coordinate Reference Systems check

Source : Own elaboration

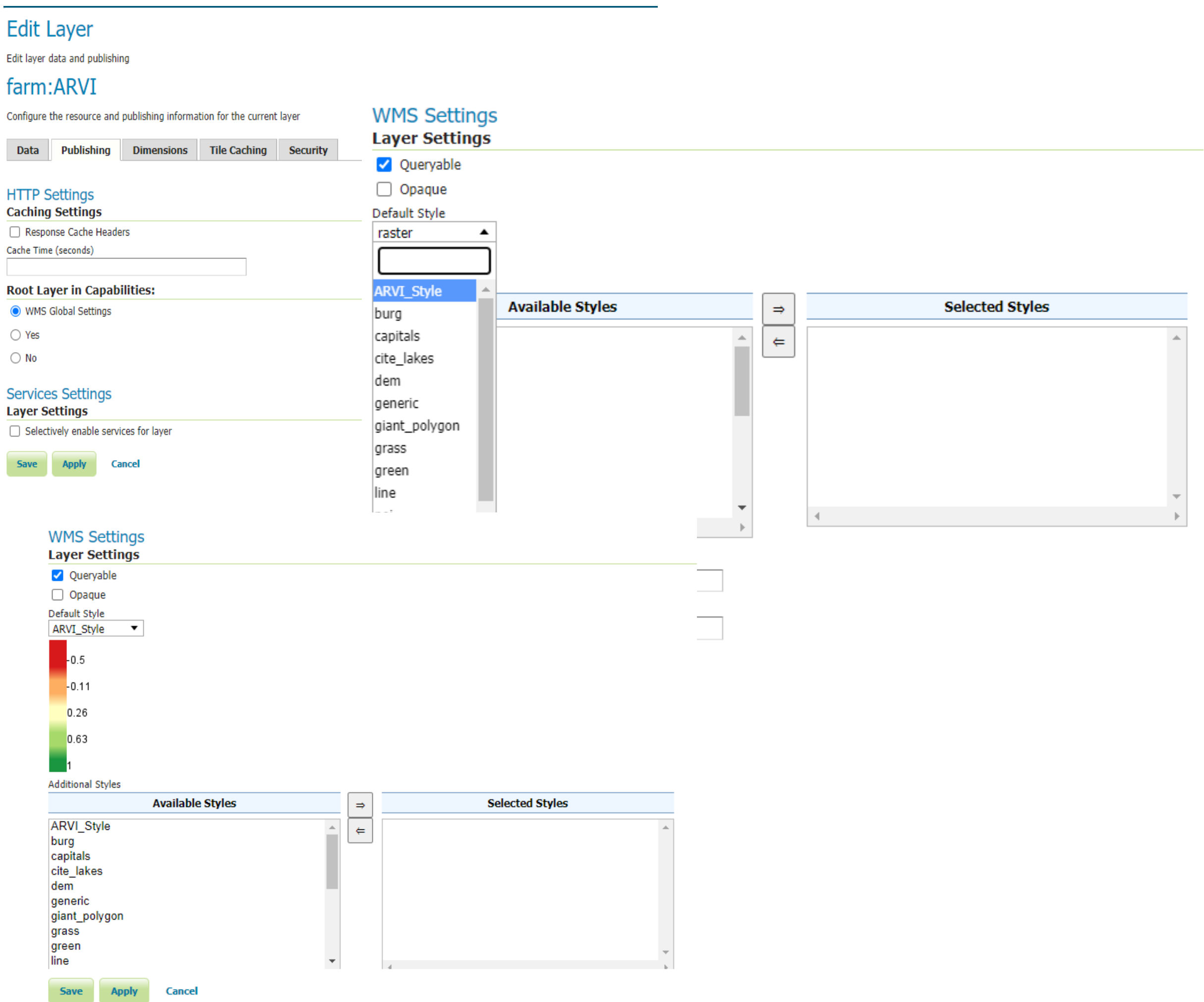


Figure 66 : Style import

Source : Own elaboration

Here is the OpenLayers map loaded with the style downloaded on Geoserver in Figure 67 and we continue in the same way as for the other raster layers.

Figure 67 : Map view (ARVI)

Source : Own elaboration

III.5.5 Creating the web map viewer

All the data is generated and organized in a database, so the final step of our project is to provide this data to our farmer by providing a website containing a web map page. The web map viewer emerged as an option to visualize all the generated information, overlay it, organize it, and define its styles in a simple and useful way.

For the creation of the web viewer, we used OpenLayers3, which is a JavaScript library with many functions for a wide range of cartographic needs, making it easy to create and insert a dynamic map into a web page, on the OpenLayers website, it is possible to find several examples of web map viewers, which can be used and adapted to the user's needs, as was done in this work.

One of the primary goals of the project is to design the webmapping interface because it enables online valorization of the project's outcomes. There were two steps in this phase :

1) Using GEOSERVER to build online services.

2) Creating a web mapping interface.

For the coding part of the website, we used the program Visual Studio Code (VS Code) and the development languages used were CSS, JavaScript and PHP.

- CSS (Cascading Style Sheet), It is a computer language used to describe the presentation of HTML and XML documents.
- PHP (Hypertext Pre-processor), is a server-side scripting language that was designed specifically for the Web. PHP code is included in an HTML page and will be executed each time a visitor views the page. The PHP code is interpreted at the web server level and generates HTML code or any other data that can be displayed in the user's browser.

The realization of the web mapping interface requires a wide knowledge in the field of programming since each result will be displayed requires a specific command, as an example from our work, to visualize the map online, we did use the script shown in the following figure 68.

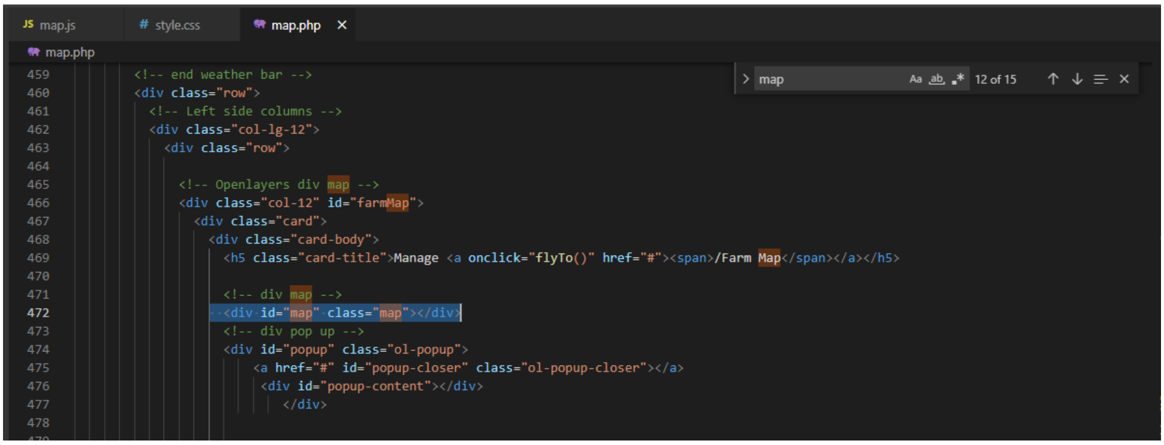


Figure 68 : Map code

Source : Own elaboration

- JavaScript, is a scripting language mainly used in interactive web pages but also for servers. It is an object-oriented language with a prototype.

We show here (figure 69) the JavaScript code en relation with the map visualization.

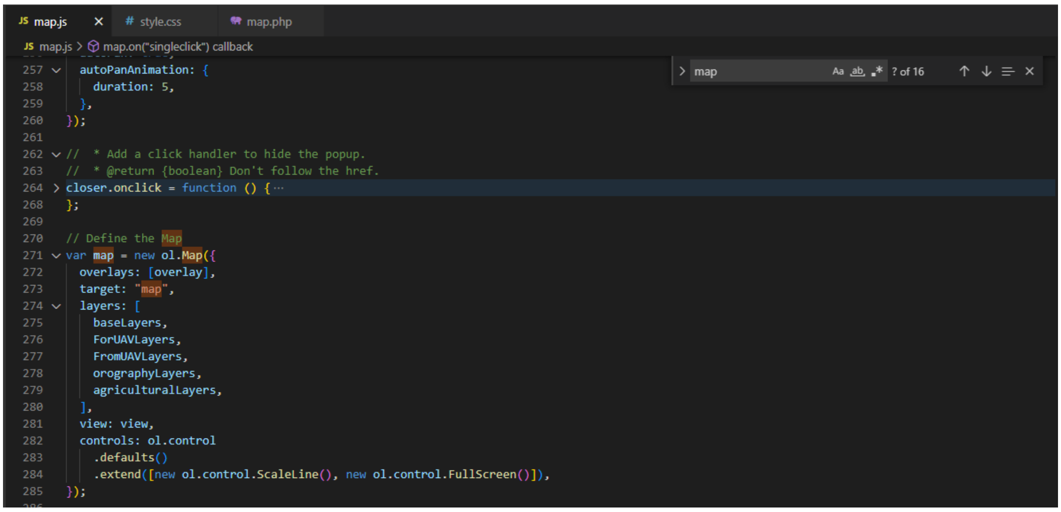


Figure 69 : Map code in JavaScript

Source : Own elaboration

-

In other words, the layers must be defined in the javascript, one by one, and we tried to make it clear and precise as shown in the figure 70 down below.

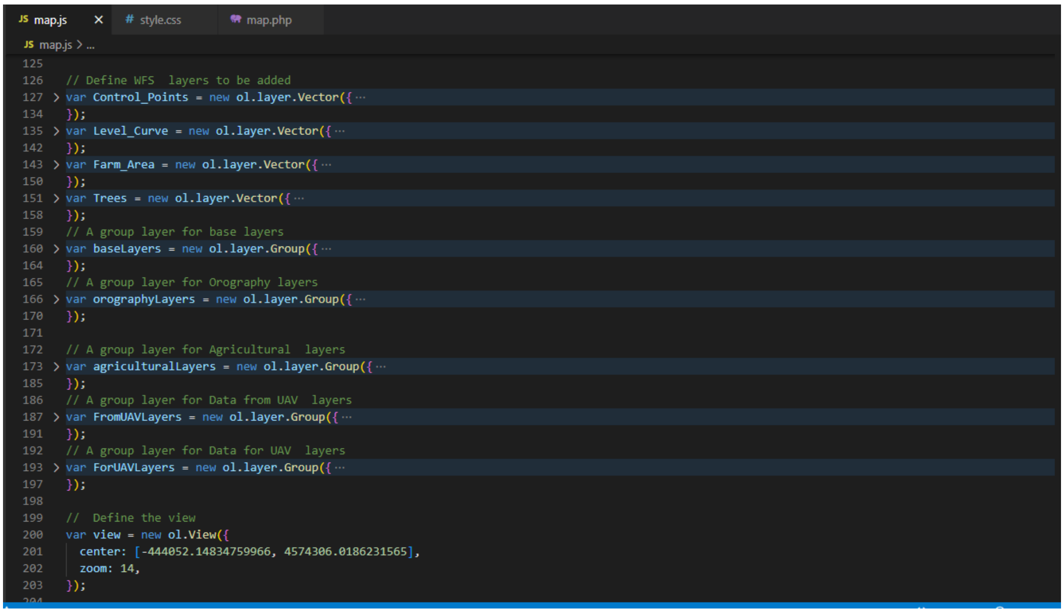


Figure 70 : Add layers code

Source : Own elaboration

III.6 Exploitation of the service

In this part we will present the interest of the spatial analysis in the configuration of the different data used in this project, followed by a broad description of the system implemented.

But first, we will start with an important phase in the life cycle of an application. This phase is the analysis which aims to explain the development of our website and to ensure a good understanding of the user needs. For our project, we have opted for the UML language as a design approach.

III.6.1 Methodology and adopted approach

For the design of our application, we have adopted an object method, indeed the object approach is an essential approach in the framework of application development.

To better present the architecture of our application, we will present the most adopted modeling language UML (Unified Modeling Language)

Because it has several advantages:

- It facilitates the understanding of complex abstract representations.
- Its versatility and flexibility make it a universal language.
- It provides a framework for analysis.

III.6.1.1 Presentation of the UML:

UML (Unified Modeling Language) is a formal and standardized language for object modeling. Its independence from programming languages, application domains and processes, its versatility and flexibility have made it a universal language.

In addition, UML is essentially a communication medium, which facilitates the representation and understanding of object solutions. Its graphical notation allows to visually express an object solution, which facilitates the comparison and evaluation of solutions.

III.6.1.2 Use case study :

Identification of actors, an actor represents the abstraction of a role played by external entities (user, hardware device, or other system) that interact directly with the system under study,

An actor can directly consult and/or modify the state of the system, by adding data.

The use case diagram describes the required uses of a system, or what a system is supposed to do. Its main concepts are actors, use cases and subjects. A topic represents a system with which actors and other topics interact.

Farm

III.6.1.3 Conception

III.6.1.3.1 Activity diagram

The activity diagram is used to deepen the internal behavior of a method, or to concatenate the activities or the flow of use cases. It allows the specification of basic actions, control structures and interacting instructions.

As shown in the Figure 72 below, we have represented an example of an activity diagram that explains the steps for adding new data in the first link (Agricultural Data), and this will be the same flow of steps for the rest of the functionalities.

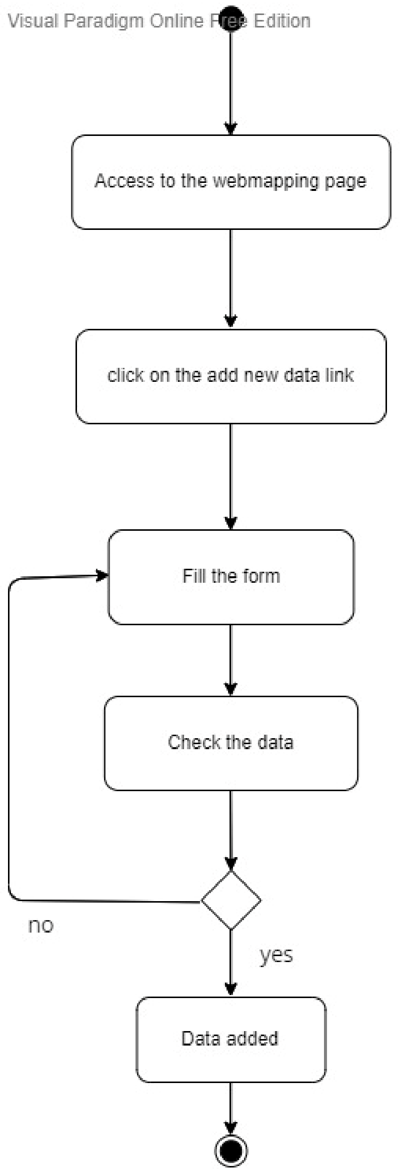


Figure 72 : Activity diagram of adding new farm data

Source : Own elaboration

III.6.1.3.2 Class diagram

The class diagram is a diagram used in software engineering to present the classes and interfaces of systems as well as their relationships. In the following (see Figure 73) we will present the diagram used during our design phase.

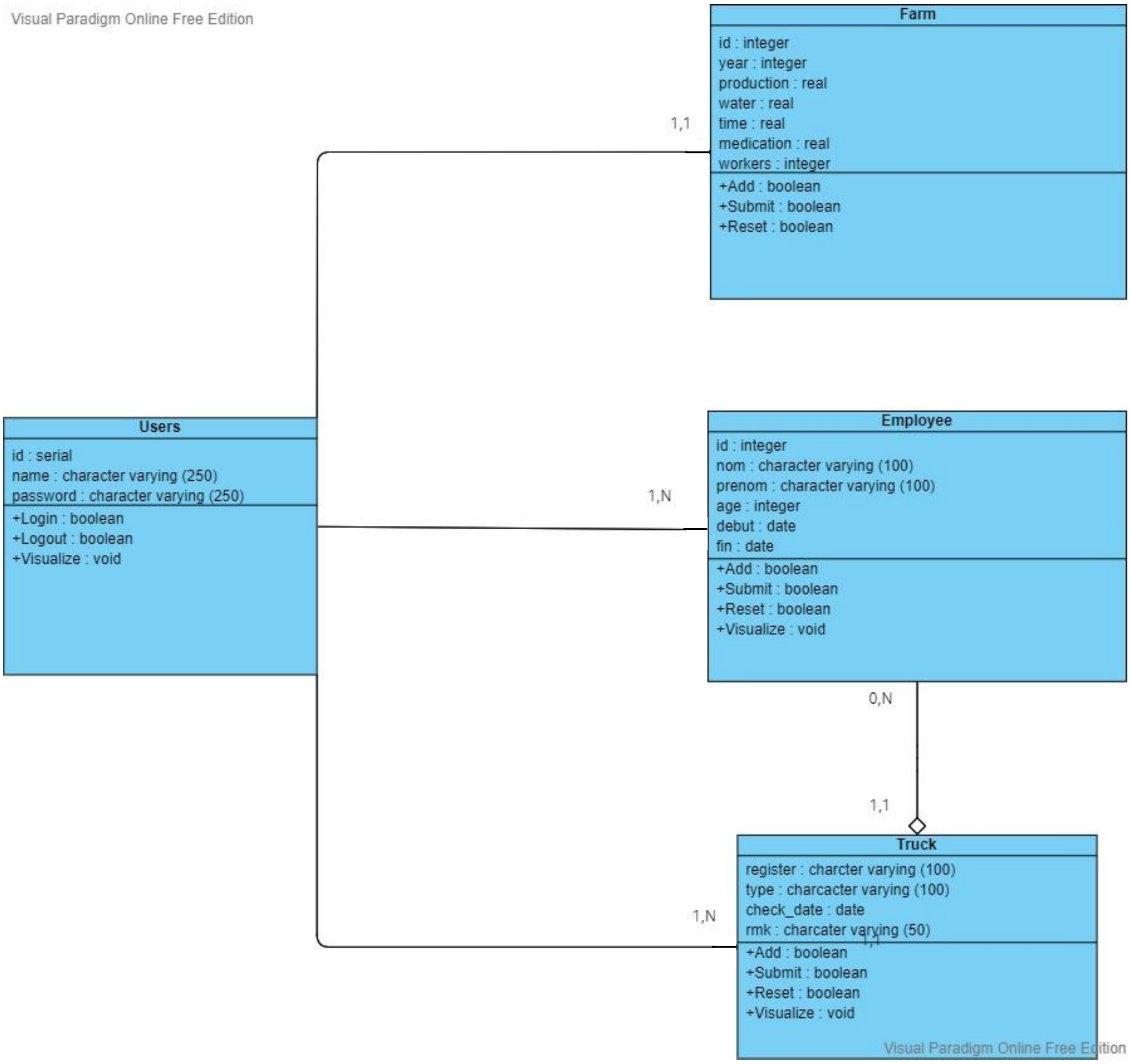


Figure 73 : Class diagram

Source : Own elaboration

III.6.2 Spatial analysis

III.6.2.1 Introduction and Definition

Spatial analysis can be done using various techniques with the help of statistics and geographical information systems (GIS). A GIS facilitates attribute interaction with geographical data in order to enhance interpretation accuracy and prediction of spatial analysis (Gupta, 2005). The spatial analysis that is involved in GIS can build geographical data and the resulting information will be more informative than unorganized collected data. According to the requirement of end user, a suitable geospatial technique is chosen to be implemented with GIS. This selection of the geospatial technique will define the classification and method of analysis to be used (Burrough, 2001).

Analytical tools for the determination of a variable's spatial distribution, the link between variables' spatial distributions, and the association of variables in a given area. Modeling is a term used to describe spatial analysis. It refers to the study of phenomena that are spatially distributed and have physical dimensions (the location, proximity, or orientation of objects in relation to one another; relating to a map area as in spatial information and spatial analysis; referenced or relating to a specific location on the Earth's surface).

The process of extracting or developing new information about a set of geographic features in order to execute routine examination, assessment, evaluation, analysis, or modeling of data in a geographic area based on pre-established and computerized criteria and standards is known as spatial analysis. Spatial analysis is a method of modeling, assessing, and interpreting model results that can be used to assess suitability and capability, estimate, predict, evaluate and comprehend data.

The Spatial overlay and contiguity analysis, surface analysis, linear analysis, and raster analysis are the four conventional forms of spatial analysis in GIS. It comprises topological overlay, buffer generation, and spatial or network modeling, among other GIS features. SA stands for Short Abbreviation.

So we can say that the spatial analysis is a formalized study of the arrangement and properties of space produced and experienced by human societies. She covers a wide range of theories and methods for analyzing and measuring the effects of geographic situations.

III.6.2.2 Spatial Analysis in Agriculture

"Precision agriculture is spatial information technology applied to agriculture. Also known as site-specific farming, it encompasses collecting and analyzing data for different locations within a field in a way that allows management decisions to vary in those diverse locations." (Thirkawala, 1999).

Overview of Precision Agriculture :

Precision farming, often defined as server crop management, includes a variety of technologies such as GPS, remote sensing, and drones.

Varying technology and geographic information systems, there are various aspects to consider.

III.6.2.3 Use of analysis in Agriculture

A Geographic Information System (GIS) is a way of visualizing data and doing spatial analyses so that informed decisions can be made. It's a technique that brings together hardware, software, and data. As much as the information has a geographic dimension, it can describe practically anything. A desktop computer or laptop can be used, as well as satellites, drones, and handheld GPS systems.

Traditional mapmaking uses GIS to layout items like fire hydrants across a road or create borders, such as the area of various crop fields on a land.

The true strength of this technology is its capacity to examine various data levels or variables. A map showing the number of farm illnesses by region, or the percentage of crop hectares lost to flood by tax map area, are both simple instances of this in the agricultural arena.

The changing color ramp is the most typical approach for the polygons representing different property or municipality to indicate the alteration.

More comprehensive spatial analyses for farming might evaluate variables including many important information, perspective, terrain, elevation to aid agricultural production, site suitability, as well as flood, drought, erosion...

III.6.2.4 Objectives

Spatial analysis offers several objectives such as :

- Define spatial reference bases.
- Develop and use tools to locate various elements of the territory, whether existing or to be installed.
- Integrate or make integrable the data obtained based on the reference systems selected.
- Improve data processing, storage, and distribution using technology.
- Analyze various decision-making scenarios based on the information obtained.

III.6.2.5 The benefits for the Farmer

The SIG tools and online resources help farmers do things like :

-Make harvest forecasts and manage their agricultural productivity.

-Assist farmers in achieving increased production.

-Reduce costs by allowing better management of financial resources.

-Allow farmers to map and forecast current and future precipitation, temperature, and agricultural production changes, among other things.

III.6.3 Description of the system

To begin, presenting the service we have offered in our web site including the web mapping page, we will describe a general overview of the system.
For the home page, we opted for simplicity, as can be seen in the Figure 74 that follows.

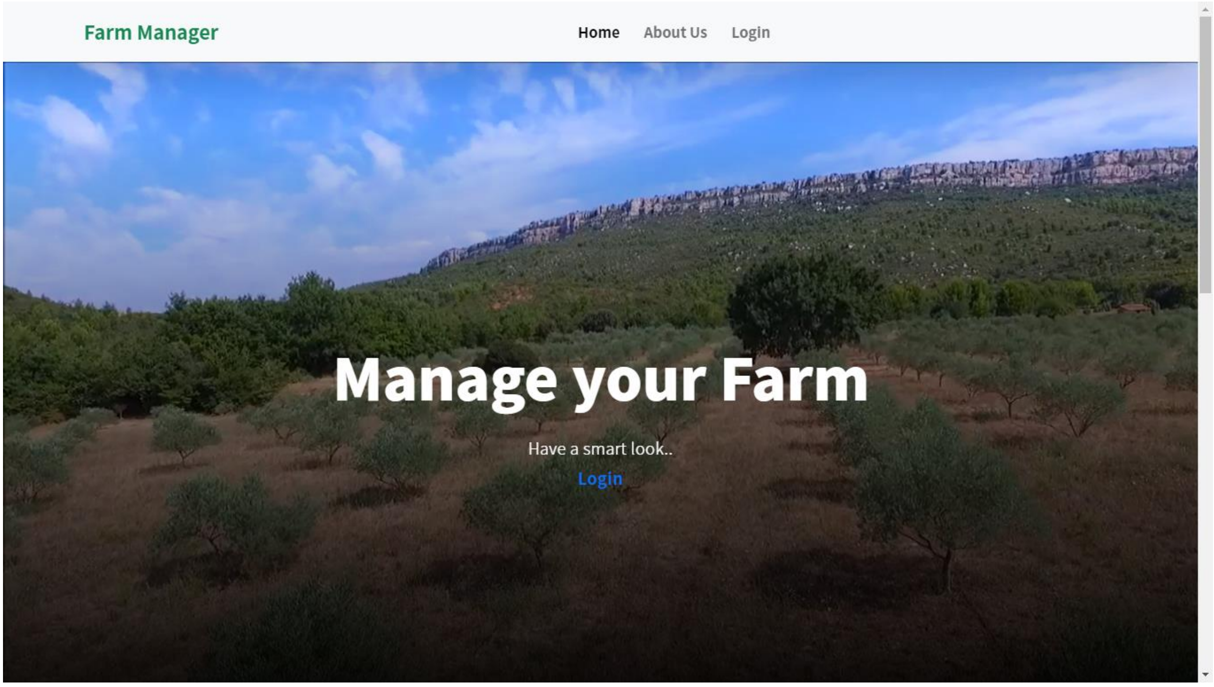


Figure 74 : Home page

Source : Own elaboration

This page contains a background video, a short description of the site and a form to connect to our farm (Figure 75), this interface allows access to the administrator area via a name and password, the site has been designed so that access is restricted, only authorized persons can access it.
only authorized people can access it, to do so, you must have a login and a valid password.

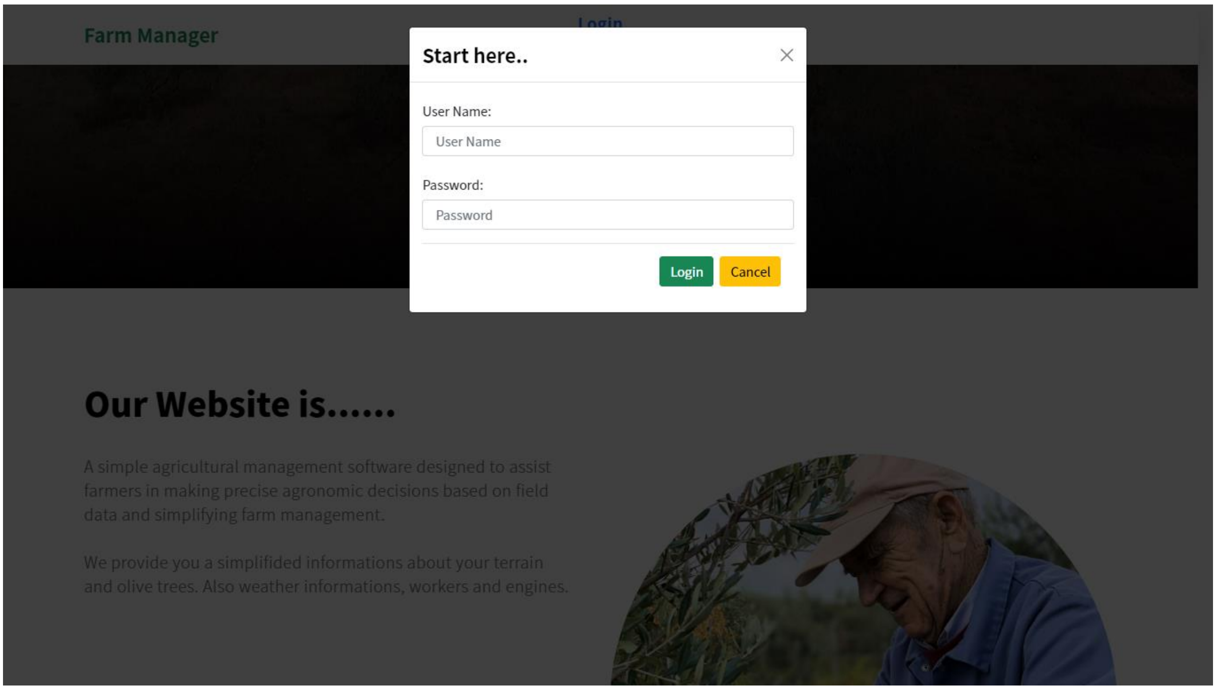


Figure 75 : Login

Source : Own elaboration

In light of this, the first step is to decide what should be in this viewer in order to make it as straightforward and practical as feasible for a farmer, thus, to highlight the result of our service, we tried to realize a readable interface, containing as instruments :

- Basic mapping elements, zoom in and out, full screen and scale.
- Pop-up window that allows to choose the layer(s) to visualize.
- Possibility to visualize two layers at once.
- Legend for all layers.
- Representative bar of temperature.
- Forms dashboard.

These last elements offer several functionalities, which will be mentioned in the following part.

The main system interface gives access to interactive and informative maps on agriculture, olive trees, the temperature and in a general way to the geographical information of the olive grove area.

The general view of the realized site allows to consult the majority of the maps realized during this project, project in the form of cross-border layers on an interactive map.

III.6.4 Main functionalities of the system

A precise description of the implemented tools and their functions in the system will be mentioned afterwards.

The tools used and their functions are listed like depicted in Figure 76 down, you can see where each tool is located in the display.

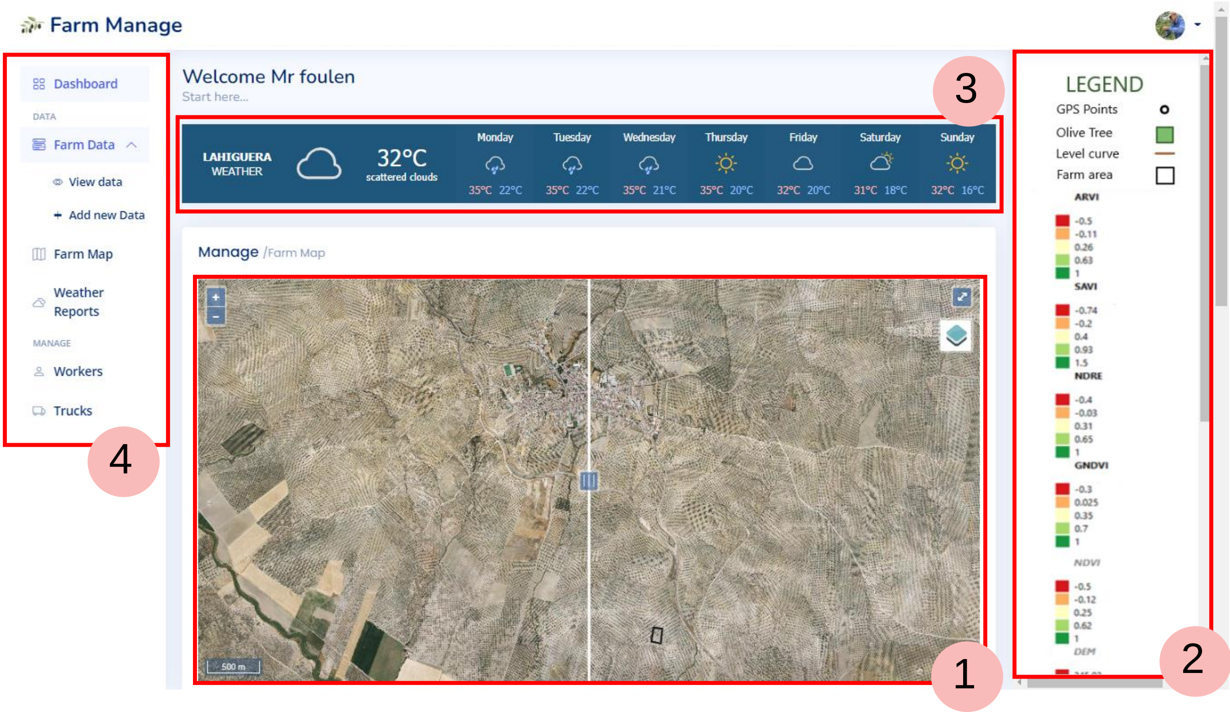


Figure 76 : Web mapping page

Source : Own elaboration

1. Map viewer :

In this interface, the farmer can monitor the available layers in the layer bar, which are organized in groups, agricultural, orography, data from UAV, data for UAV and base layers available with two choices, open street map and ESRI map, for the construction of our layers and their style, openlayers3 was used.

And the presence of a two-sided map display that allows the layers to be viewed on two sides right and left, which facilitates the overlay and analysis in a more fluid way, with a pop-up showing the data of each map.

We will display a screenshot underneath in Figure 77 that shows a selection of trees polygons on one side as well an NDVI map on the other side and an ESRI map in the background.

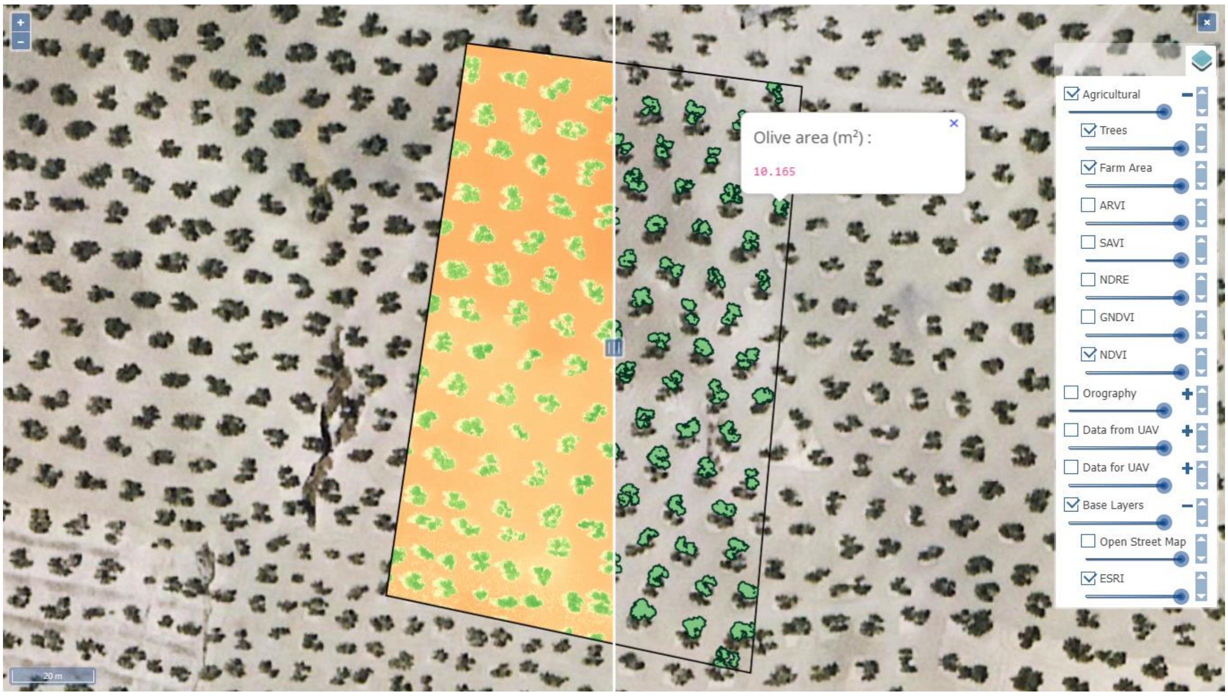


Figure 77 : Display of layers (trees, NDVI)

Source : Own elaboration

Below in figure 78, is the demonstration of the code of the layer Trees with its style using openLayers.

```
var Trees = new ol.layer.Vector({
  title: "Trees",
  visible: false,
  style: new ol.style.Style({
    stroke: new ol.style.Stroke({
      color: " #013220",
      width: 2,
    }),
    fill: new ol.style.Fill({ color: "#81C784" }),
  }),
  source: new ol.source.Vector({
    format: new ol.format.GeoJSON(),
    url:
"http://localhost:8080/geoserver/farm/ows?service=WFS&version=1.0.0&request=GetFeature&typeName=farm%3AOlive_Trees&outputFormat=application%2Fjson",
  }),
});
```

Figure 78 : The trees layer code

Source : Own elaboration

As another example in Figure 79, with a selection of level curve lines on one side and a DEM map on the other, and an Open Street Map for the background.

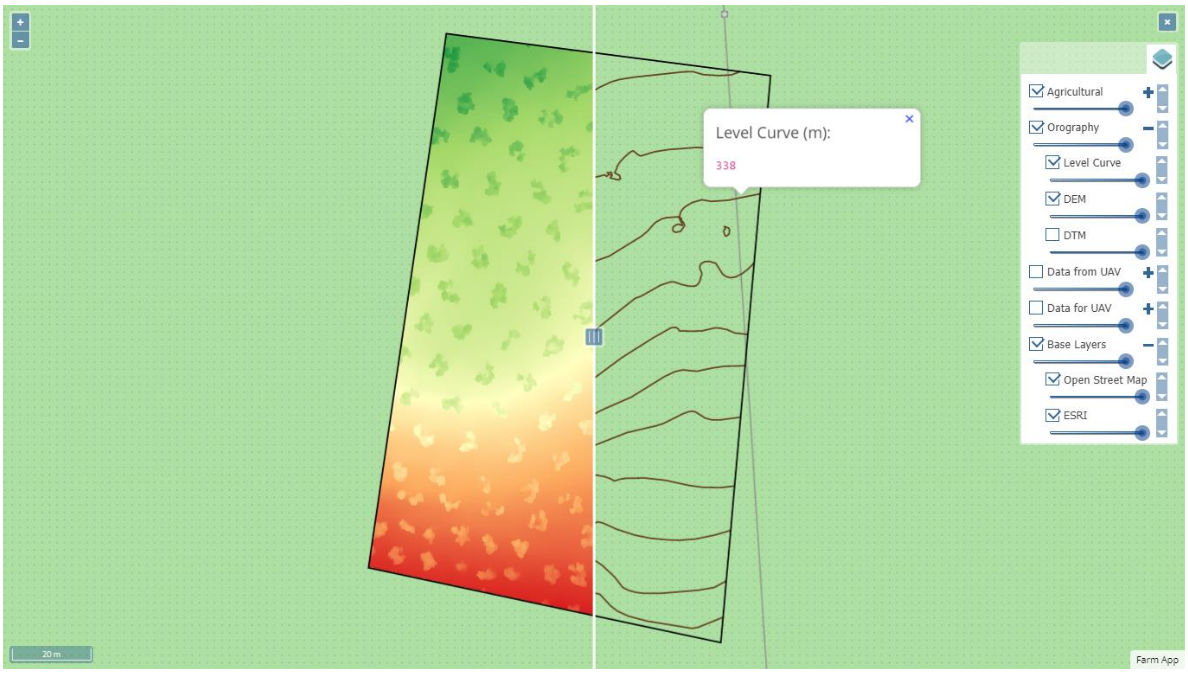


Figure 79 : Display of layers (Level curve, DEM)

Source : Own elaboration

Also in figure 80 the demonstration of the code of the level curve layer with its style using openLayers.

```
var Level_Curve = new ol.layer.Vector({
  title: "Level Curve",
  visible: false,
  style: new ol.style.Style({
    stroke: new ol.style.Stroke({
      color: "#654321",
      width: 2,
    }),
  }),
  source: new ol.source.Vector({
    format: new ol.format.GeoJSON(),
    url:
"http://localhost:8080/geoserver/farm/ows?service=WFS&version=1.0.0&request=GetFeature&typeName=farm%3ALevel_curve&maxFeatures=50&outputFormat=application%2Fjson",
  }),
});
```

Figure 80 : The level curve layer code

Source : Own elaboration

2. Legend :

Allows the user to visualize the legends of all the layers, which are essential for a good understanding of the information on the map, the user can scroll the page to see them all.

3. Weather band :

Represents the daily weather conditions in our study area, which is an interesting data for the farmer when he overviews his farm.

4. Dashboard :

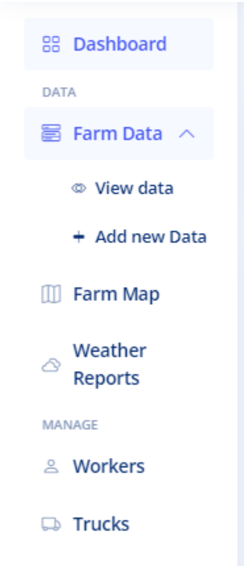


Figure 81 : Dashboard

Source : Own elaboration

- Farm Data :

When pressing of the « add new data » link, a window opens as shown Figure 82 bellow with a form to be filled by the farmer with specific information about his farm on annual bases which could be submited or reseted.

Afterwards when pressing on the view data link, the farmer will have acces to all the information entered by himself in a table form (Figure 83).

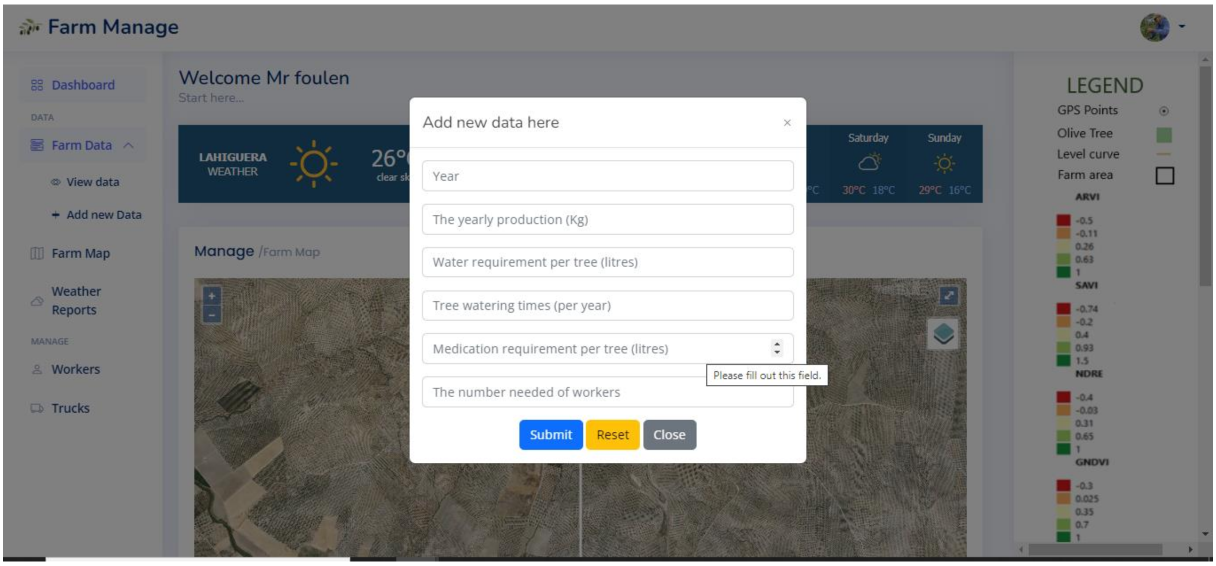
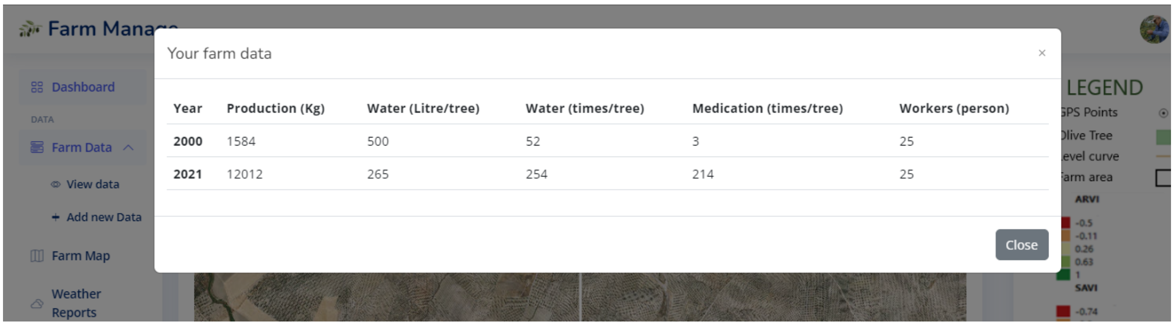


Figure 82 : Add new data form

Source : Own elaboration



Year	Production (Kg)	Water (Litre/tree)	Water (times/tree)	Medication (times/tree)	Workers (person)
2000	1584	500	52	3	25
2021	12012	265	254	214	25

Figure 83 : Farm data table

Source : Own elaboration

- Weather reports :

  Then, when clicking on the « weather reports » link, it sends us to a schematic (Figure 84) containing four different curves and a pop-up window allowing a better understanding of the different values shown by these curves. Those last represent the precipitation, humidity, temperature and the wind.

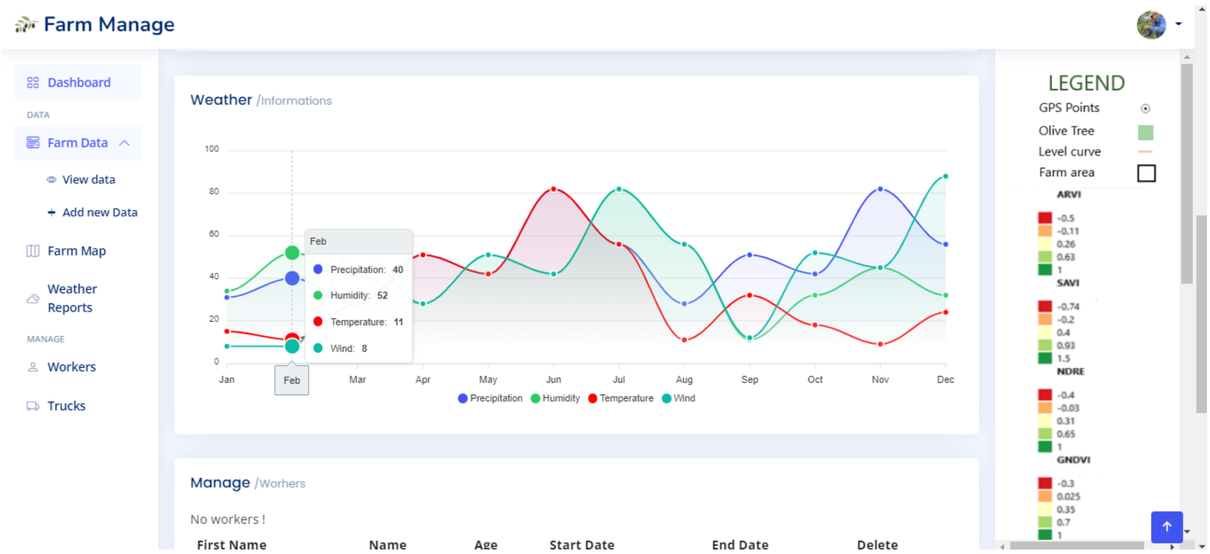


Figure 84 : Weather reports

Source : Own elaboration

- Workers :

  Later on, when pressing on the « workers » link, a new form, pops up allowing farmer to fill basic information about the workers he's employing in his farm as shown on Figure 85 bellow. When submitted those information will be availible in the « manage workers » section.

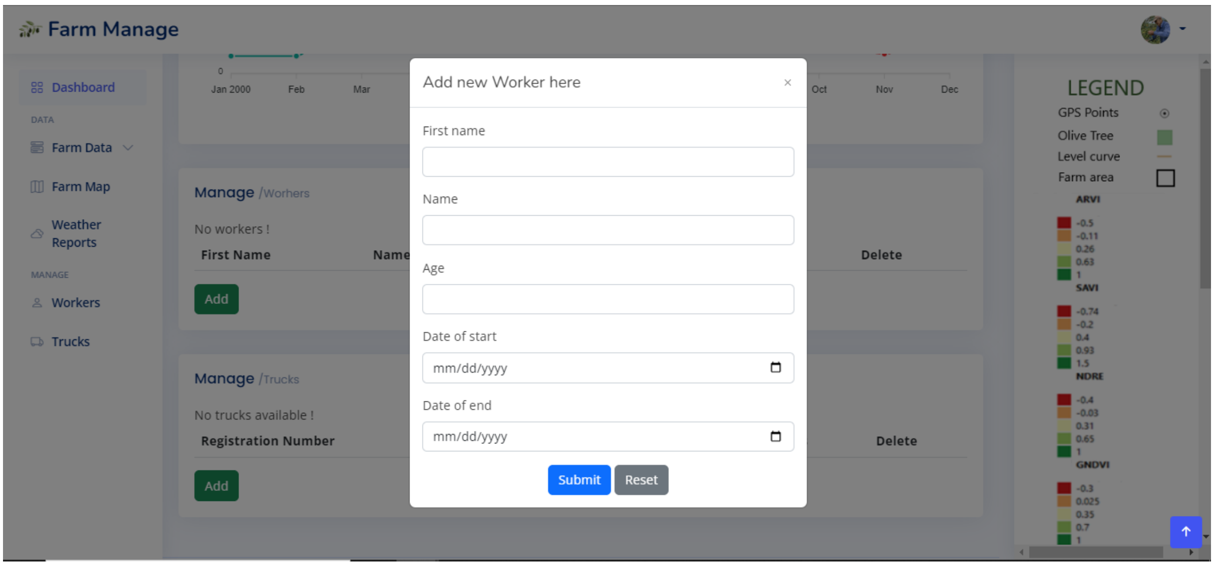


Figure 85 : Add new worker form

Source : Own elaboration

- Trucks :

Finally on Figure 86, same applies to the « trucks » link, when clicked on. The farmer will fill out information about the trucks used in the farm, making them available in the manage trucks section afterwards.

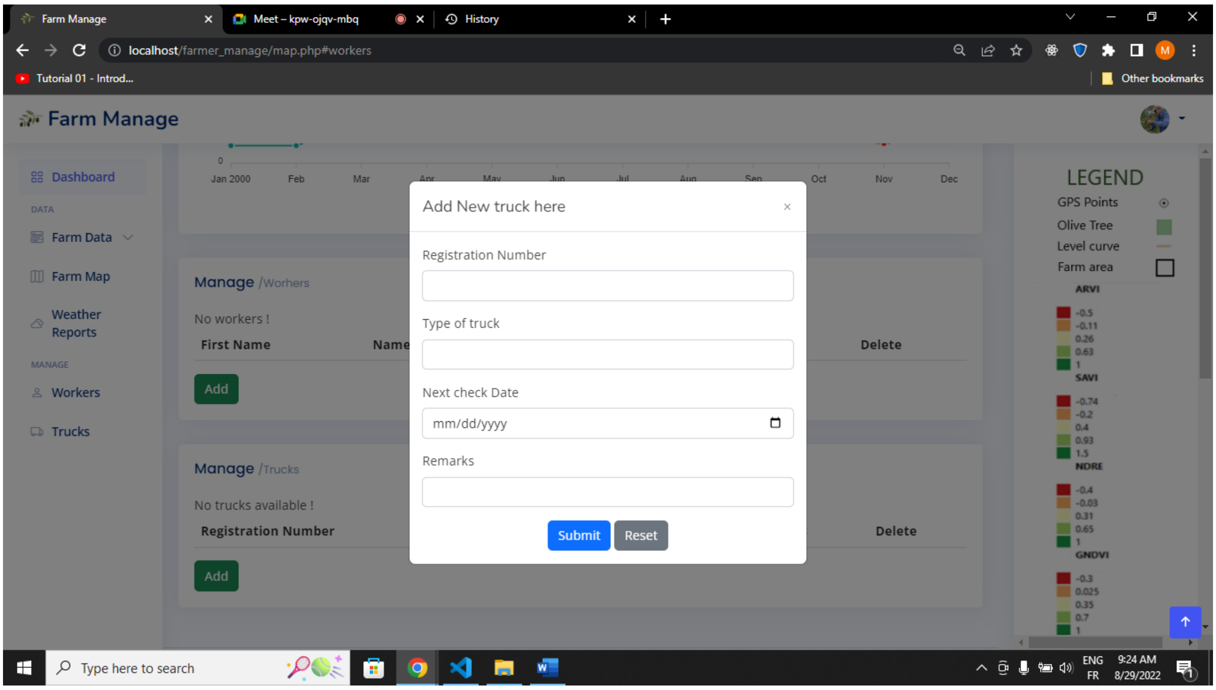


Figure 86 : Add new truck form

Source : Own elaboration

IV. CONCLUSION

The main objective of this internship is to create an appropriate method to manage an olive grove, in which two important parts are included, the collection and processing of data and the implementation of a webmapping interface.

In this project we focused on the strategy of precision agriculture management as a reference.

At the beginning the university drone equipped with two kinds of sensors was used in the study zone in order to collect the data needed. Images were taken and then treated to extract the RGB DEM DTM and multispectral results useful to this work. We've taken the multispectral image made out of five different bands to calculate the chosen vegetation indexes : NDVI, GNDVI, NDRE, SAVI, and ARVI. These results by the discrepancies that they show, enables us to make a comparison through an analysis.

For instance, the NDVI results permitted us to extract the vegetation in shape file out of which we were able to obtain few data about the olive trees.

Then out of the DTM image we were able to extract level curves to give of data about the ground elevation.

In a second phase, an implementation of webmapping was done.

To reach that objectif we needed to structure the project data throughout the conception and the implimentation of a geo-relational database and develop the cartographic web interface.

It's realization was rigorous because of it's diversity and the availability of the data to create the database itself. The conception and the storage of this last one were done with PostgreSQL and Pgadmin online servers.

In final the display of the data was done by geoserver.

To improve and expand the webmapping interface we used different programming languages HTML, PHP, CSS and JavaScript which allowed us to add practical functionality for the farmer, in the system, we have tried to provide an interface that can be navigated and managed easily by a non-expert user, so we have provided tools that are convenient to access, such as the appearance of the meteorological information necessary for the management of farms that have appeared and automatically connected to other web services.

Even though the tools throughout this study are still missing some basic data, they show great progress compared to traditional farming techniques particularly in the olive grove culture.

V. PERSPECTIVE

The cartographic development of the interface is not completely finished. Therefore it could be necessary to :

- Finalize the development of the interface by integrating a data update module and to improve the overall design of the site.

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