Project No. 1650376

Project acronym: SMARTROOT

Project title:

Smart faRming innOvatiOn Training

Intellectual Output 3:

SmartROOT Virtual Farm Hub

Final report

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Document History

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0.2	31/12/2022	Final version	Anastasios Petridis	INFALIA

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Executive Summary

Smart Farming paves the way for sustainable and clean production of food leveraging latest trends in Information and Communications Technology (ICT). Though ICT the agricultural sector can automate tasks, monitor large number of animals or farmlands, make decisions based on aggregated data and accelerate decision making processes. Moreover, Smart Farming enables collaboration between technical experts like software engineers and agriculturists or veterinaries. Agricultural and veterinary experts possess domain expertise but lack the technical knowledge to automate their tasks and accelerate using hardware and software deployments.

SmartROOT Virtual Farm Hub aims to gather data from mixed farming activities that will be presented for educational purposes. Based on this hub, SmartROOT aims to start building the training material to foster discussion, trigger cooperation and knowledge exchange of each group of students. This action will end up in an interactive ecosystem of knowledge around MFS, where post-graduate students along with their instructor's guidance, can use as a teaching environment.

1 Introduction

1.1 Purpose of the Document

The purpose of this document is to present the work made in the frame of the intellectual output O3, titled SmartROOT Virtual Farm Hub, from the starting date, September 1st, 2020, till the ending date of the intellectual output, December 31st, 2022. The document consists an update of the interim progress report providing a detailed analysis of all educational tools included under the umbrella of the SmartROOT Virtual Farm Hub.

More specifically, the remainder of this document is structured as follows: **Section 2** presents an overview of the SmartROOT Virtual Farm Hub, which consists of five educational tools. **Section 3** describes the educational platform (e-Class). It presents the user roles, the functionalities for each user role, and the virtual features that can be supported by the e-Class platform to enhance the educational experience with engaging and interactive content. Last, Section 3 provides a demonstration of the e-Class platform with the creation/management of a course and several educational activities using the interactive content created with the use of the virtual features. **Section 4** describes the farm management tool that will enable practising with an interactive farming ecosystem of knowledge around MFS for educational purposes. **Section 5** presents a data visualization tool that is useful for monitoring and better understanding farming data. **Section 6** documents a tool for web-based geospatial catalogue exploring that can enable users to build spatial data federations. Last, **Section 7** describes the material/data expected (in accordance with the proposal) to be filled in by SmartROOT partners, who are experts in the MSF field, for the creation of the training courses and educational activities.

This document also aims to be a reference manual for non-technical users that wish to get an overview of the offered functionality of the SmartROOT Virtual Farm Hub.

2 The SmartROOT Virtual Farm Hub

2.1 Overview of the SmartROOT Virtual Farm Hub

Our initial vision was to offer the **SmartROOT Virtual Farm Hub** as two separate tools, an educational platform (e-Class) and a virtual farm platform, which would be offered as web-based applications representing a virtual farm hub where data from mixed farming activities (along with experimental data from the MARS project[1]) would be presented for educational purposes. Figure 1 depicts the initial vision for the SmartROOT Virtual Farm Hub planned to be developed and delivered by the intellectual output O3.

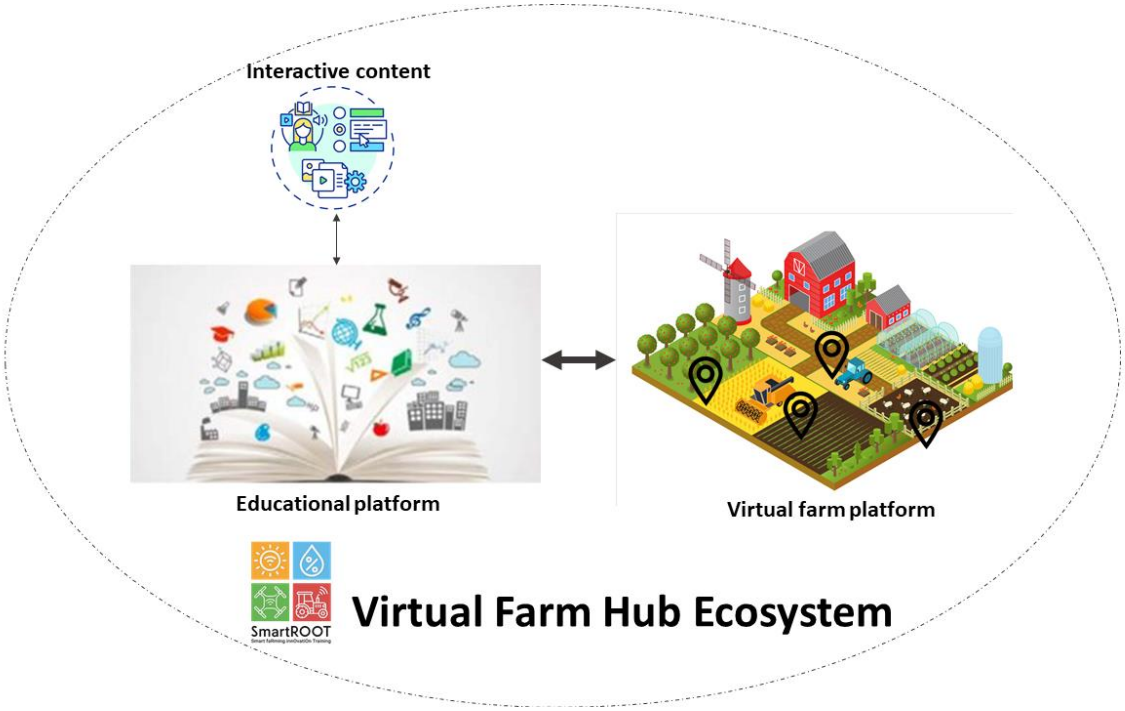


Figure 1: Initial vision for the SmartROOT Virtual Farm Hub

After some months of intensive work, we concluded to an updated vision for the **SmartROOT Virtual Farm Hub**. We decided to serve it as a central hub which will gather and offer a set of different educational tools (Figure 2), including the two separate tools of the initial vision (i.e., the educational platform (e-Class) and the virtual farm platform).

[1] https://project-mars.eu/

Figure 2: The SmartROOT Virtual Farm Hub https://virtualfarm.infalia.com/

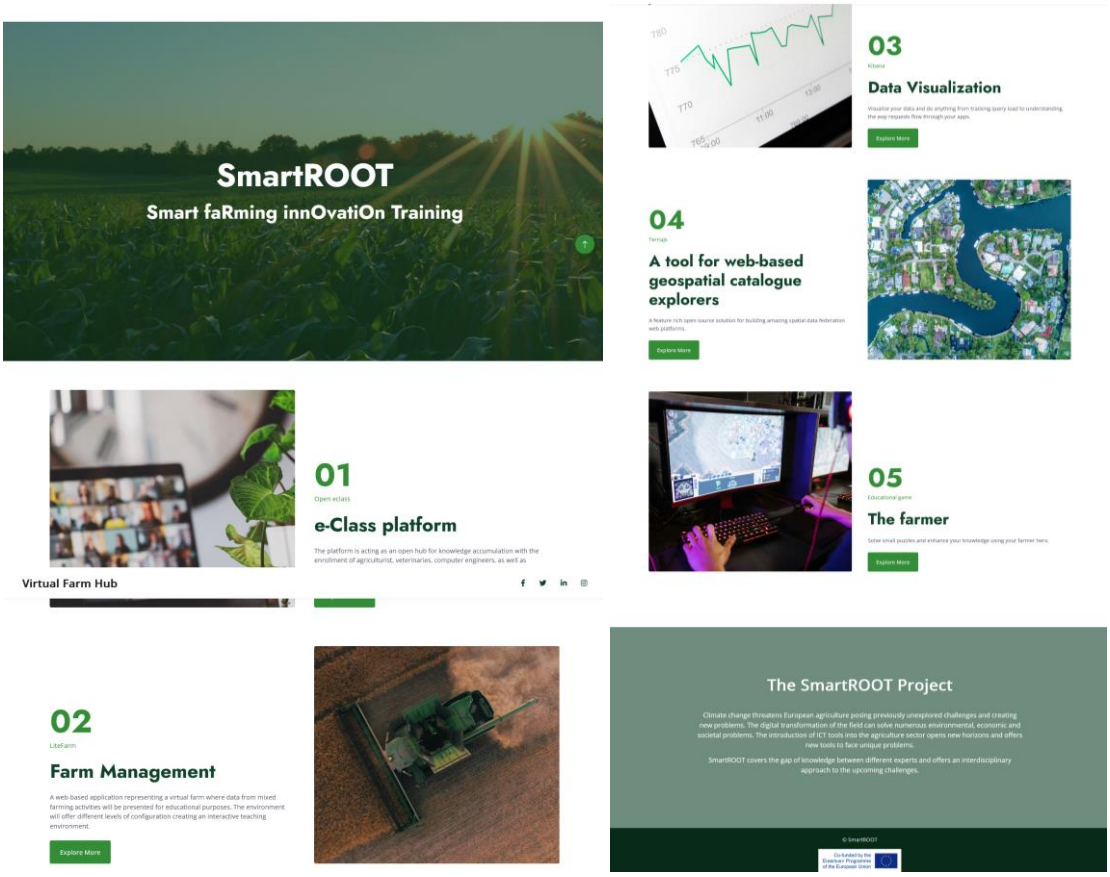


Figure 3: The navigation page of the SmartROOT Virtual Farm Hub

Finally, the navigation page of the **SmartROOT Virtual Farm Hub** platform (IO3), depicted in Figure 3, allows access to five different tools:

- **e-Class platform:** The 1st available tool of the SmartROOT Virtual Farm Hub platform is the e-Class platform https://eclass.smartroot.eu/.
- **Farm Management tool:** The 2nd available tool of the SmartROOT Virtual Farm Hub platform is the Farm Management tool https://litefarm.infalia.com/.
- **Data Visualization tool:** The 3rd available tool of the SmartROOT Virtual Farm Hub platform is the Data Visualization tool https://cattle.infalia.com/.
- **A tool for web-based geospatial catalogue explorers:** The 4th available tool of the SmartROOT Virtual Farm Hub platform is a tool for web-based geospatial catalogue explorers https://terria.infalia.com/.
- **The farmer educational game:** As an extra feature, on top of the frame of the SmartROOT Virtual Farm Hub platform, an educational farmer game has been created, which is also available in the platform at https://farmer.infalia.com/.

2.2 Impact of the SmartROOT Virtual Farm Hub

The SmartROOT Virtual Farαm Hub is acting as an open hub for knowledge accumulation and practise with the enrolment of agriculturist, veterinaries, computer engineers, as well as agriculture stakeholders such as farmers and breeders.

This hub aims to:

- reveal the capabilities of ICT applications in MFS,
- define the technical skills that the ICT post-graduate student should acquire based on the requirements analysis carried out by agronomists and veterinaries post-graduate students,
- constitute the platform that agronomists and veterinaries post-graduate students will be trained on.

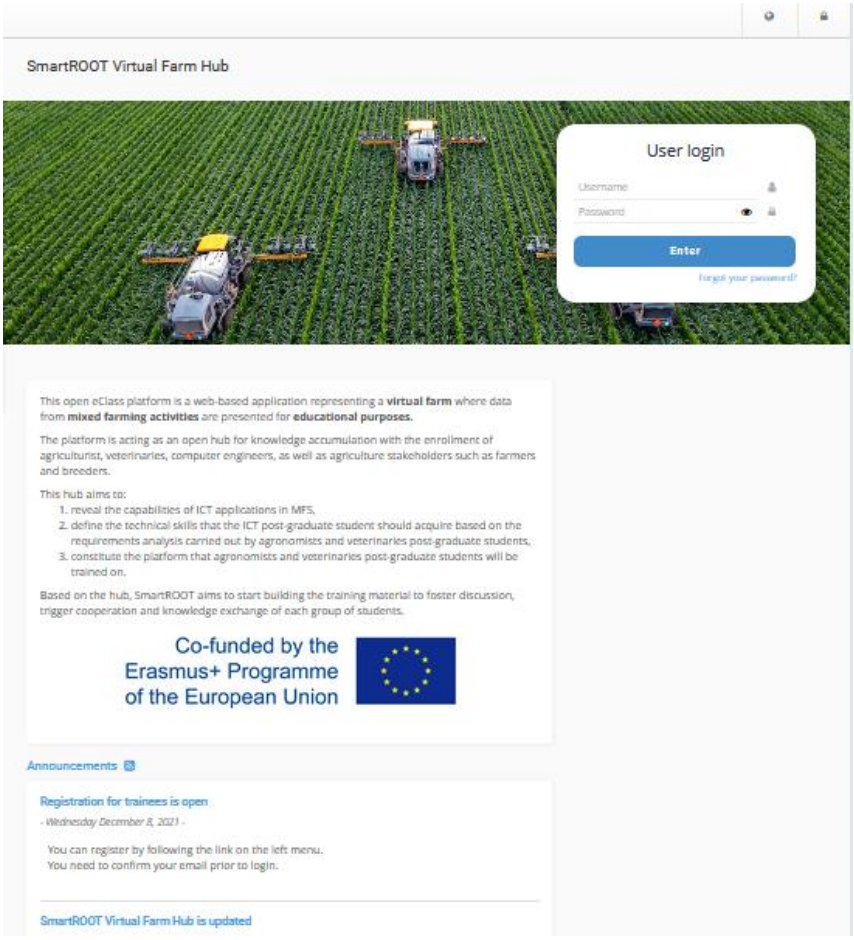
Based on the hub, SmartROOT aims to start building the training material to foster discussion, trigger cooperation and knowledge exchange of each group of students.

The different tools which are made available in the frame of the SmartROOT Virtual Farm Hub will have various options for configuration in order to be useful for education for ICT students. This action will end up in an ecosystem of knowledge around MFS, where post-graduate students along with their instructor's guidance, can use as a teaching environment. **ICT post-graduate students shall be trained to develop such a Virtual Farm Hub while non-ICT post-graduate students shall be trained on using this hub and manage the real information derived from it.**

3 e-Class Platform

3.1 Overview

The e-Class platform is acting as an open hub for knowledge accumulation with the enrollment of agriculturist, veterinaries, computer engineers, as well as agriculture stakeholders such as farmers and breeders.



The e-Class platform will serve as the mean for preparing and delivering training courses and interactive educational activities to the MFS students. The e-Class platform supports two main role types (administrator and regular user), two main regular user types (student and teacher) and different functionality based on the role type.

3.2 Roles

The educational platform will enable two (2) roles, **administrators** and **regular users**, each one having capabilities tailored to their needs and requirements within this platform. Specifically, regular users are further categorized into two (2) types, namely, **students** and **teachers**.

Regular Users:

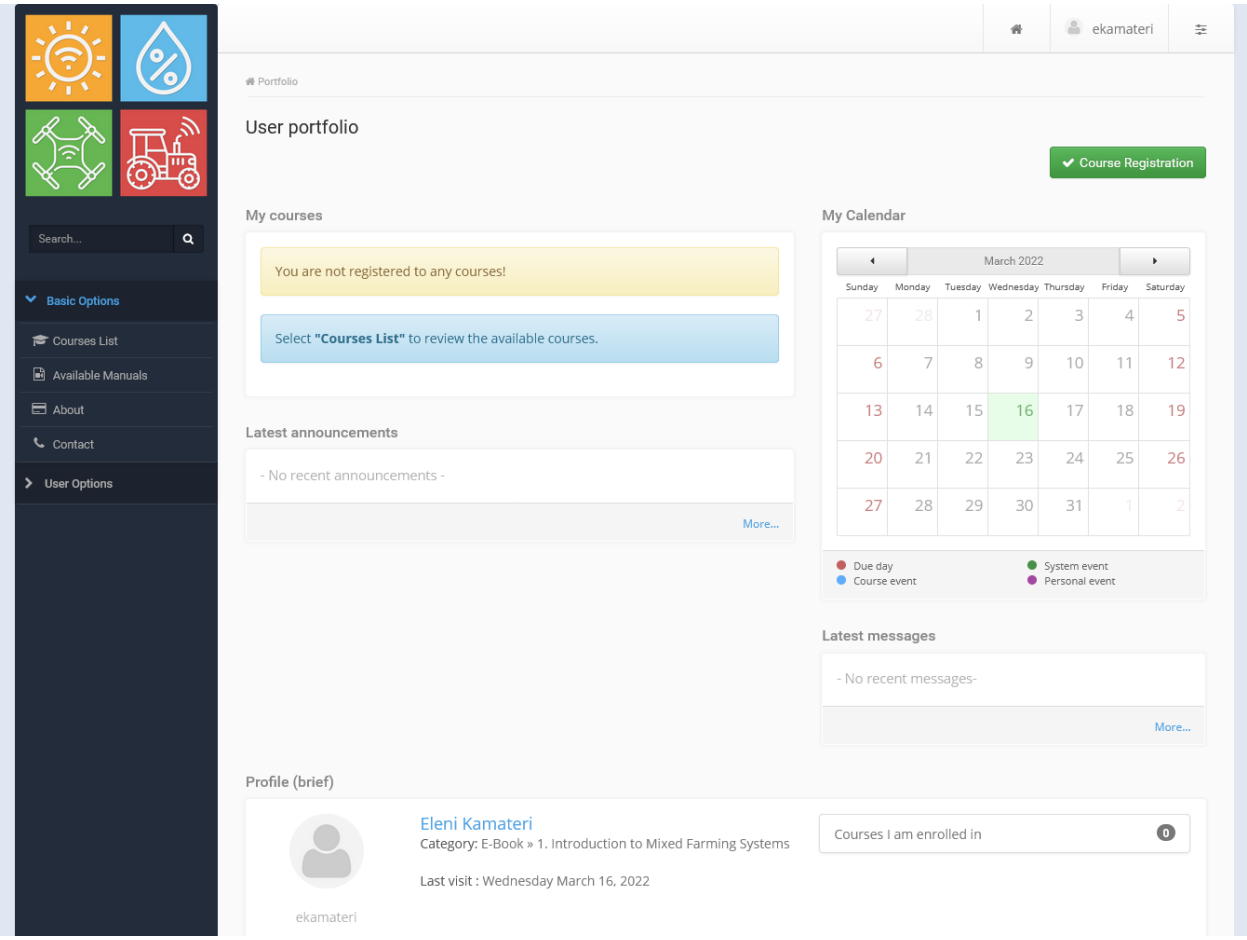
- Student is an individual who joins the educational platform in order to be trained on using this educational platform and manage the real information derived from it. A student can register to courses making an open registration, access educational materials, and participate in working groups, discussion forums and exercises. A student can also participate in educational activities with tailored and interactive content, which are created/managed by the teacher to enhance the educational experience. Student accounts can be created either automatically, by allowing open registration of new users, or by the platform administrators themselves after an on-line request.
- Teacher is an individual who joins the educational platform in order to be trained to develop such a Virtual Farm Hub and learn how to use it and the educational platform as a teaching environment. A teacher is responsible for the creation and administration of electronic courses. Teacher accounts are created by the platform administrators, on demand or after an on-line request. They can create an unlimited number of courses, contact student users registered to them, upload educational materials (texts, images, presentations, video, assignments, exercises, etc.), create discussion forums where course participants can interact and generally control the educational process. They can also create and manage educational activities using interactive content and include them in their course structure or as individual educational components.

Finally, the administrator has general control over the platform. Administrators can create and administer user accounts and courses, monitor the server and database operation.

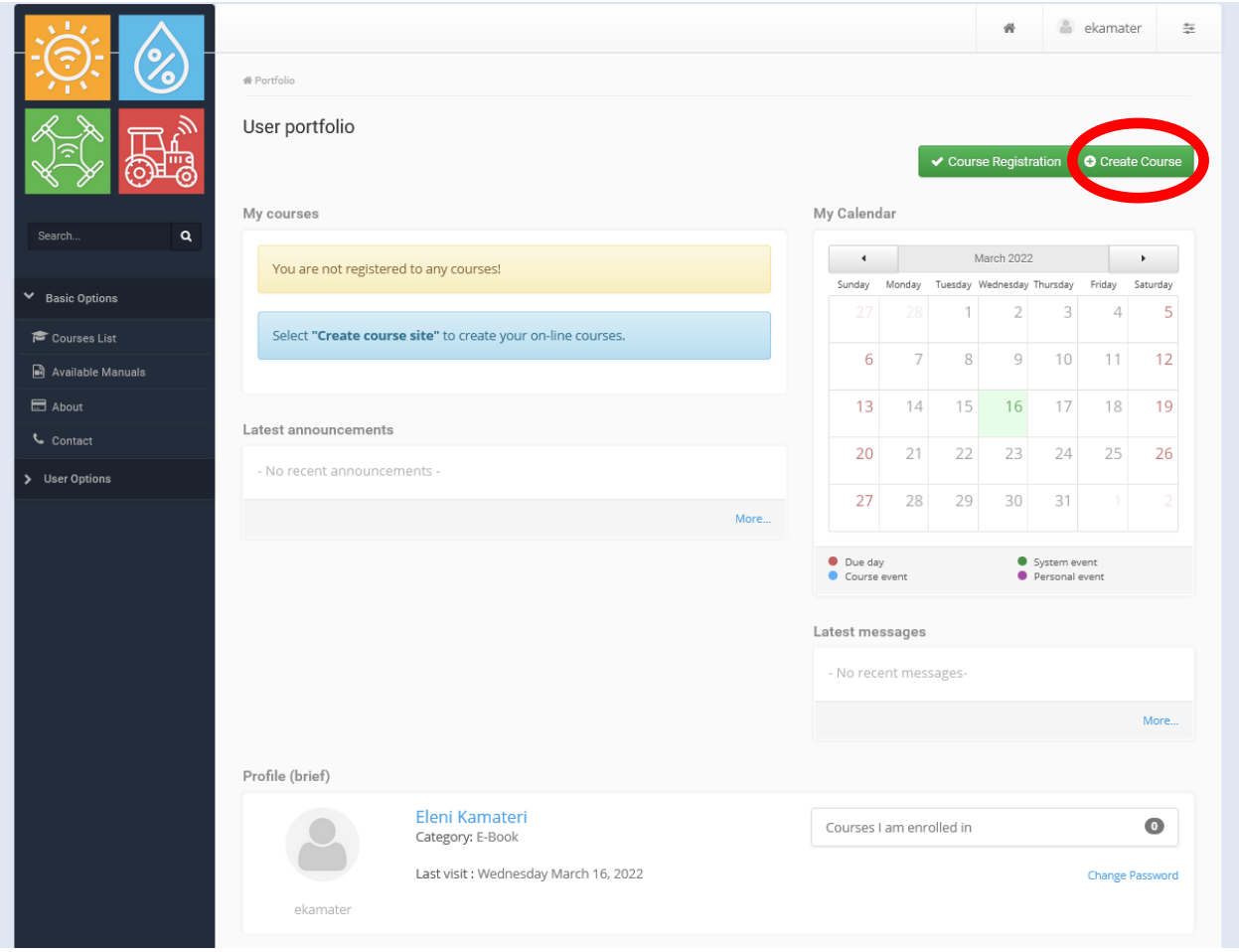
3.3 Platform's Functionality

The educational platform's functionality differs based on the "regular user" role. More specifically, the functionality is mainly the same between the teacher and the student role with some slight differences, which are depicted below.

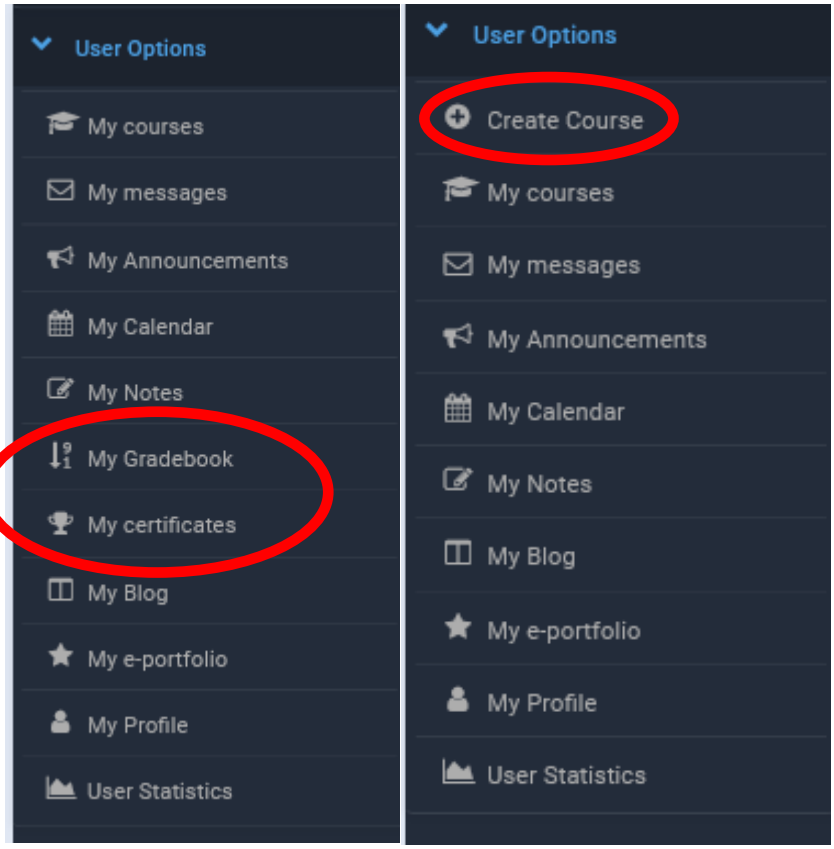
We start with the landing page when a user logs into the educational platform. The platform's functionalities which are available when a student is entering the platform are shown in the following figure. A student can see the list of courses where they are enrolled, the latest announcements of the courses they are attending, their calendar and latest messages.



The platform's functionalities when a teacher is entering the platform are similar, with the only exception that the teacher can create a new course.



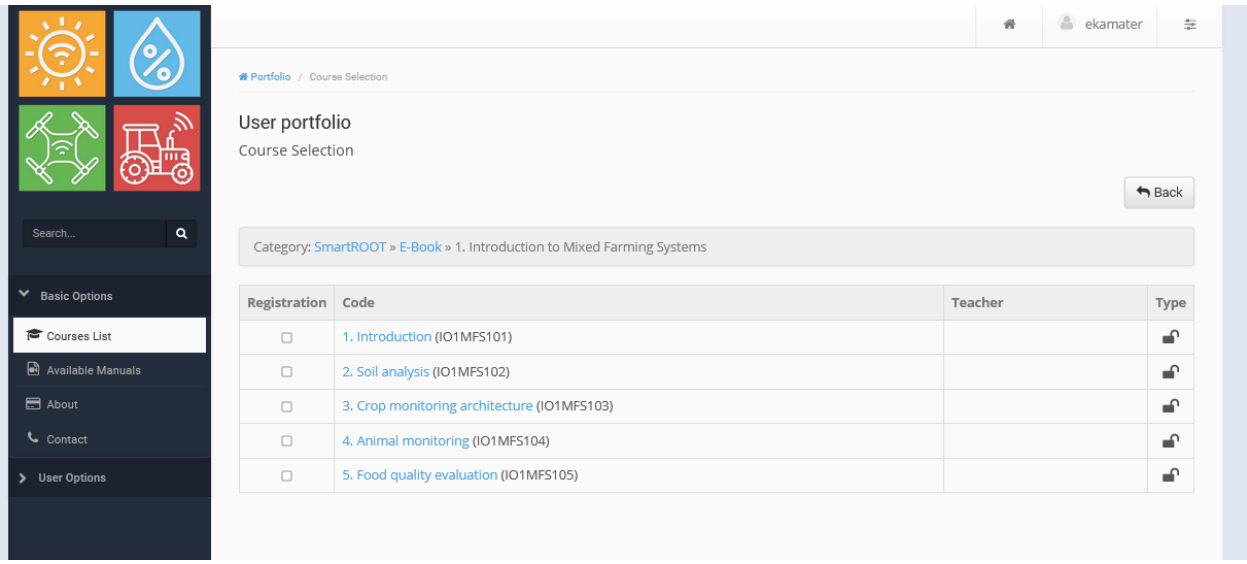
In the following figure, the list of available tools, named as user options, for students and teachers are presented, where differences of the two roles are highlighted.



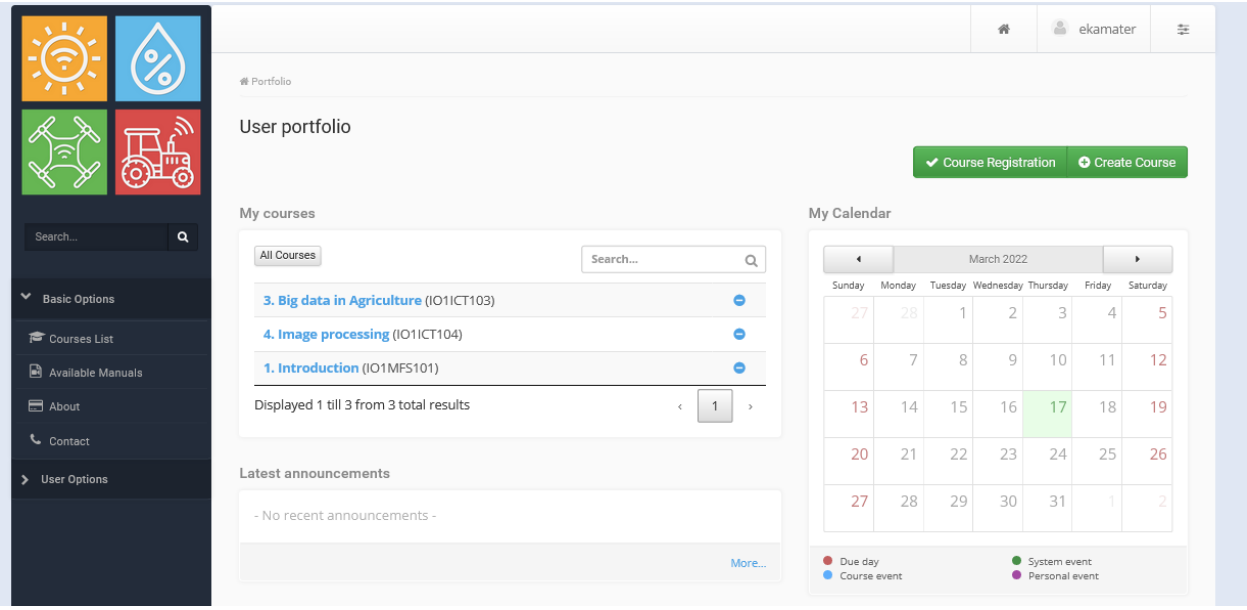
As we can see, the core difference in the user options is that a student can access the gradebook and the certificates while a teacher can create and manage a new course.

Registration in a course

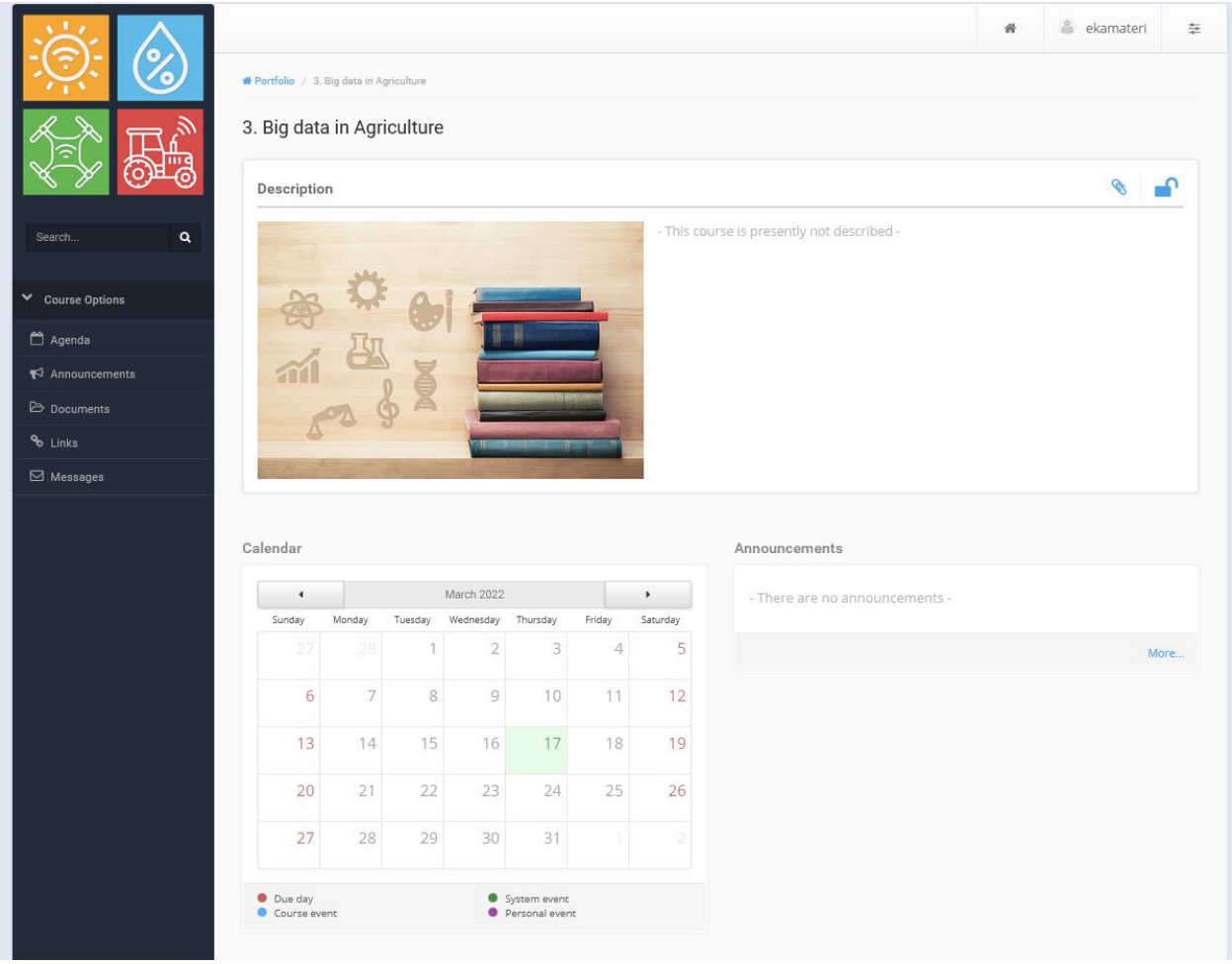
Both user roles, students and teachers, can see the list of courses and register to them.



After registering in a number of courses, the courses are presented in their main page.

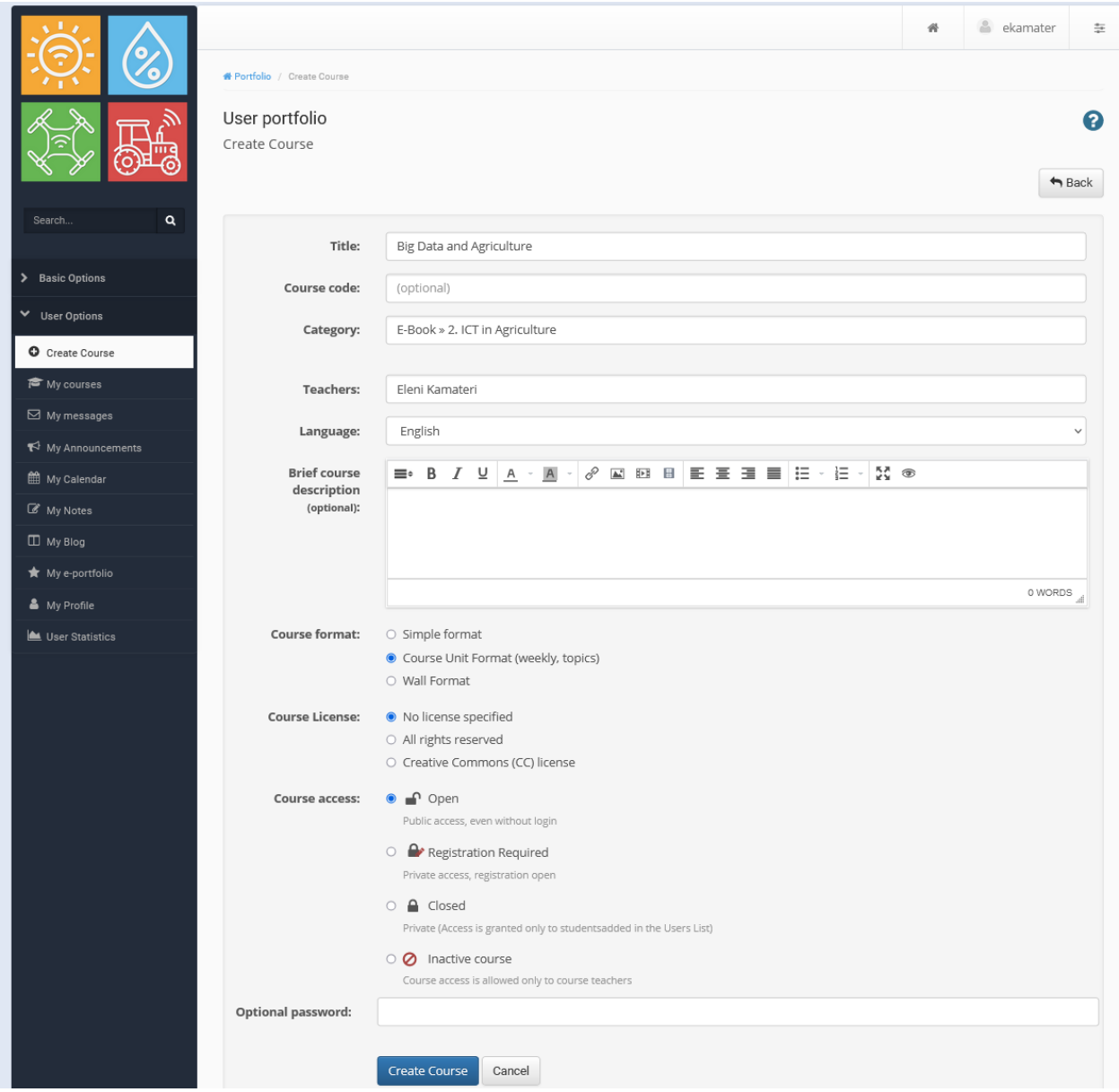


When clicking to a registered course, a new page dedicated to this course is accessed.

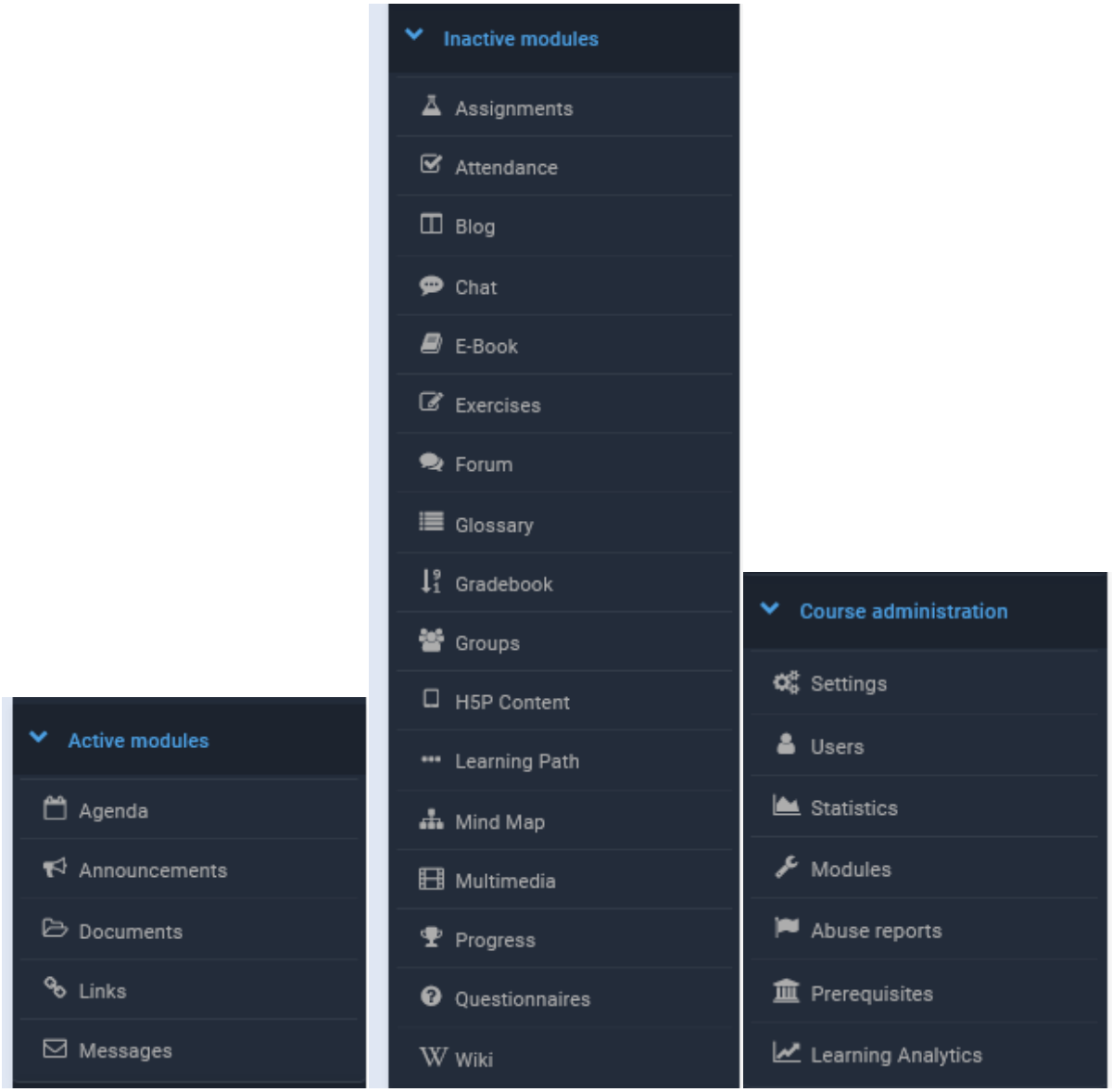


Create and manage a new course

A teacher can click to create a new course. This will be done after specifying some details about the course.



After creating a new course and entering to its management board, the teacher has available three types of tools: Active modules, Interactive modules and Course administration.

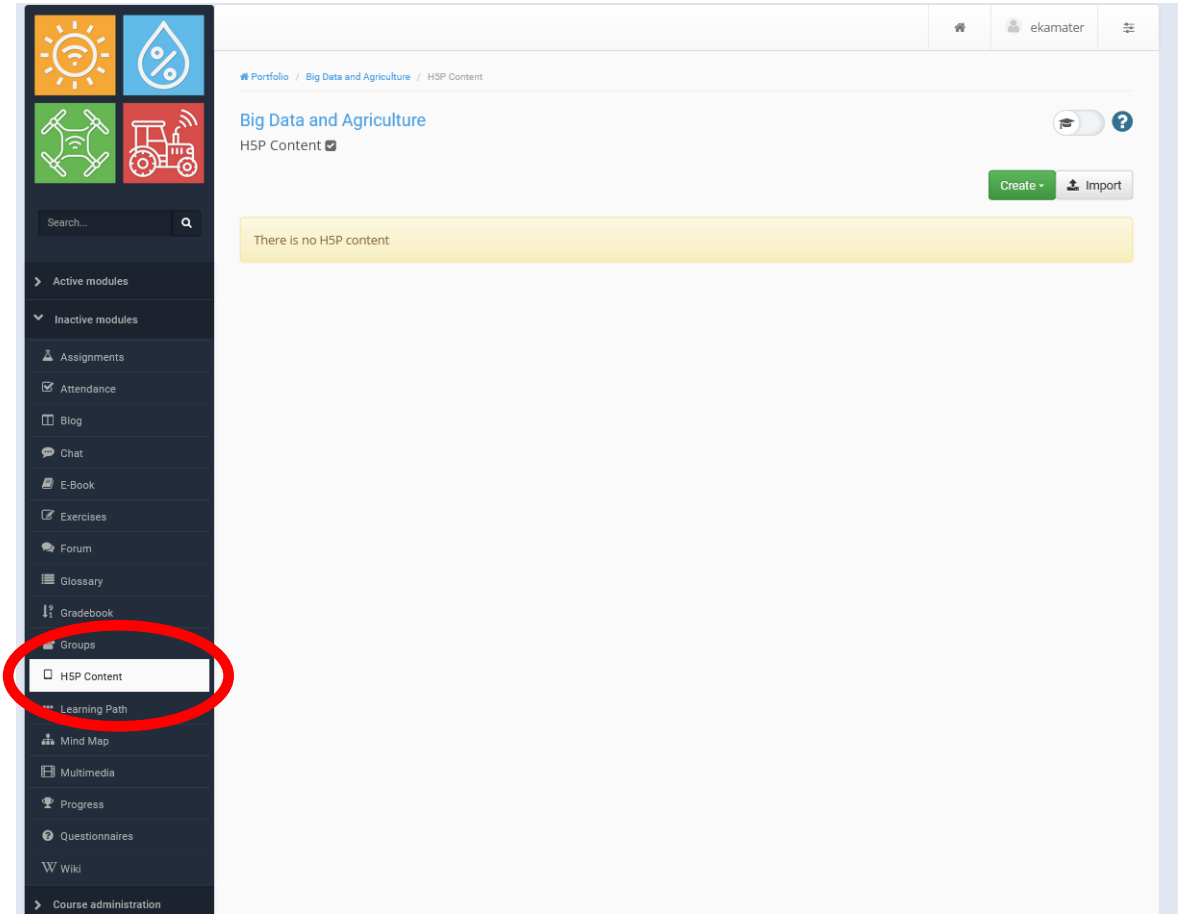


3.4 Interactive Virtual Features

In order the data from mixed farming activities to become the basis for “engaging” educational activities, the e-class platform was extended with a list of “virtual” features. Using these features/tools, a teacher can re-use the available content and material from the e-class platform provided in the frame of courses and create interactive educational activities.

In order to extend the educational platform of the SmartROOT Virtual Farm Hub with these interactive features, the H5P plugin[2] has been installed and used that enables the system to create and integrate interactive content.

The plugin can be found in the Interactive Modules of a course and is visible for management only by the administrator of the course, a teacher role which is also the creator of the course.

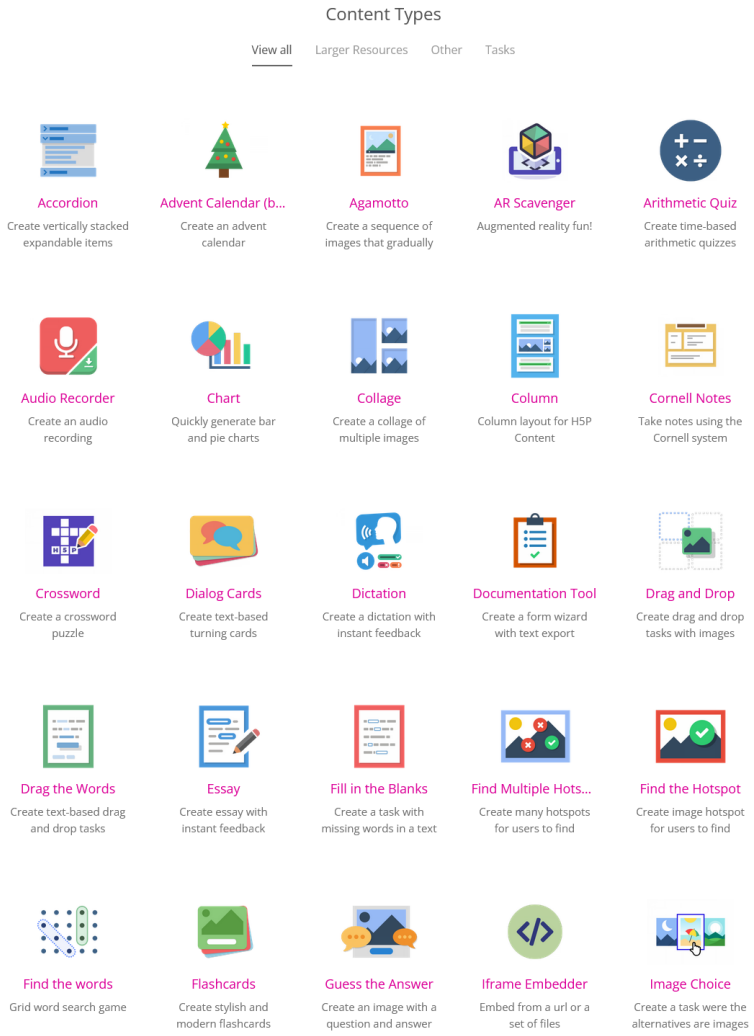


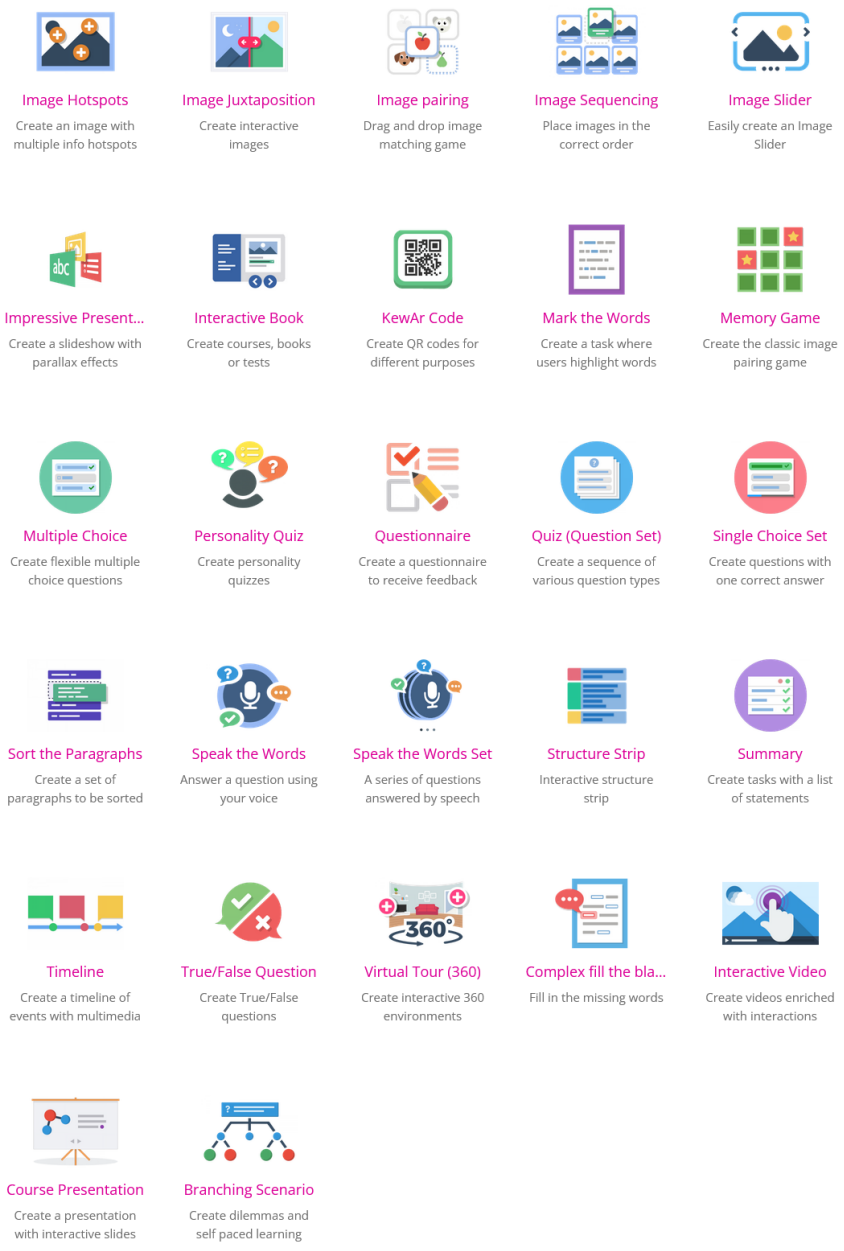
[2] https://h5p.org/

3.4.1 H5P Functionality

H5P is a plugin for existing publishing systems that makes it easy to create interactive content by providing a range of content types.

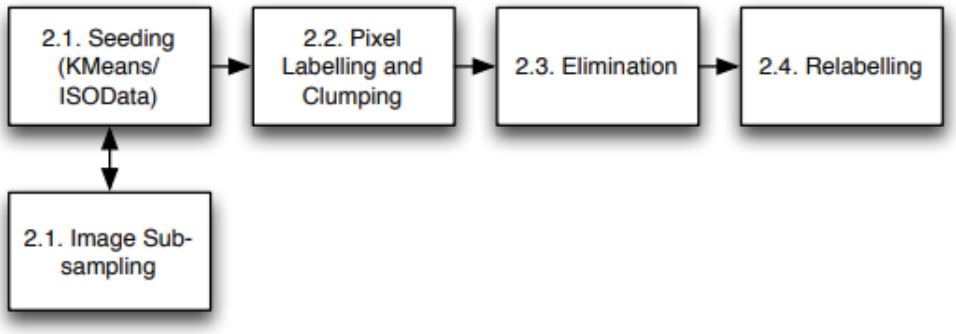
Examples of these content types are presented in the following figure.





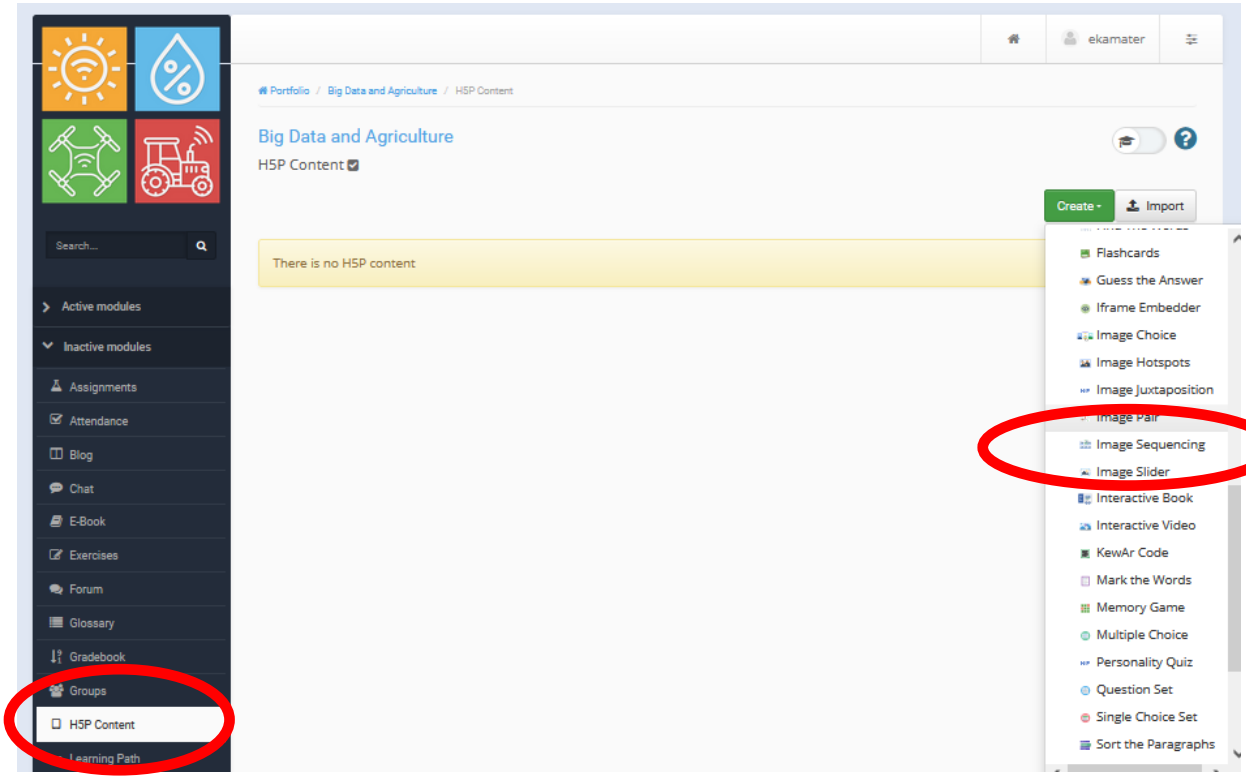
3.4.2 Example adjusted in the frame of the SmartROOT project

In this example, we create an ***Image Sequencing*** interactive module based on the steps of the below algorithm.

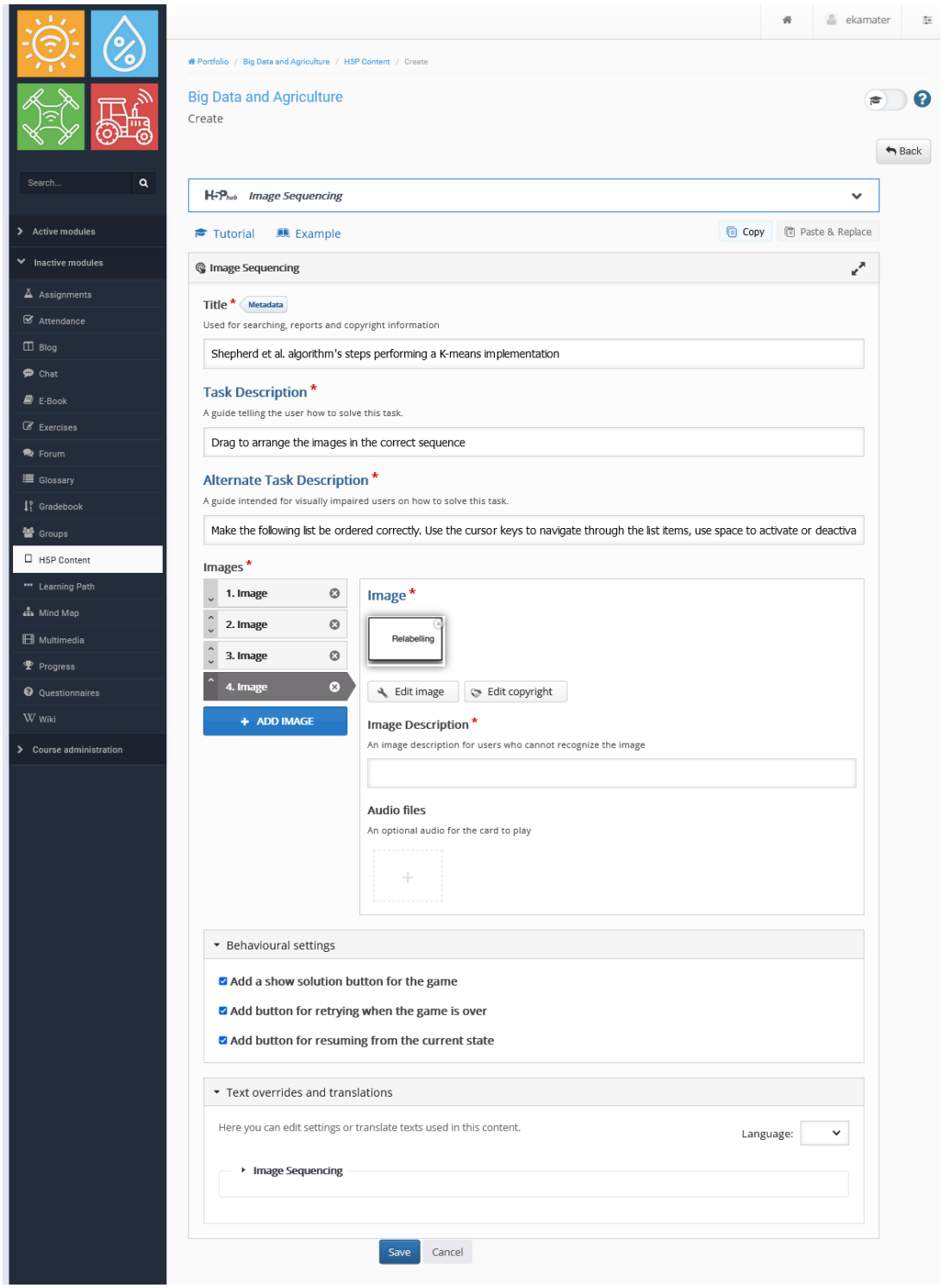


Shepherd et al algorithm performing a k-means implementation [1]

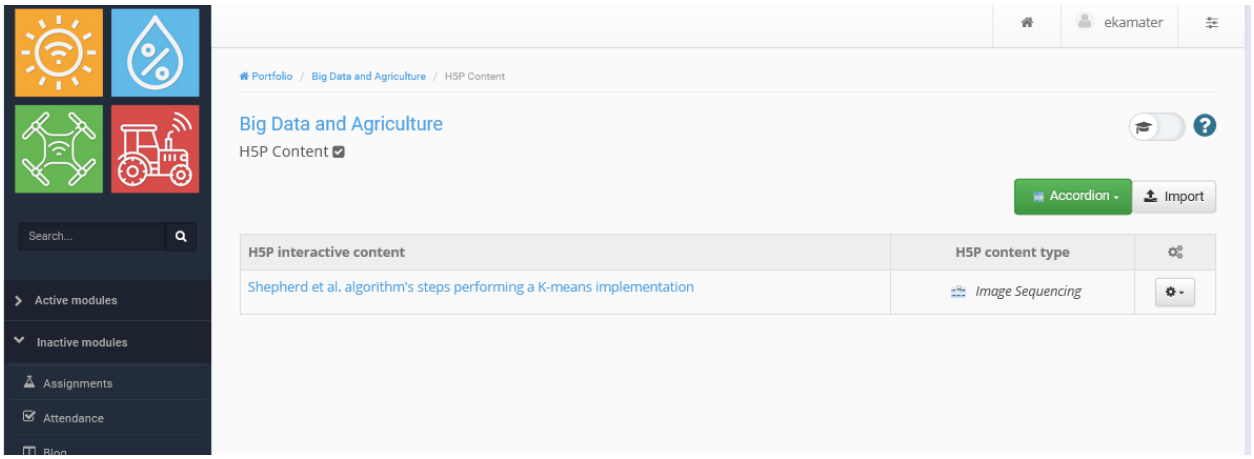
First, the administrator of the course accesses the "H5P Content" in the "Interactive modules" (from the list at the left), click on "Create" button and selects the Image Sequencing (from the list appeared under the Create button at the right).



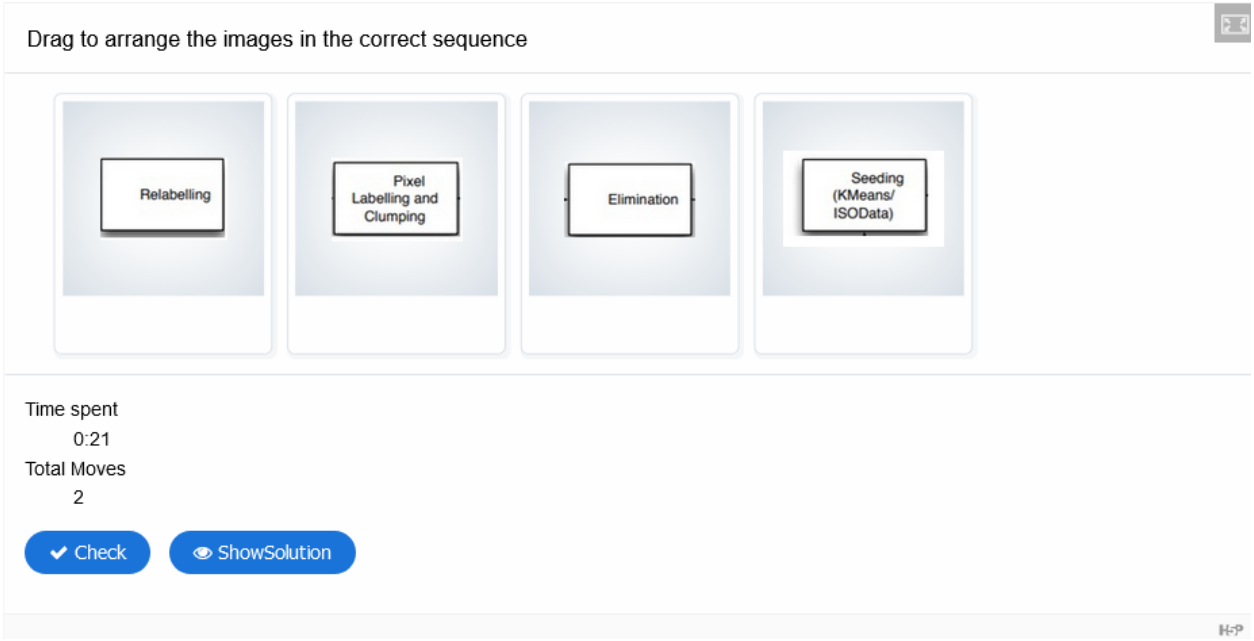
Then, the administrator of the course provides the necessary information in order to create the specific H5P interactive content and save it.



After saving it, the administrator of the course can see the list of all H5P interactive contents and select to edit/delete it or publish it to the course.



The preview of the created Image Sequencing is presented below.

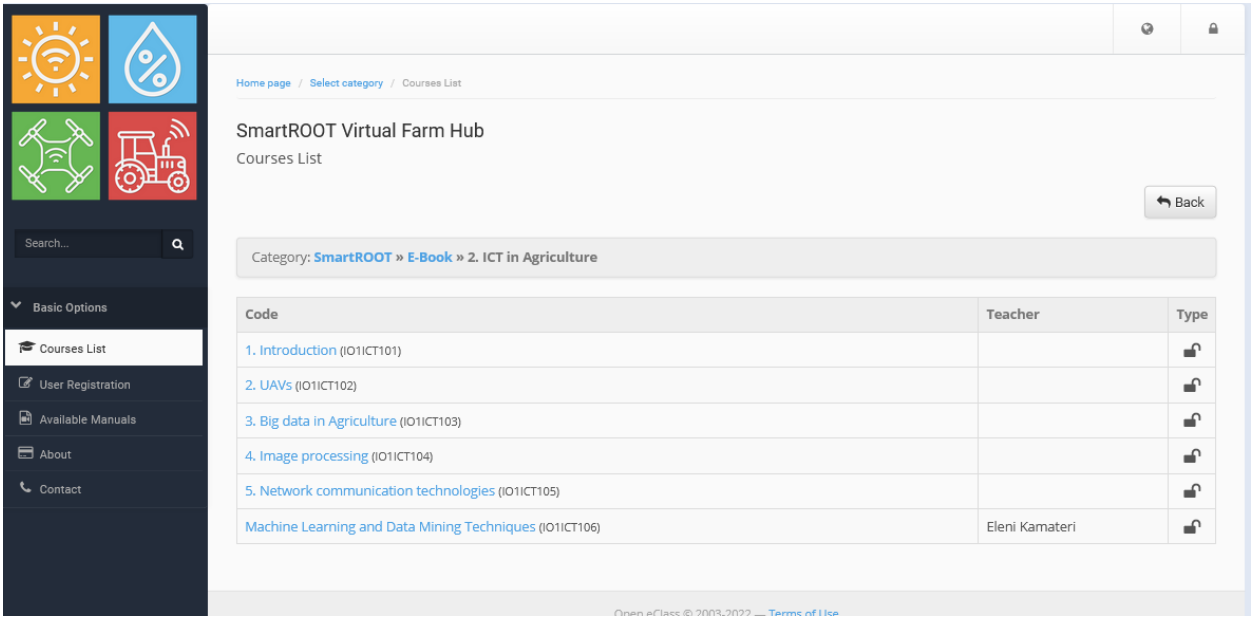


3.5 Demonstration of the Educational Platform

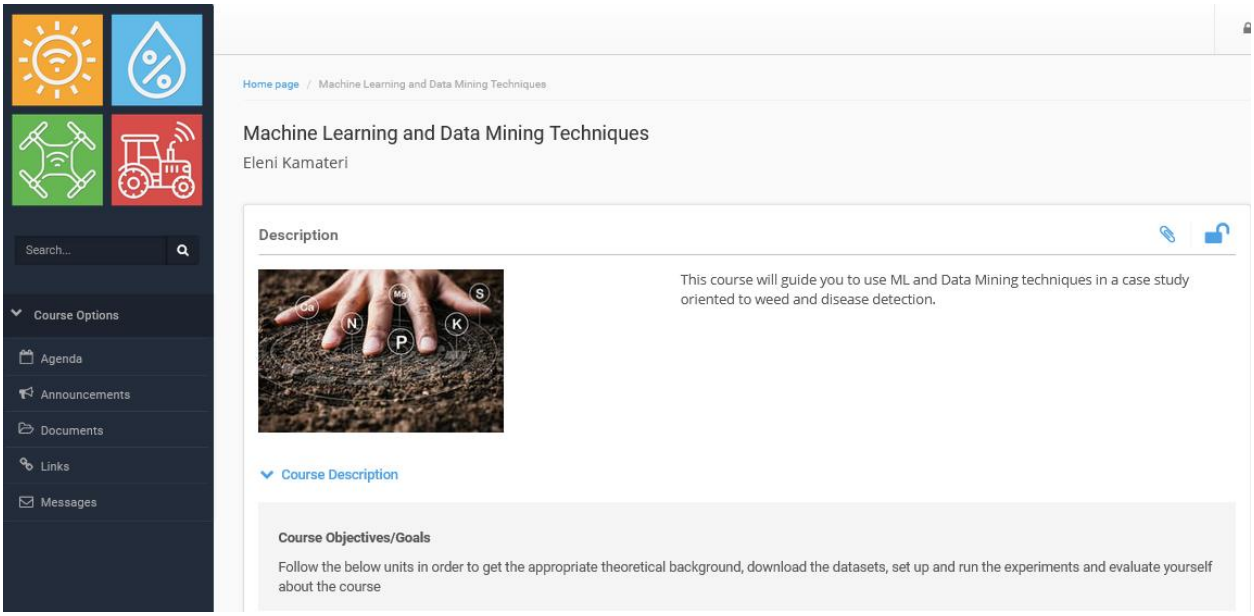
We present here the creation and management of a new course that focuses on machine learning and data mining techniques in agriculture and the inclusion of interactive educational activities under this course. For the creation and management of the interactive educational activities, we use the interactive content created with the use of the interactive virtual feature add-on and the interactive features provided by the educational platform itself.

Step 1: Creation of the new course.

We log in the educational platform with a teacher account. After that, we create a new course, named "Machine Learning and Data Mining Techniques", under the "Main Course 1. ICT in Agriculture" of the existing structure of courses.

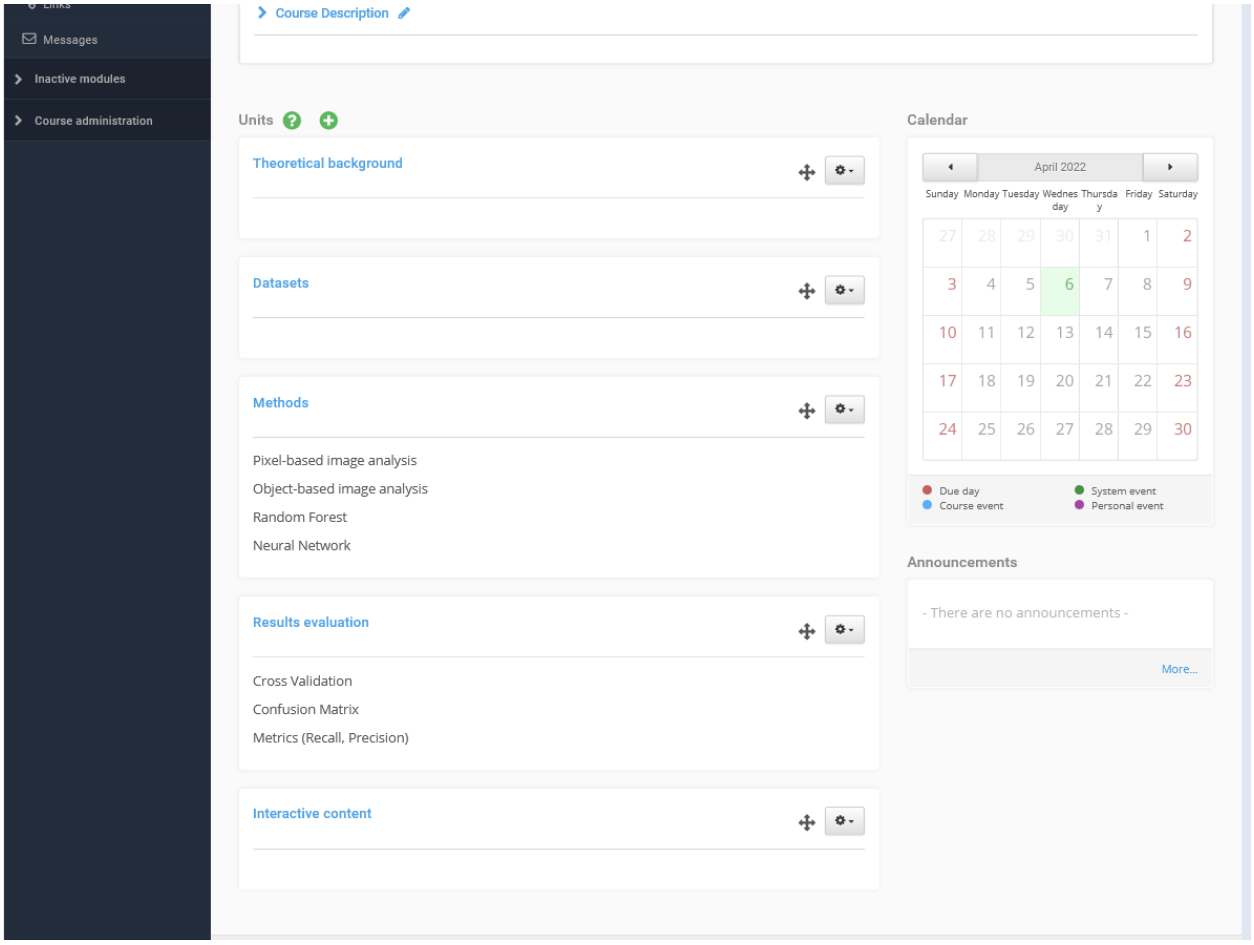


Then, we provide a general description and a course description.

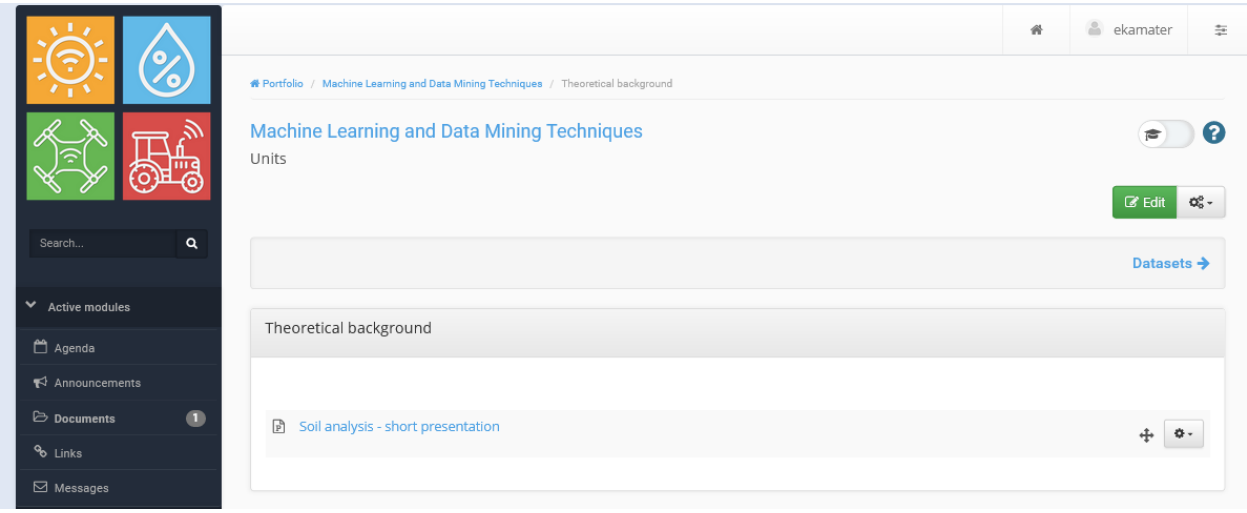


Step 2: Creation of the course units.

After that, we start with the creation of the course units. For this course, we decided to include 5 course units, including the Theoretical background, the Datasets, the Methods (Pixel-based image analysis, Object-based image analysis, Random Forest, Neural Network), Results evaluation (Cross Validation, Confusion Matrix and Metrics (Recall, Precision)), and Interactive content).



At each course unit, we add the respective notes, content and other material. Some example of the contents and material included in the course units are presented below.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Machine Learning and Data Mining Techniques
Units
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Soil analysis - short presentation
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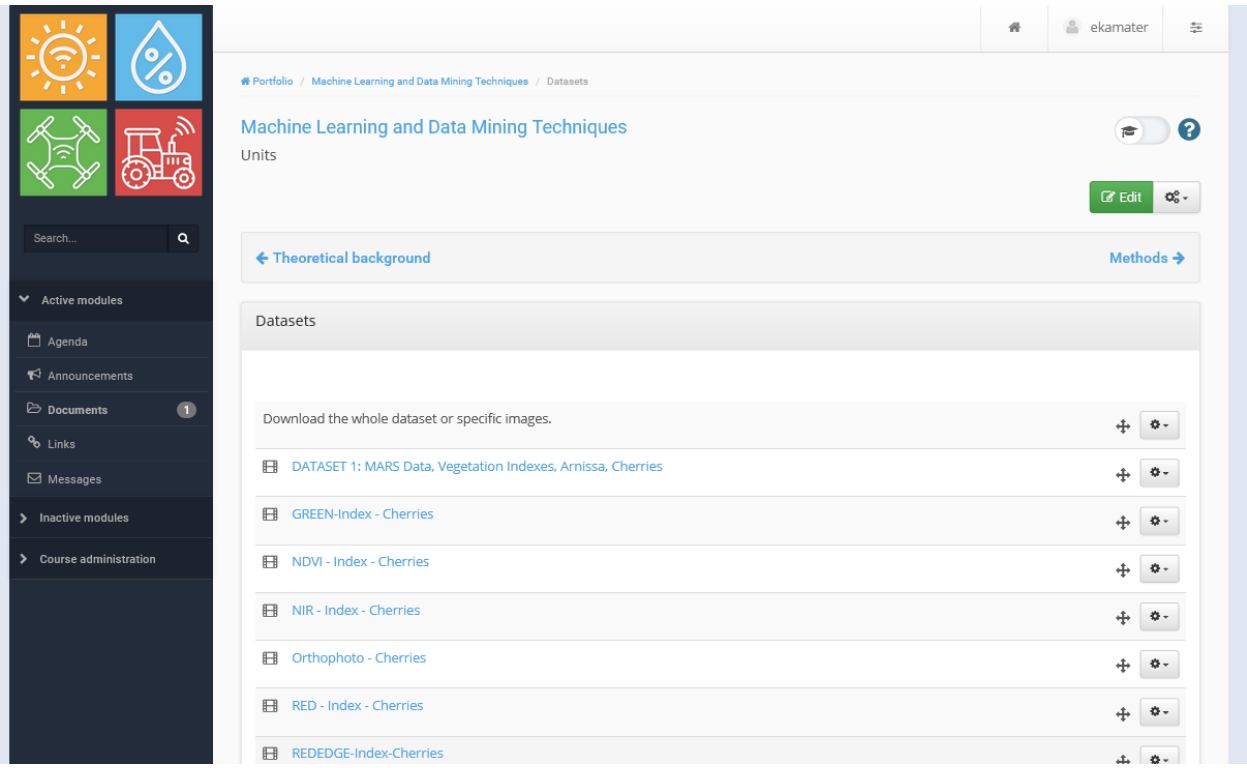
Announcements
Documents 1
Links
Messages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DATASET 1: MARS Data, Vegetation Indexes, Arnissa, Cherries
GREEN-Index - Cherries
NDVI - Index - Cherries
NIR - Index - Cherries
Orthophoto - Cherries
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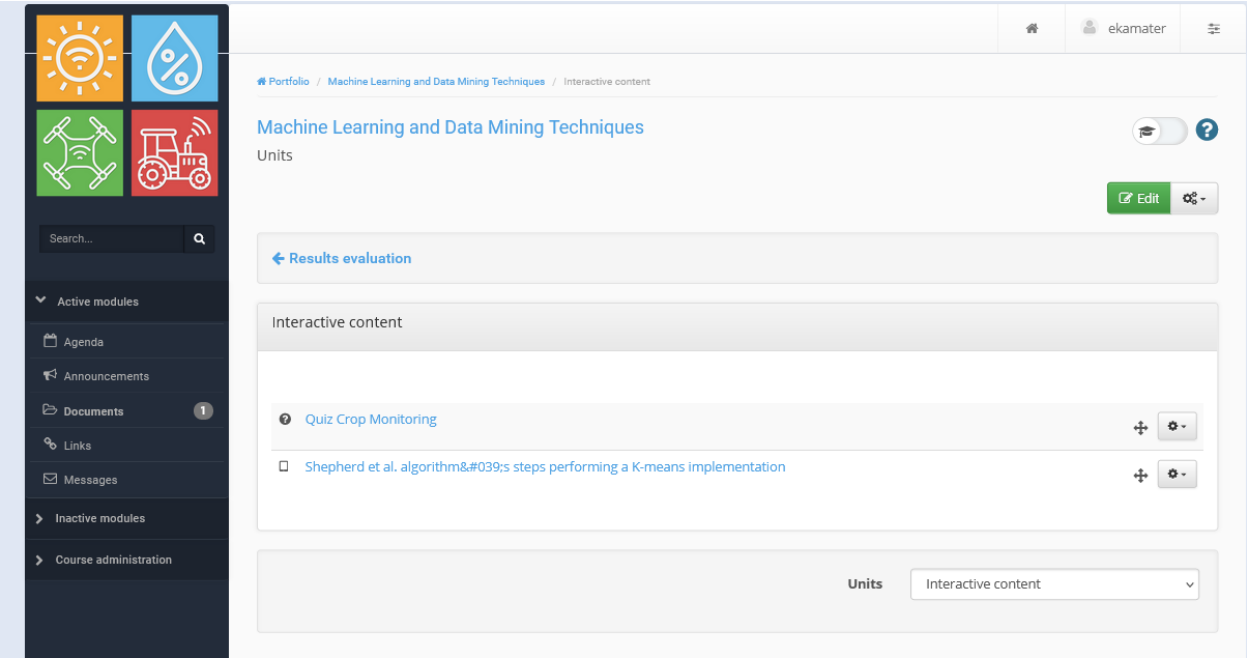
Messages
Inactive modules
Course administration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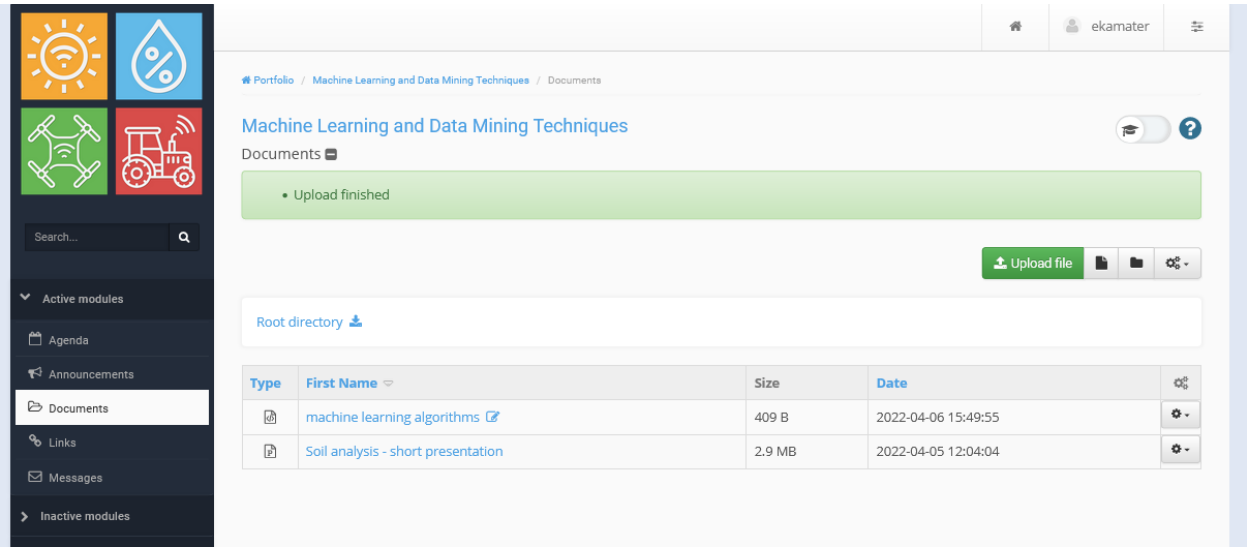
Inactive modules
Course administration
Interactive content
Quiz Crop Monitoring
Shepherd et al. algorithm's steps performing a K-means implementation
Units
Interactive content

Step 3: Creation of the content.

As we can see in the previous figures, the course units may contain documents, multimedia files, interactive content, etc.

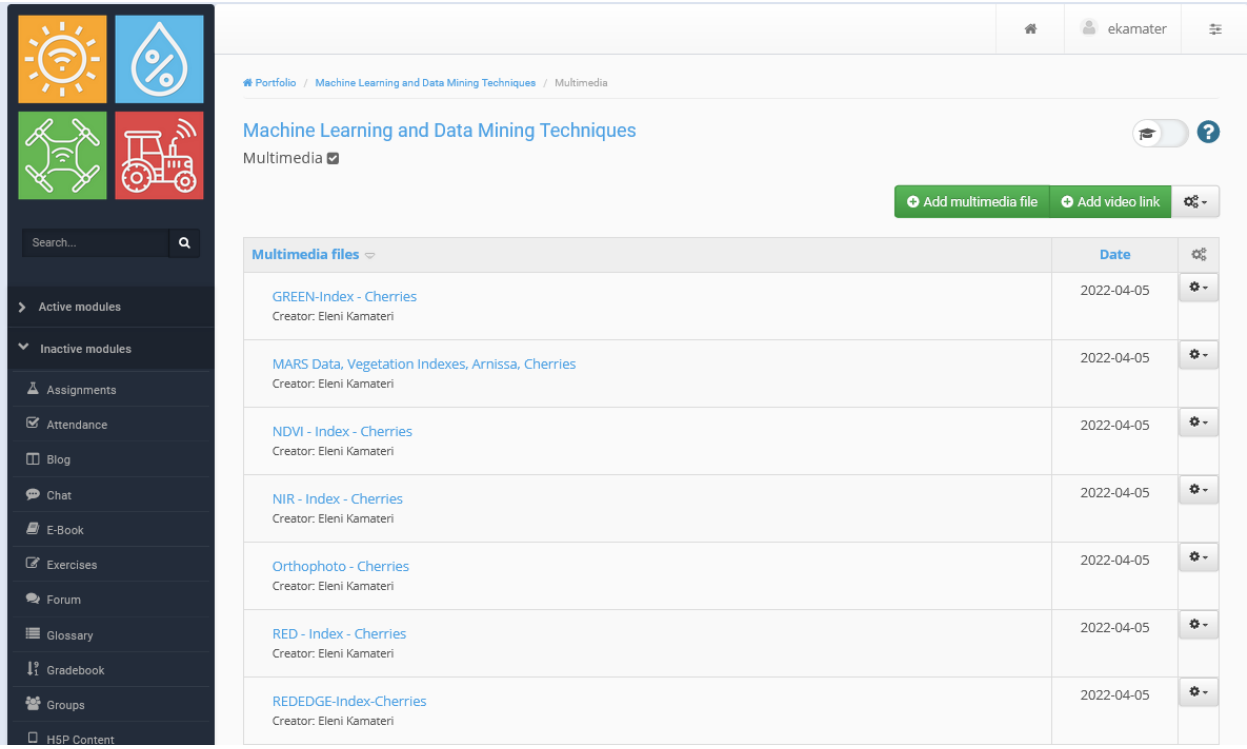
Documents

In order to create a document and add it in a unit, initially, we go to the “Documents” tool under the “Active modules”. There, we can create a new document or import a document (e.g., a presentation-pptx file) from our computer. After creating a number of documents, we can list them and select to edit them by this path.



Multimedia files

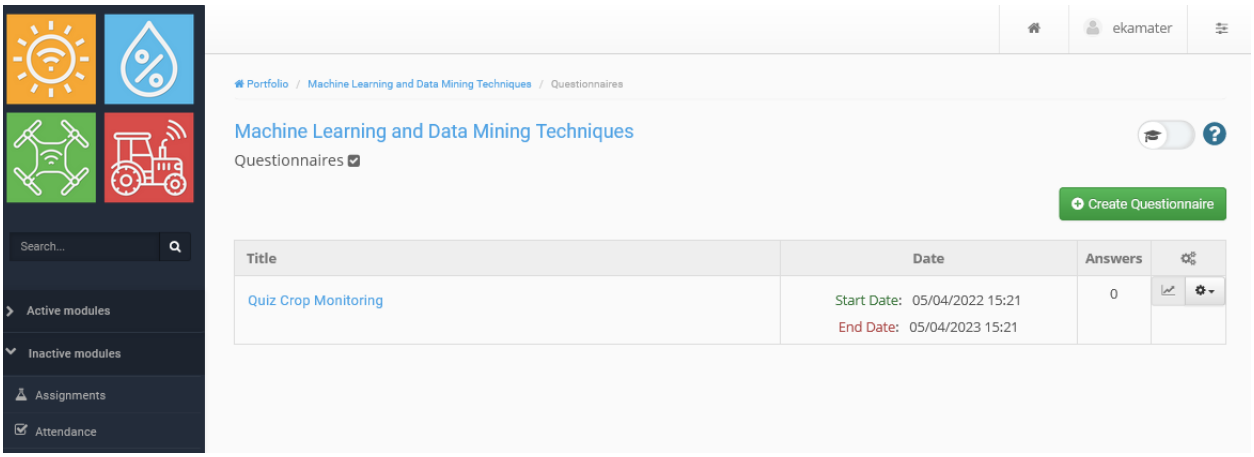
The platform can also host multimedia datasets. In order to create a dataset with images that will be used in the machine learning algorithms and add it in a unit, we go to the “Multimedia” tool under the “Interactive modules”. There, we can add multimedia files from our computer or video links from URL sources. In our example, we added several images separately and grouped in a zip file.



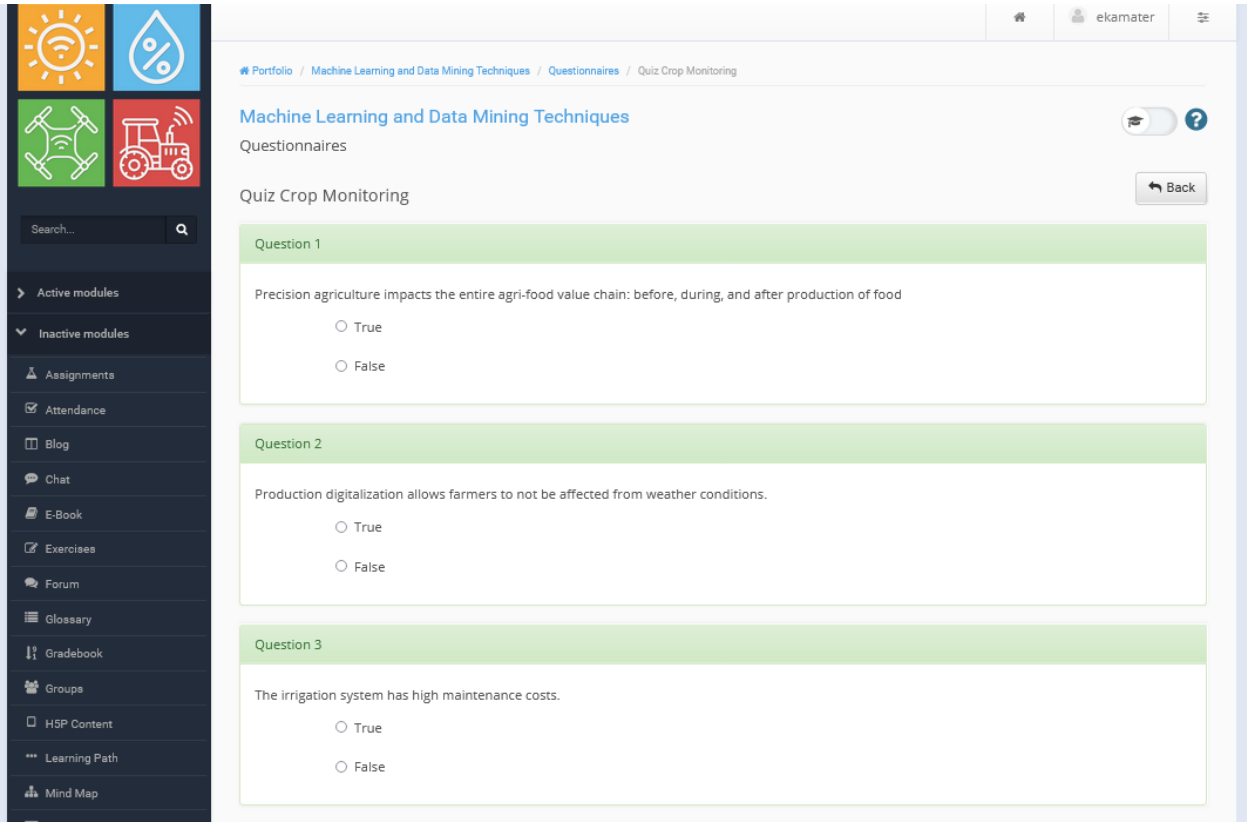
Interactive content

For the creation of the interactive content that will support the educational activities, there are two options. First, we can use the interactive tools provided by the educational platform itself under the “Interactive modules” (e.g., Questionnaires) and second, we can use the “H5P Content” provided under the “Interactive modules”.

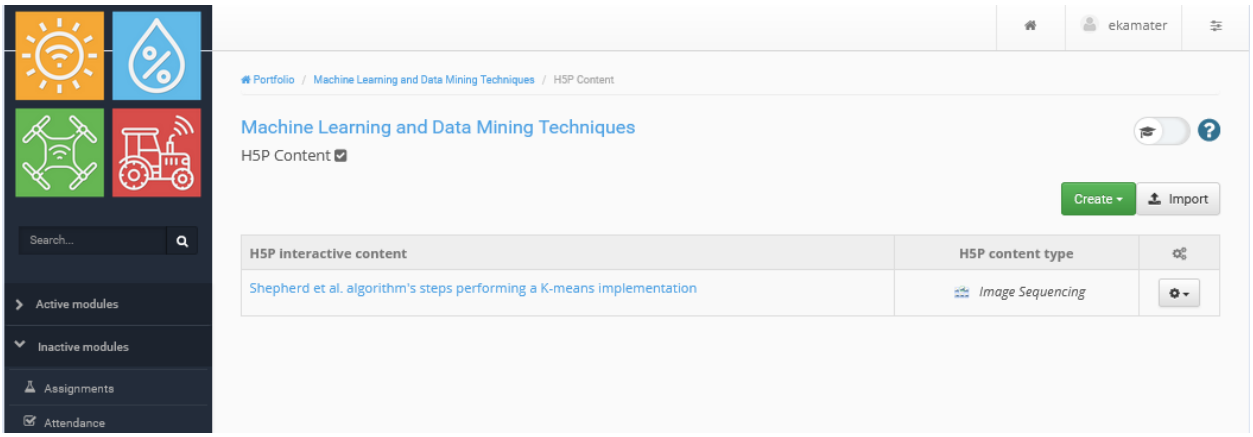
Under the “Questionnaires” option, we can see the available questionnaires.



Below, we can see the questions of an example questionnaire, named Quiz Crop Monitoring.



Under the “H5P Content” option, we can see the available interactive H5P content. As we can see, it is the same figure as the one presented in Section 5.



3.6 Implementation Details

For the development of the educational platform of the SmartROOT Virtual Farm Hub, the Open eClass platform[3] has been used which offers an integrated Course Management System.

The Open eClass platform is the solution offered by the Greek University Network GUnet to support asynchronous eLearning services. The Open eClass has been designed to enhance the learning process, it is distributed for free as an open-source software and is actively supported by GUnet. Its main goal lies in the integration and constructive use of the Internet and web technologies in the teaching and learning process.

The Open eClass platform can be combined with several add-on modules to enhance the educational experience, such as the H5P plugin which has been used for interactive content creation.

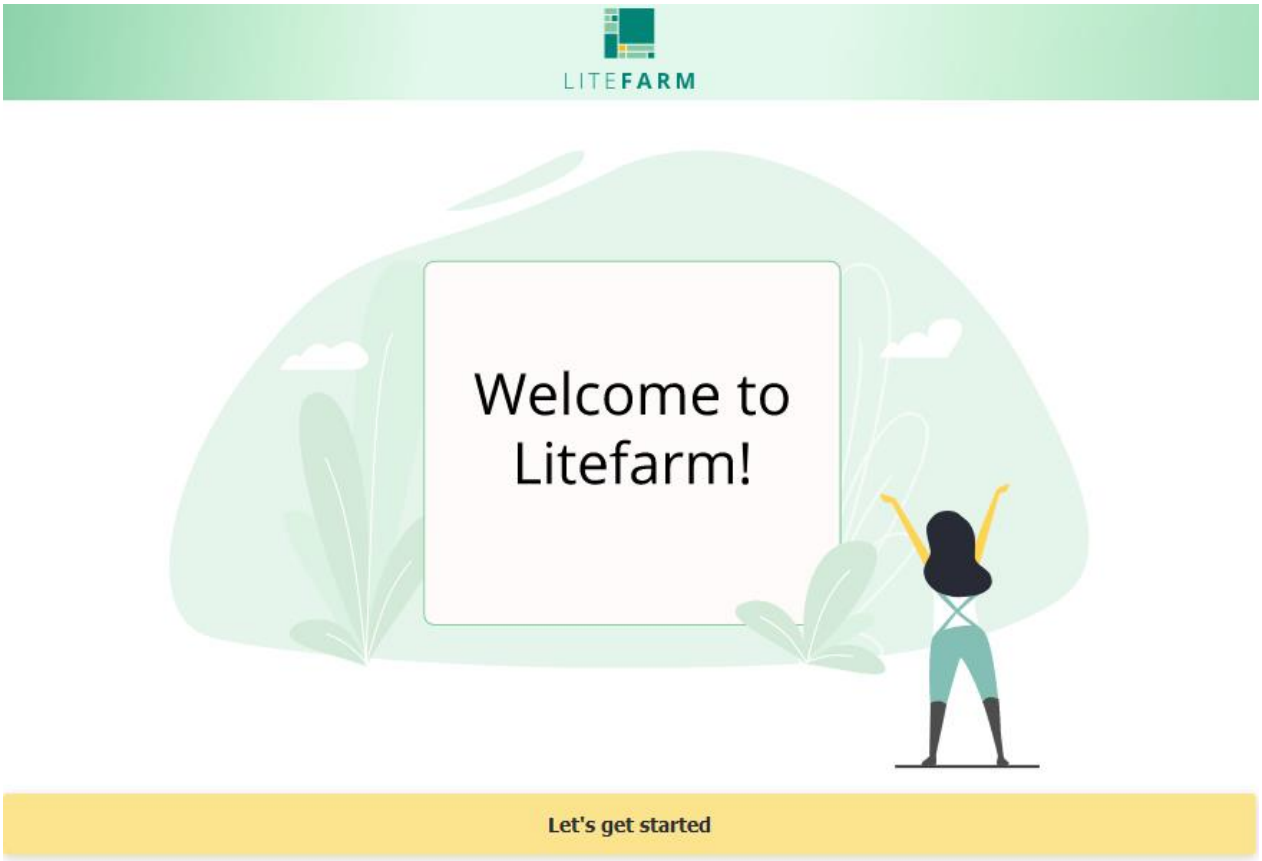
[3] https://www.openeclass.org/en/

4 Farm Management

4.1 Overview

The Farm Management tool is a web-based application representing a virtual farm where data from mixed farming activities can be introduced, managed and presented. The tool also offers different levels of configuration creating an interactive collaborative environment where many users can either create their own farms or collaborate with existing users for their farming activities.

The tool has been built in the context of the SmartROOT project for educational purposes.



4.2 Background Knowledge

The Farm Management tool is an interactive collaborative teaching environment for the management of sustainable farms by different stakeholders, such as farmers, researchers and students. The users can have different roles and collaborate among them in farming operations.

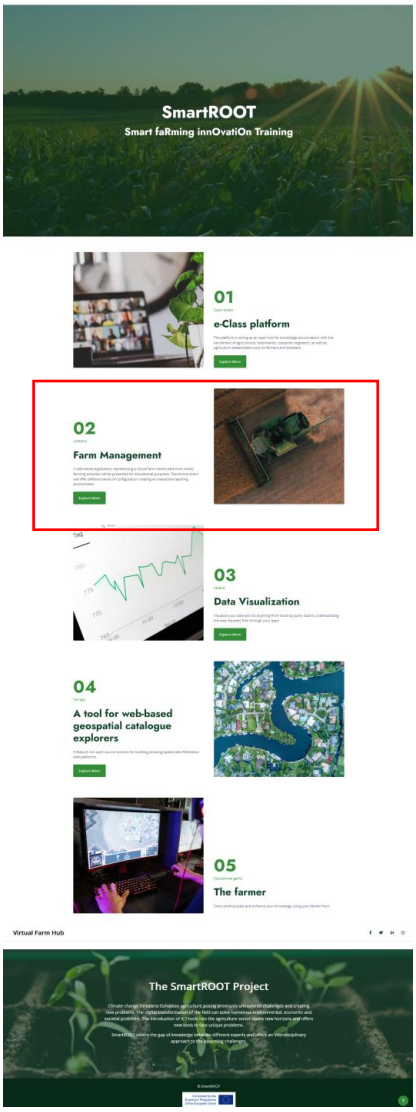
4.2.1 Technology behind the tool

The tool has been built by means of the open-source LiteFarm software[4]. The LiteFarm was built by farmers and researchers from the University of British Columbia to address many of the challenges in farm management. It's currently being used to manage farm operations in more than 125 countries internationally.

[4] https://www.litefarm.org/

4.3 Walkthrough the Farm Management tool

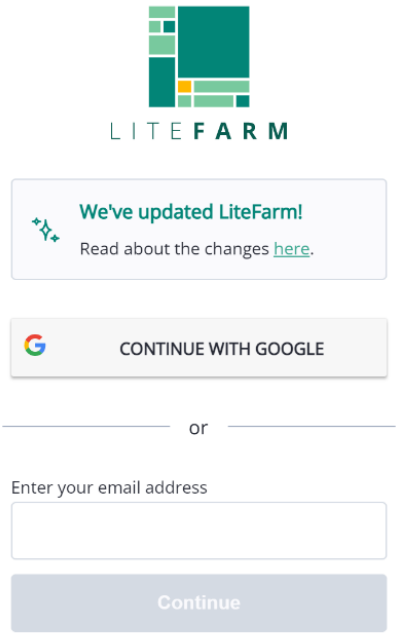
From the navigation page of the Virtual Farm Hub (IO3) https://virtualfarm.infalia.com/, anyone can access the Farm Management tool https://litefarm.infalia.com/, which is the 2nd available tool of the Virtual Farm Hub platform.



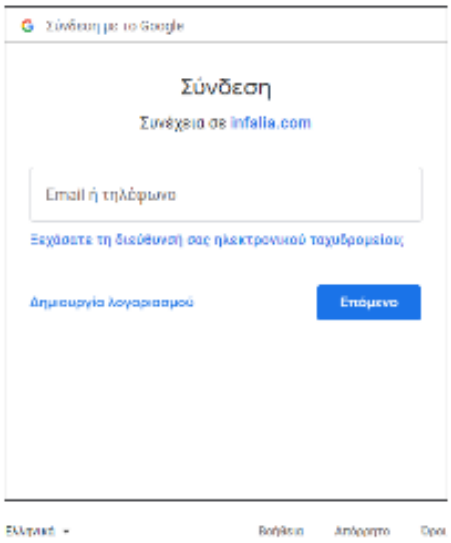
The following sections present the main functionality supported by the Farm Management tool.

4.3.1 Registration and log in

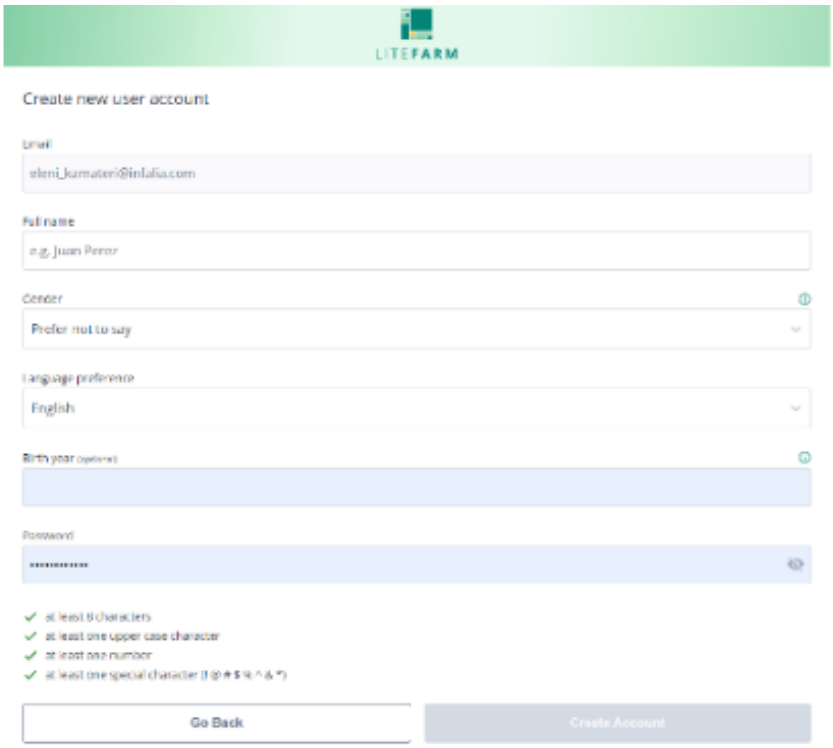
After clicking the “Explore More” button from the navigation page of the Virtual Farm Hub, the below page is presented allowing the user to provide his/her credentials and log in the tool. Two options are available: to continue with the Google account or to enter an email address.



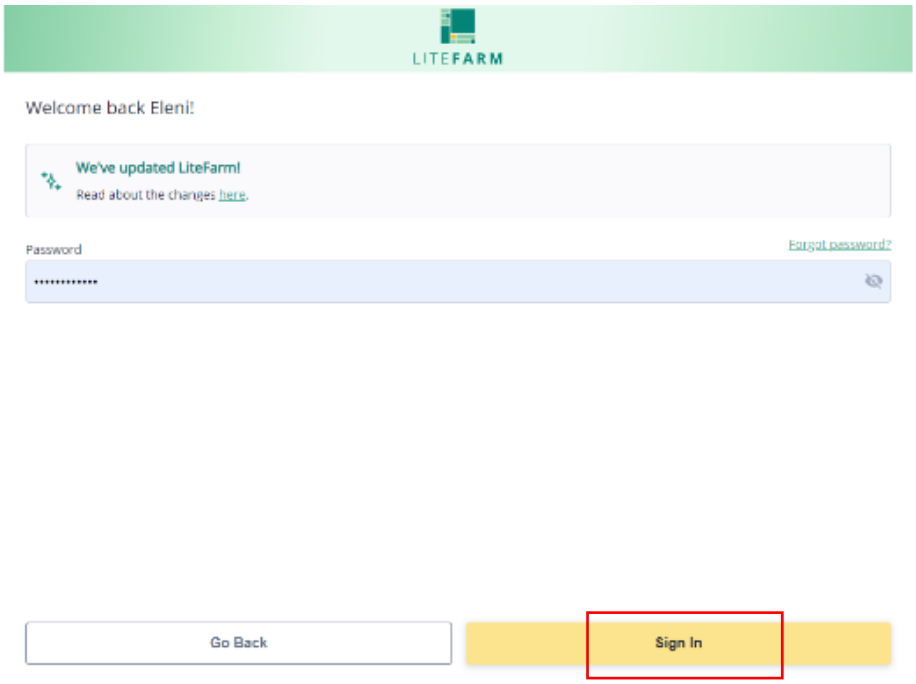
With the Google account option, the below page is presented.



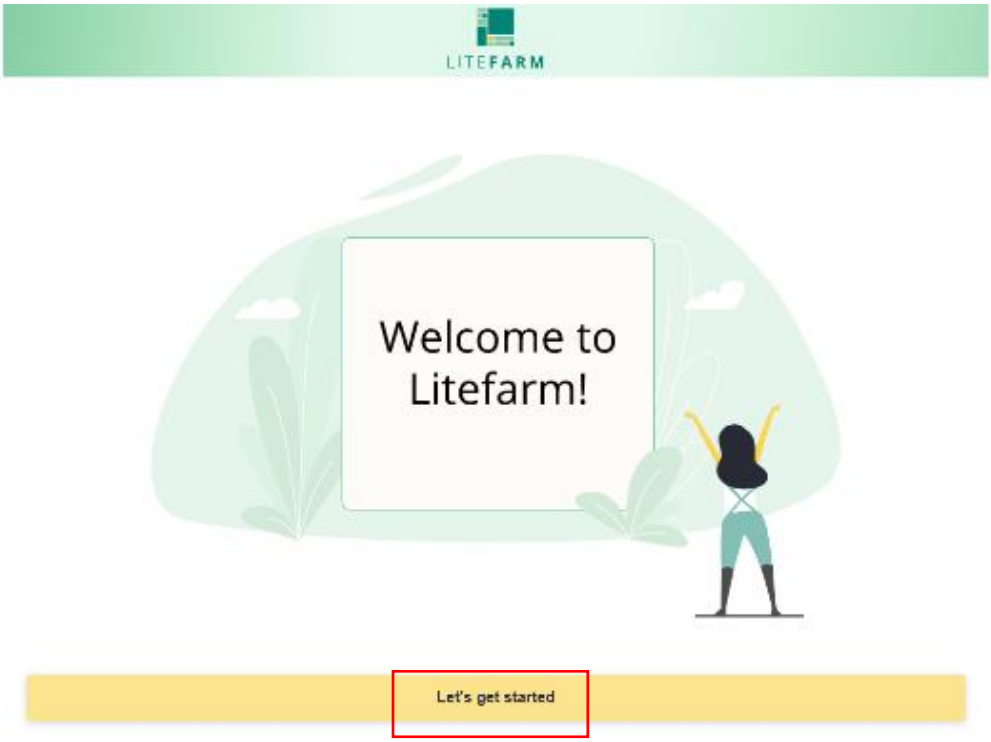
With the email address option and after entering the email address, the below page is presented if the user hasn't owned an account asking him/her to provide his/her details and create an account.



Alternatively, if the user has already owned an account, the below page is presented asking him/her to provide his/her password and connect to his/her account.



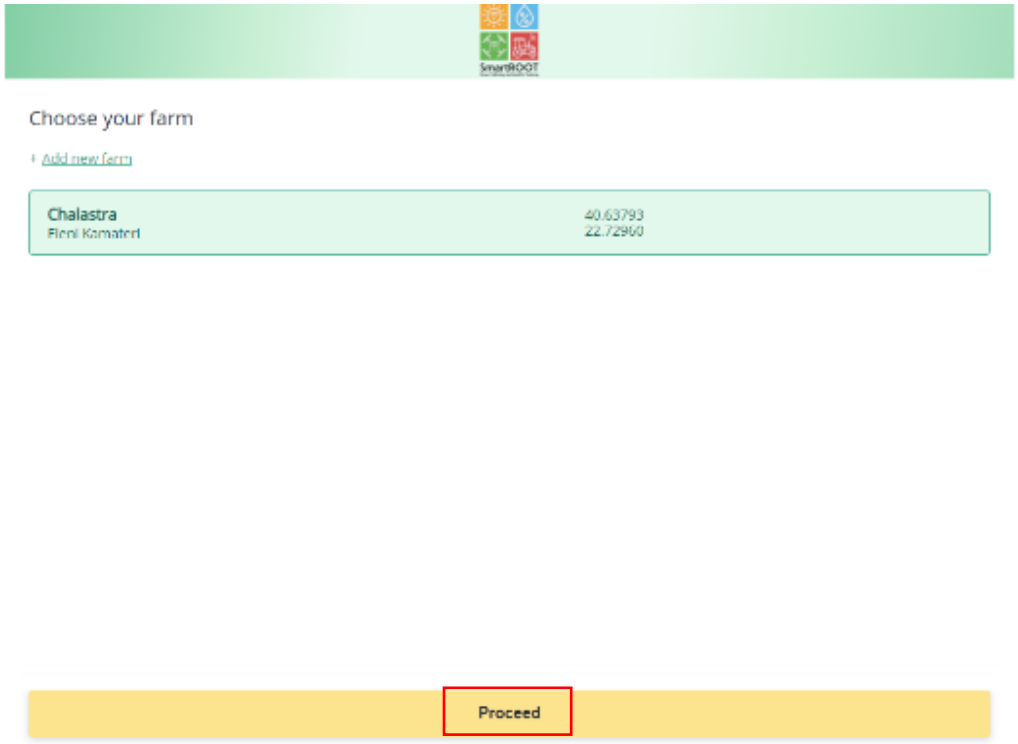
In both cases, after a successful log-in, the below page is presented.



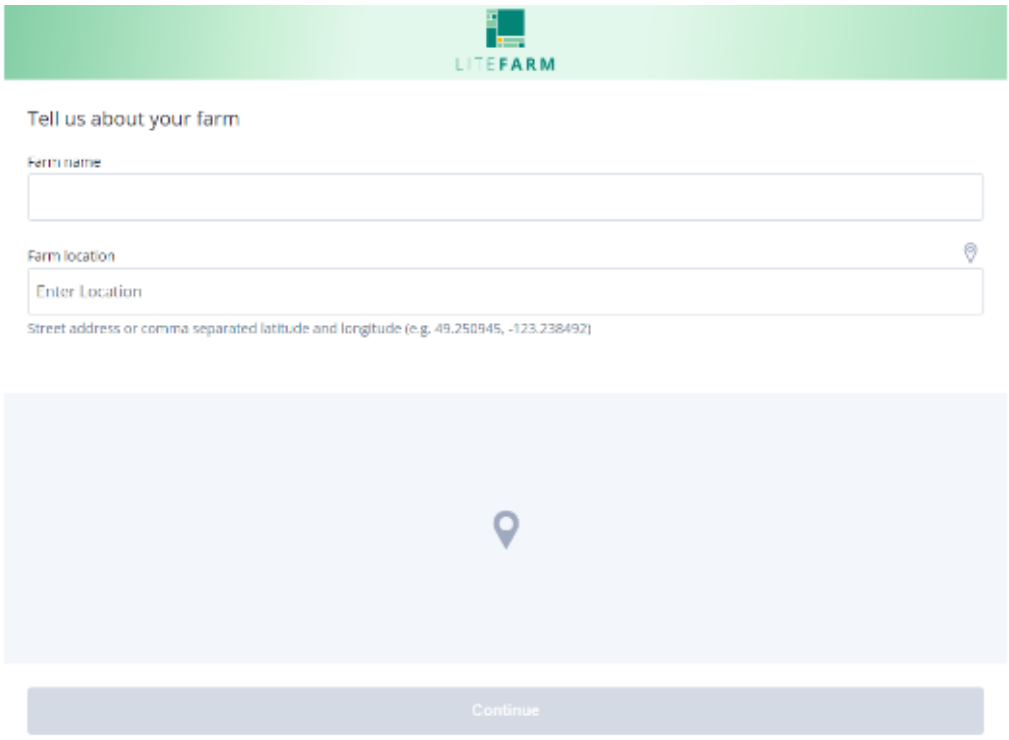
4.3.2 Add a new farm

The main functionality provided by the tool is the addition of one or more farms and the definition of the user's role with respect to the farm's activities.

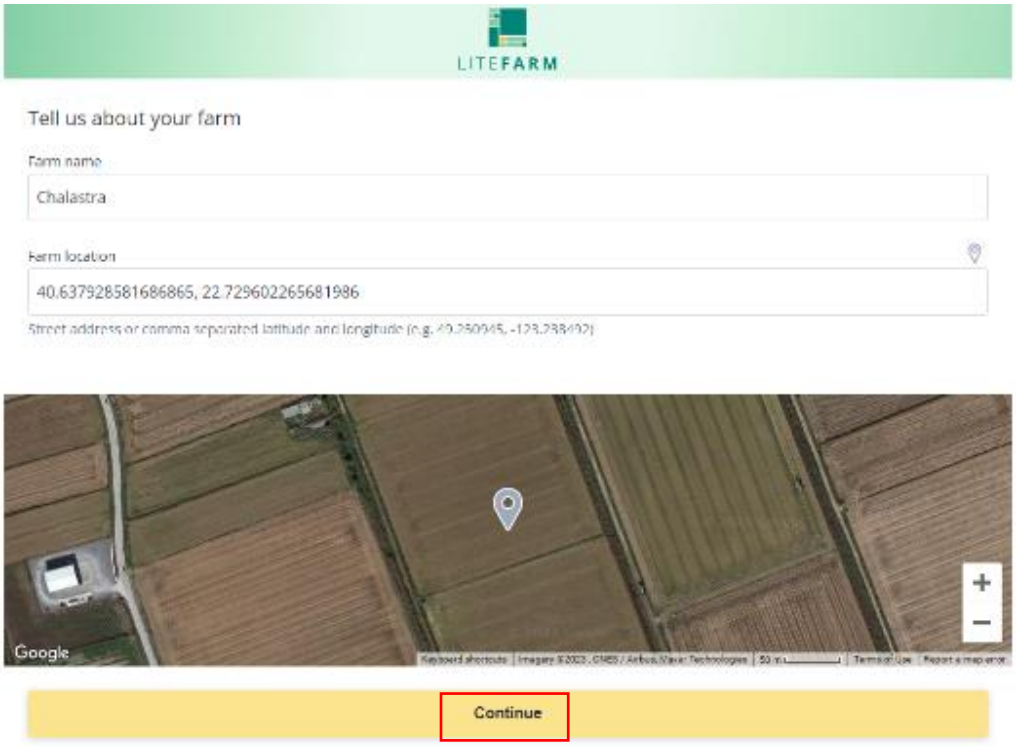
If the user has already entered the tool and created some farms, the below page is presented showing the existing farms and the option to add a new farm.



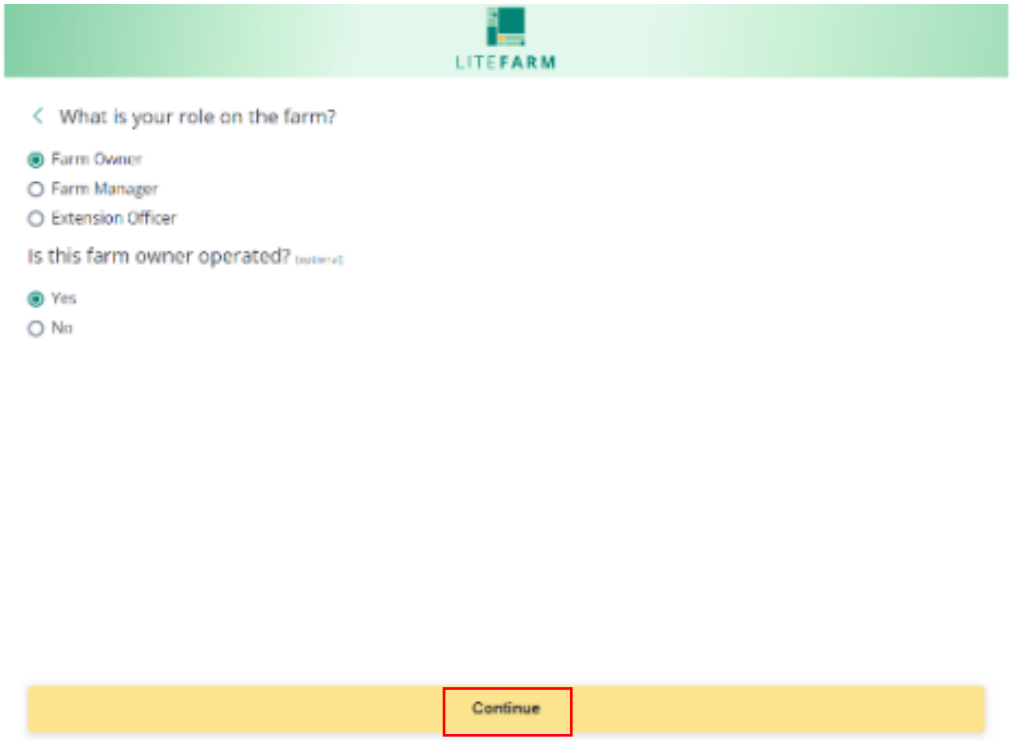
When the user logs in for first time or when the user clicks on the button "Add new farm", the below page is presented asking the user to insert the details of the new farm, including its name and its location.



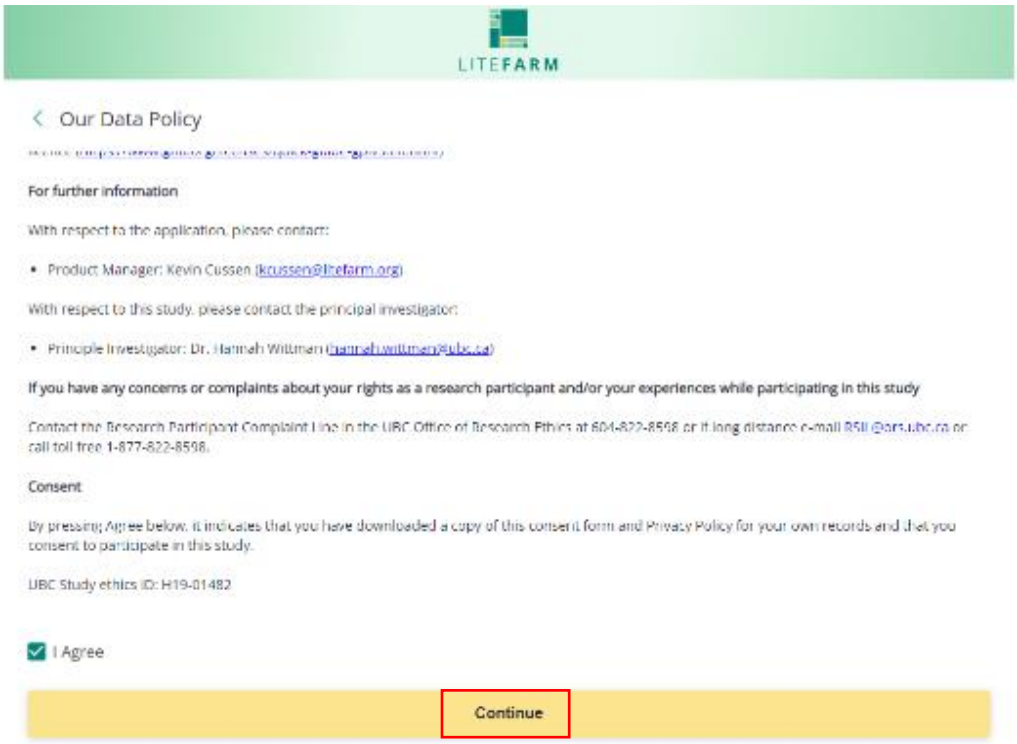
Then, the user provides the new farm's details and presses the "Continue" button.



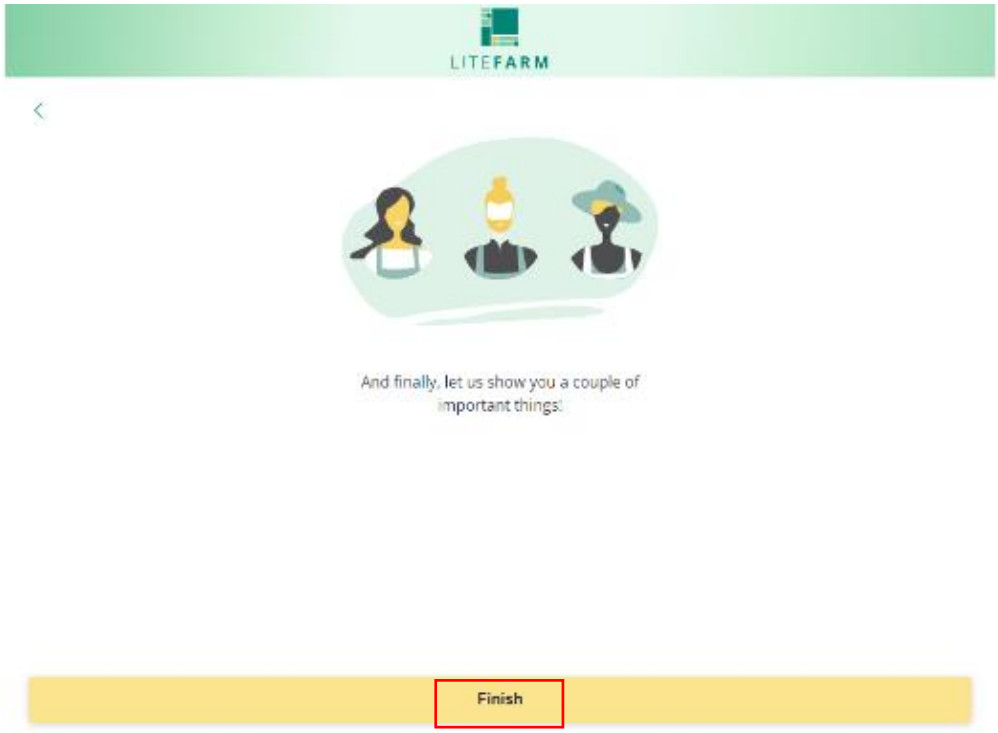
Then, the user proceeds to the next page where he/she is requested to define his/her role on the farm and whether (or not) the farm is owner operated. The user provides the requested information and presses the “Continue” button.



Then, the user proceeds to the next page. There, the user is requested to agree with the data policy of the tool before creating the new farm. The user presses the “Continue” button and proceeds to the next page.



There, the user gets a successful message and presses the “Finish” button to conclude the process.

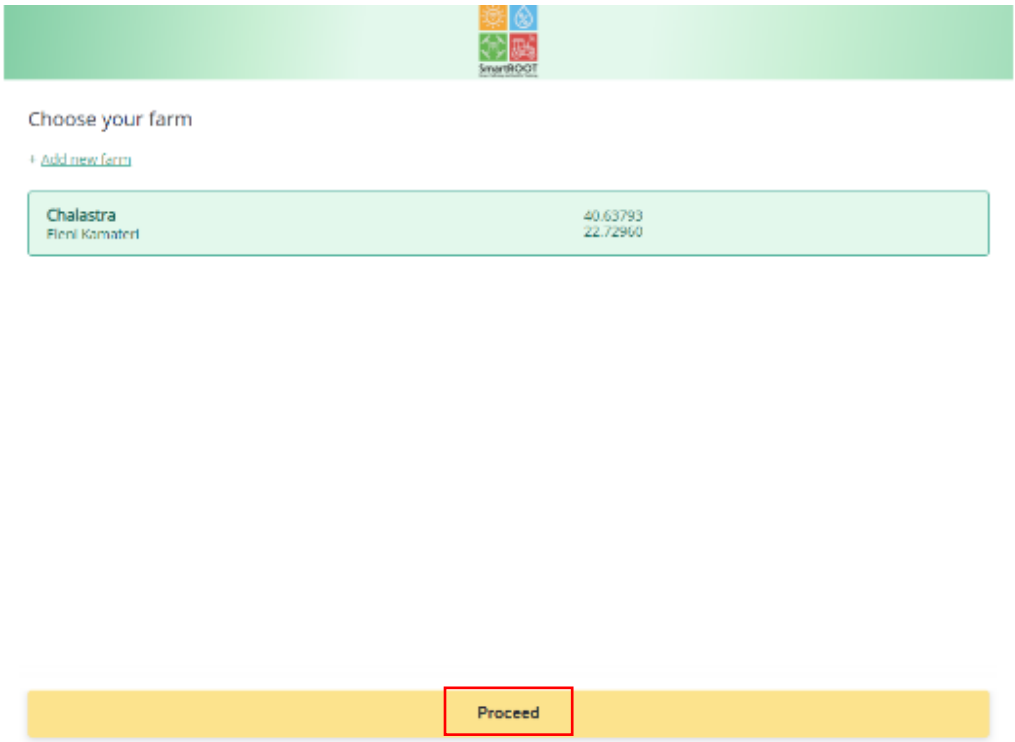


Then, the farm is presented along with the weather (temperature, wind and humidity) retrieved for the farm's location from the OpenWeather's API https://openweathermap.org/api.

4.3.3 Add a farm map

An important functionality provided by the tool is the addition of a farm map, which is a prerequisite for other functionalities, such as the addition of a new crop.

As we have already mentioned, when the user logs in the tool the below page is presented showing the existing farms.

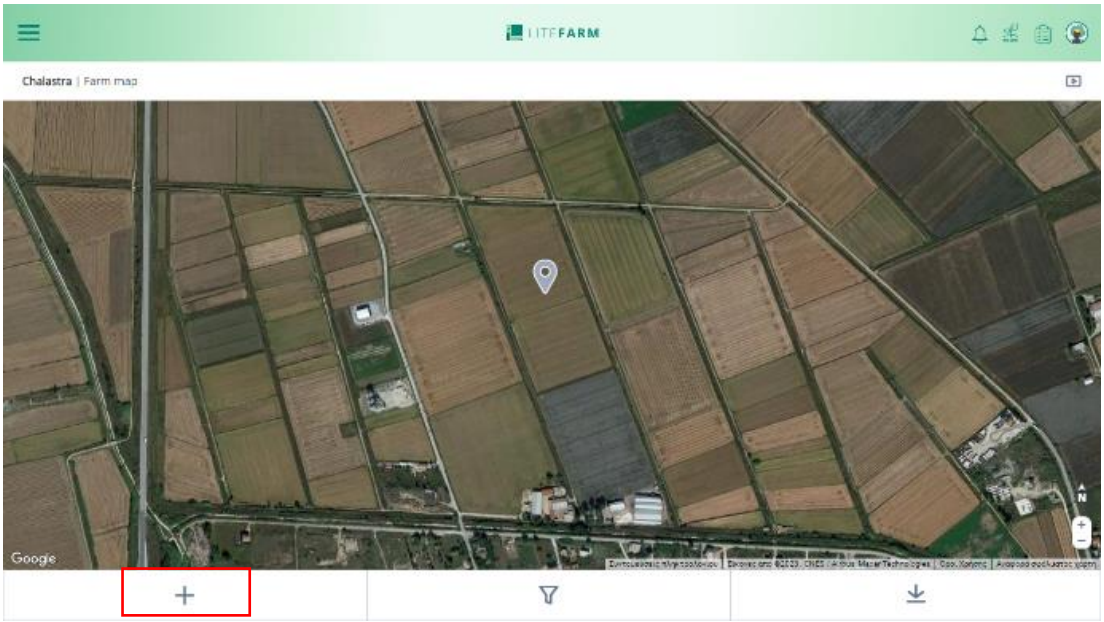


The user selects the Chalastra's farm, which has been just added, and enters the farm by clicking on the "Proceed" button.

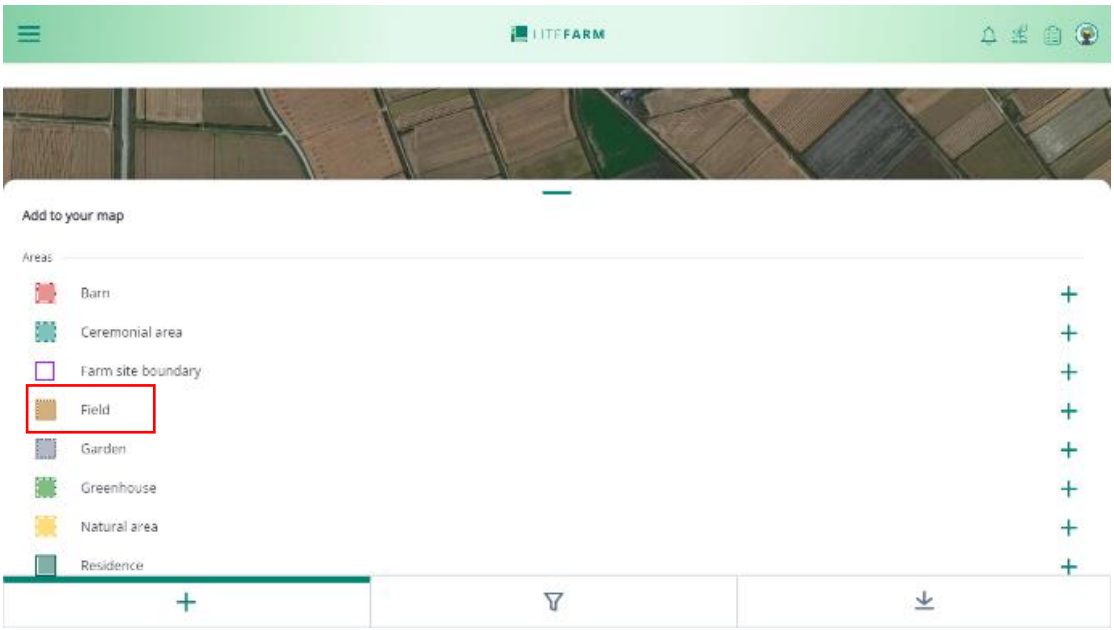
As we have seen above, when the user enters the farm, the below page is presented along with the weather retrieved for the farm's location.

There, the user checks on the “My farm” option and selects the “Farm map” option from the drop-down list.

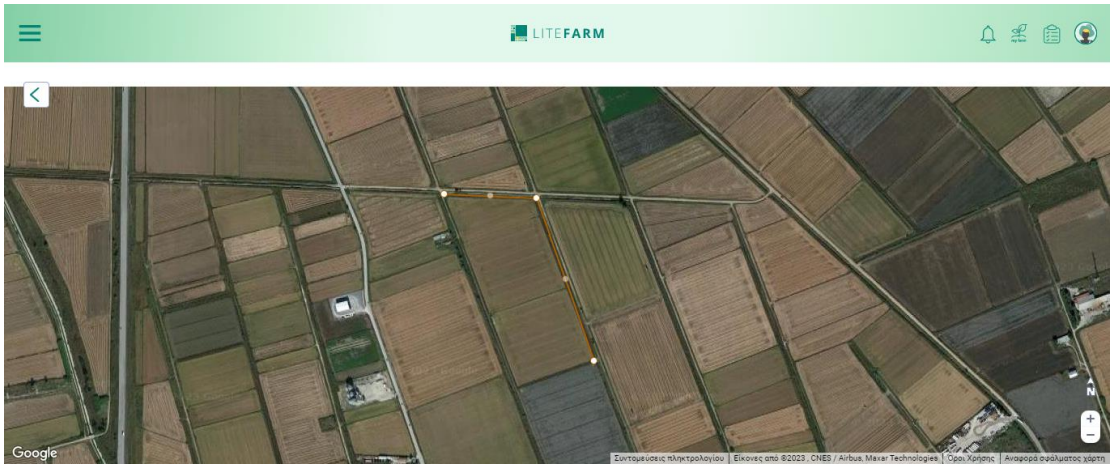
The below page is presented showing the map of the field. There, the user clicks on the “+” button and a side menu is presented.



From the menu, we select the “Field” option.

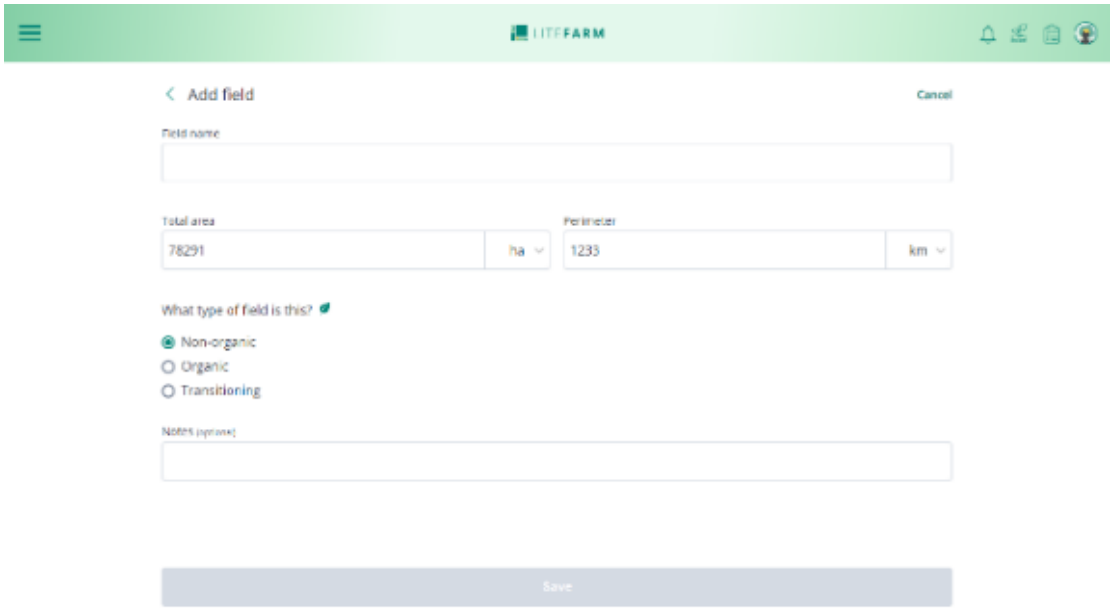


Then, the user is enabled to draw the outline of his/her farm.

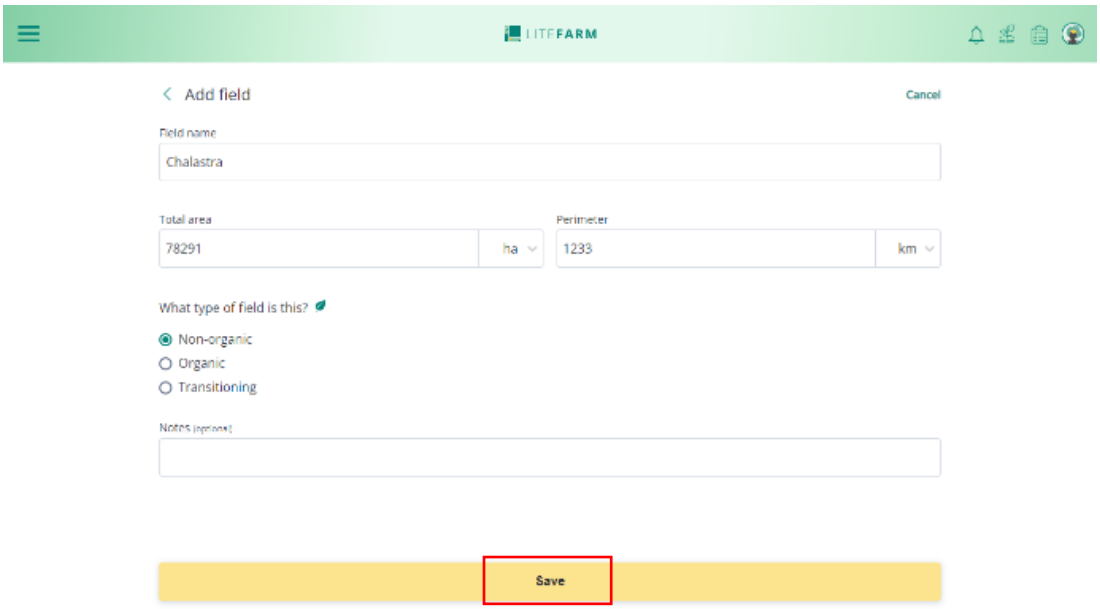


When the user finishes the outline of his/her farm, she/he is requested to redraw or confirm the outline. When the user decides that the outline is correct, he/she confirms it by clicking on the “Confirm” button.

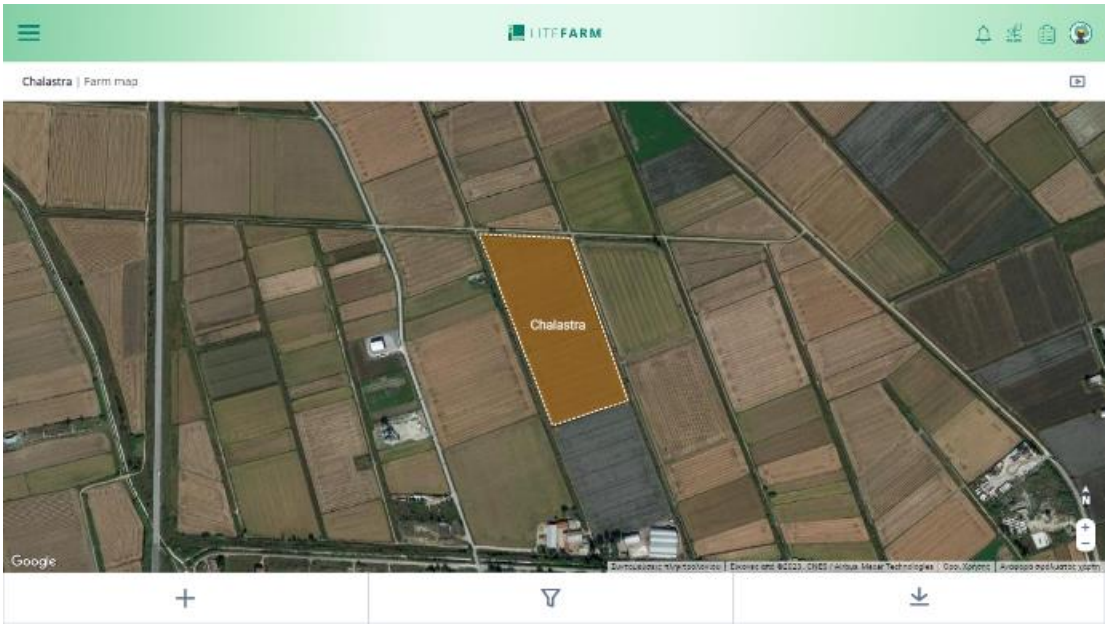
When the user confirms the outline of a farm, the below page is presented asking him/her to insert the details of the field including its name, its type and the units of the area and the perimeter, while the values of the area and the perimeter are automatically filled in.



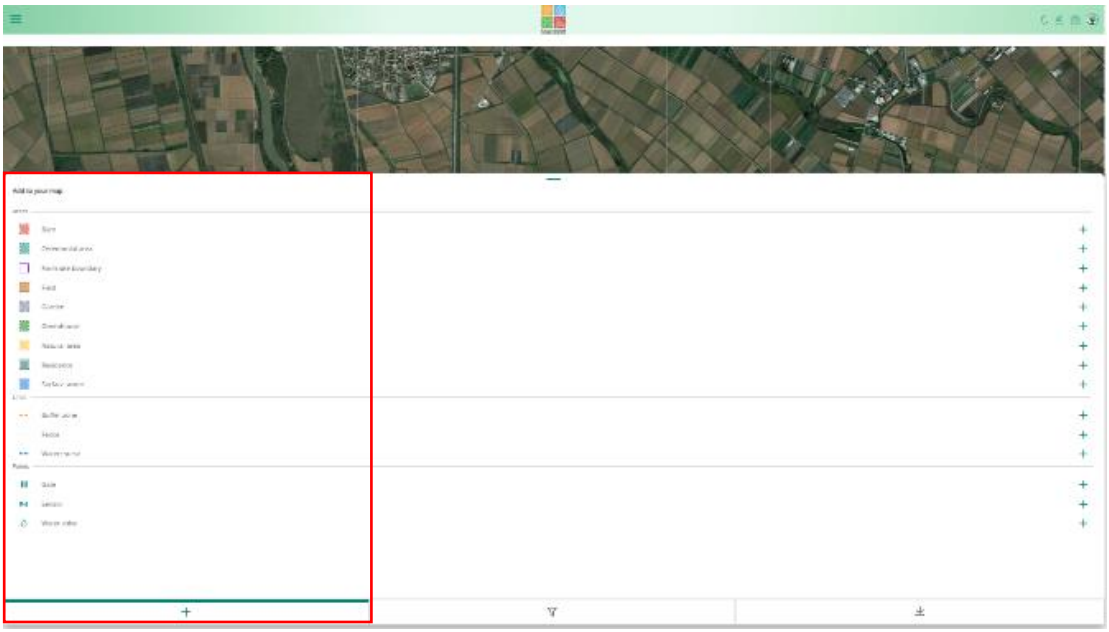
The user provides the field's details and presses the "Save" button.



The user proceeds to the next page where he/she can see the farm's field.

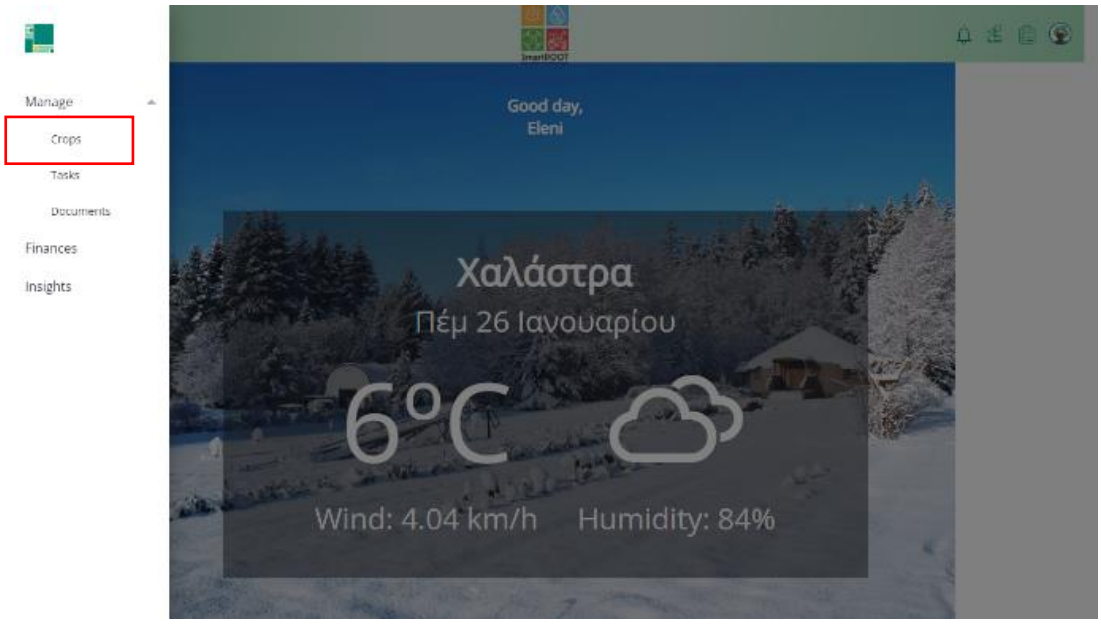


Besides the addition of an "Area" descriptor to the farm, like the "Field", the user can also add other descriptors, such as i) "Lines" descriptors including the "Buffer zone", the "Fence", and the "Watercourse", and ii) "Points" descriptors including the "Gate", the "Sensor", and the "Water valve".

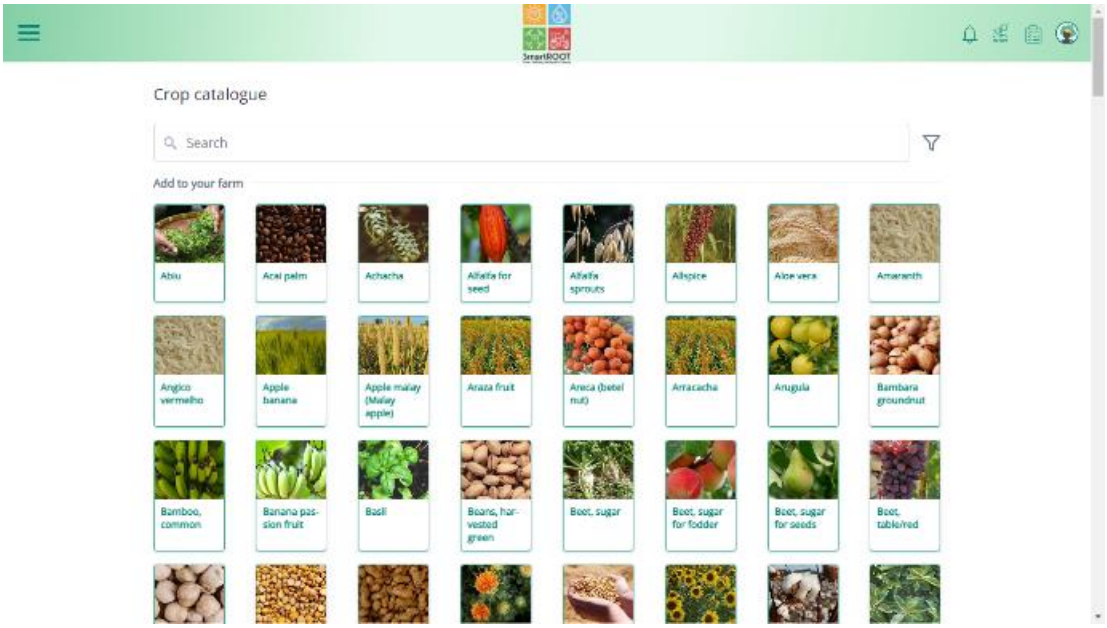


4.3.4 Add a new crop in a farm

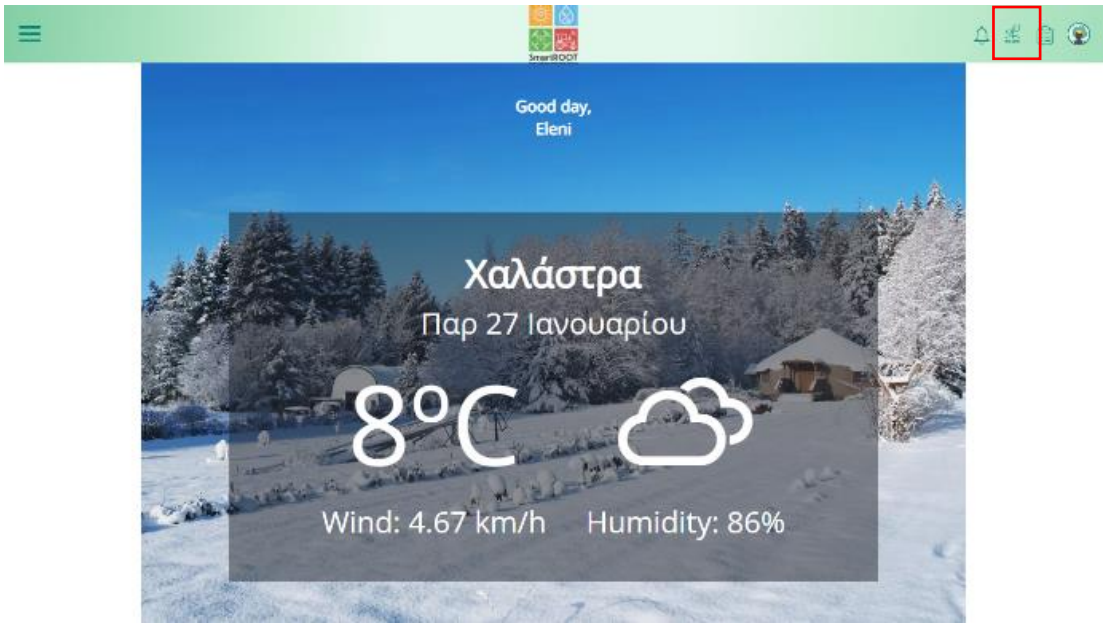
Another functionality provided by the tool after the addition of a new farm is the addition of a new crop. Let consider that the user has entered the Chalastra's farm and the below page has been showed. Then, the user has two alternative paths to create a new crop. The first is to click on the left side's menu button and selects the "Crop" option from the drop-down list.

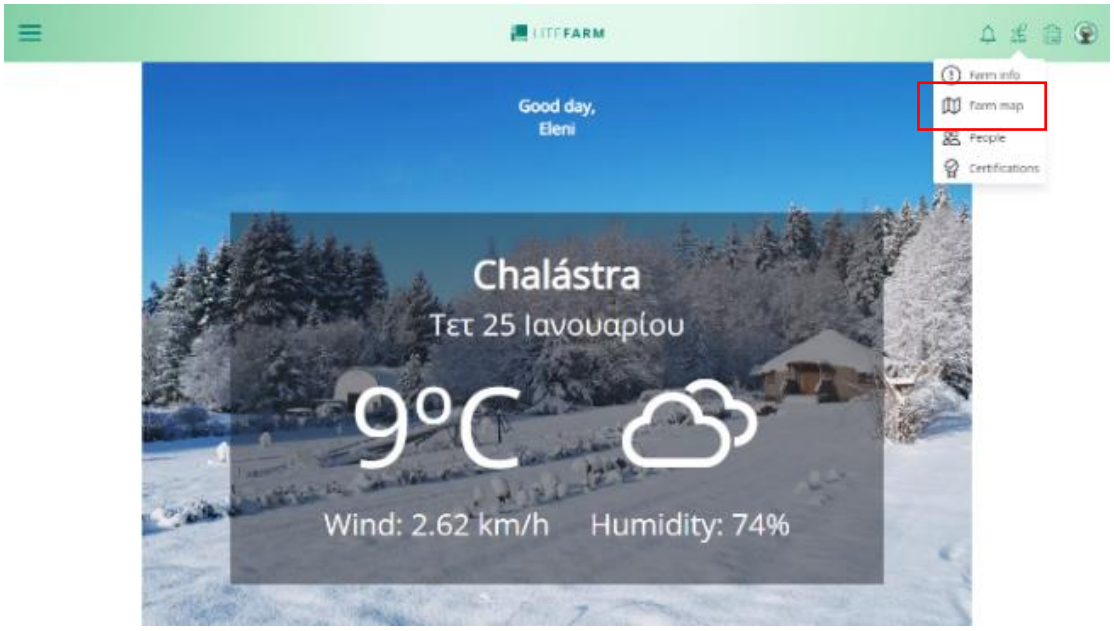


Then, the below page is presented where the user can search for a crop item or scroll down the big list of crops and select a crop to add to his/her farm.

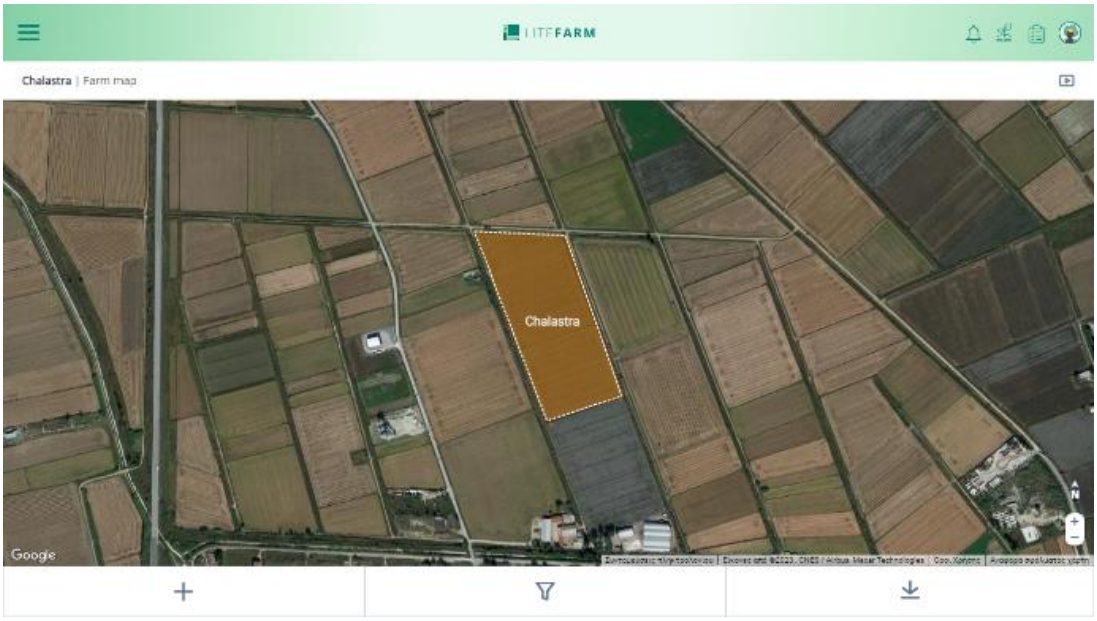


The second path is to click again on the “My farm” option and select the “Farm map” option from the drop-down list.

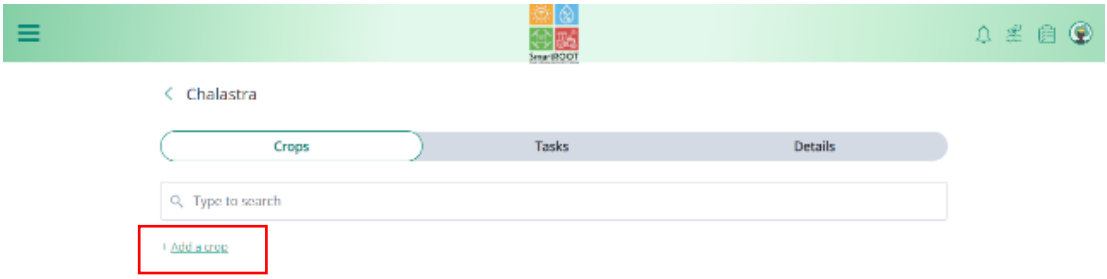


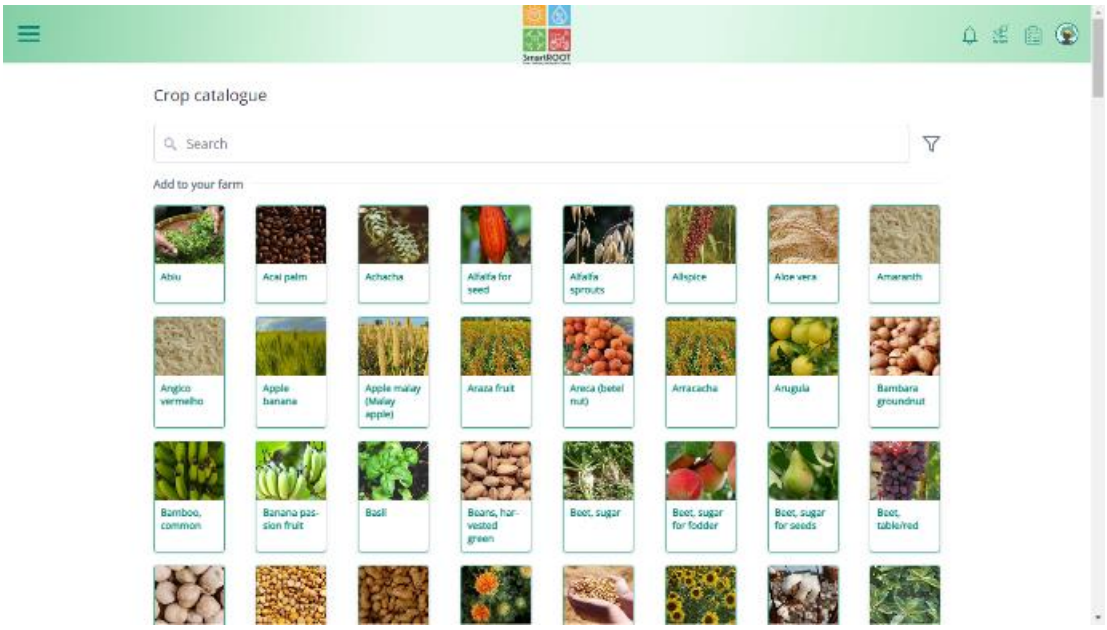


Then, the below page is presented requesting the user to check on the farm's field.

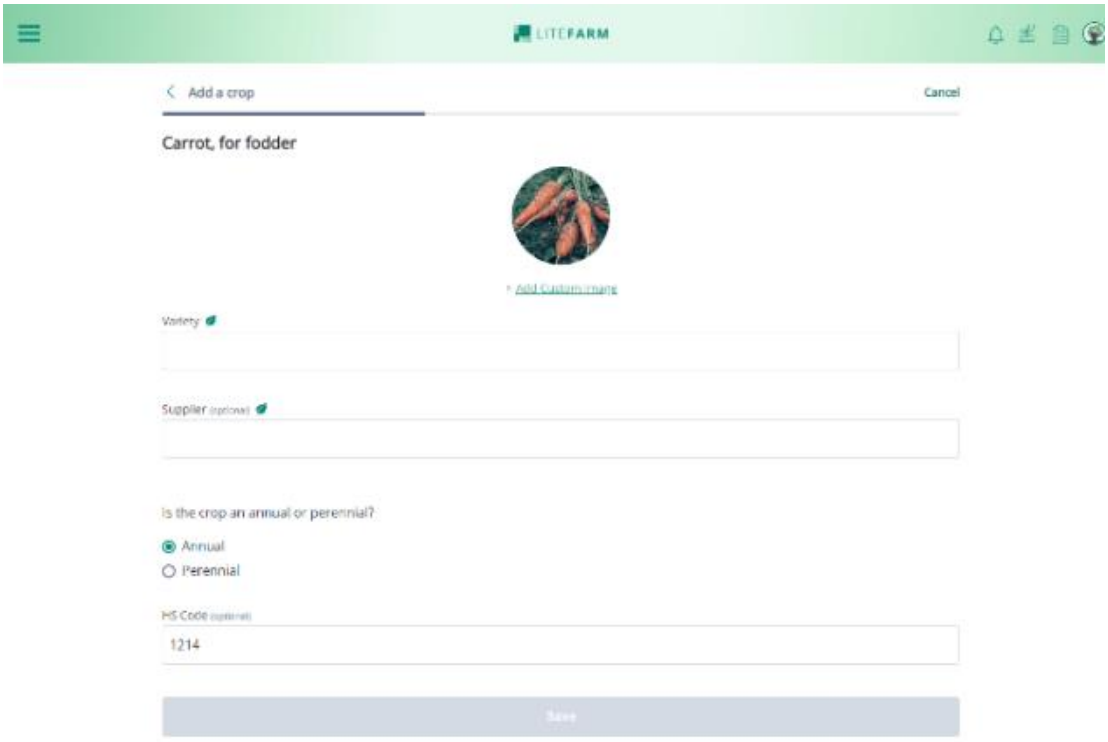


When the user checks on the farm's field, the below page is presented where the user can select among three available options, including "Crops", "Tasks", and "Details". The user check on the "Crops" button, selects the addition of a crop and is re-directed on the same page with all available crops from the first path.

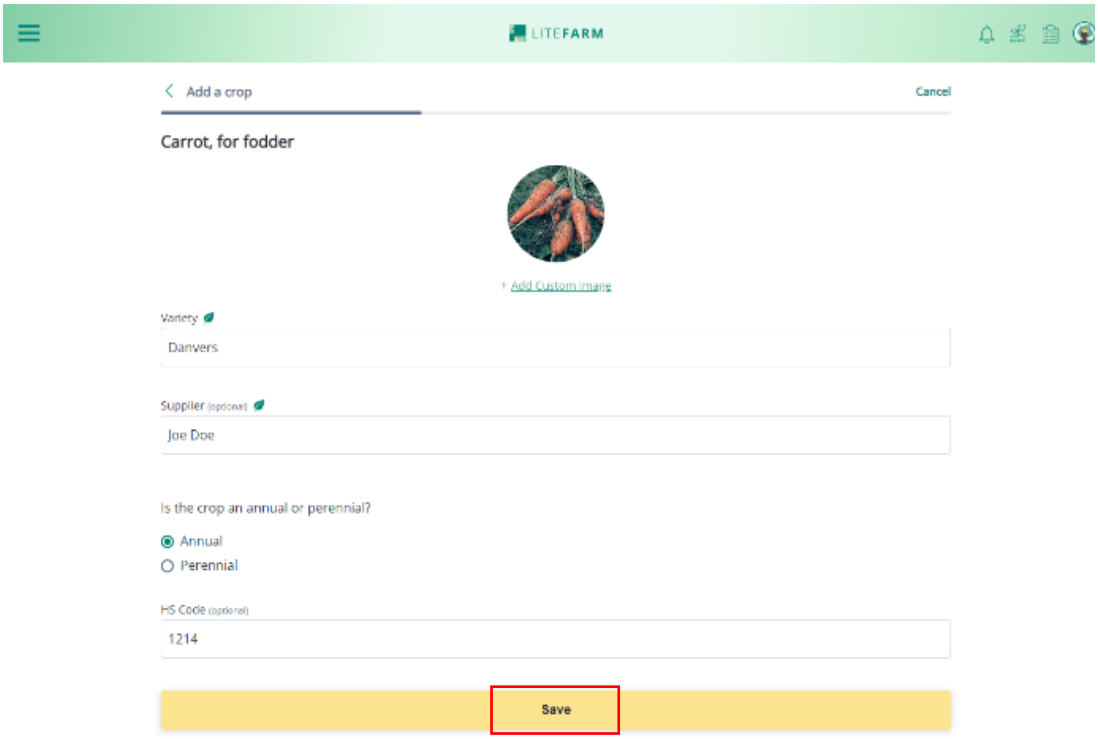




After the user finds and selects the desired crop, the below page is presented asking the user to insert the details of the crop including its variety, its supplier, whether it is an annual or perennial crop and its HS code.



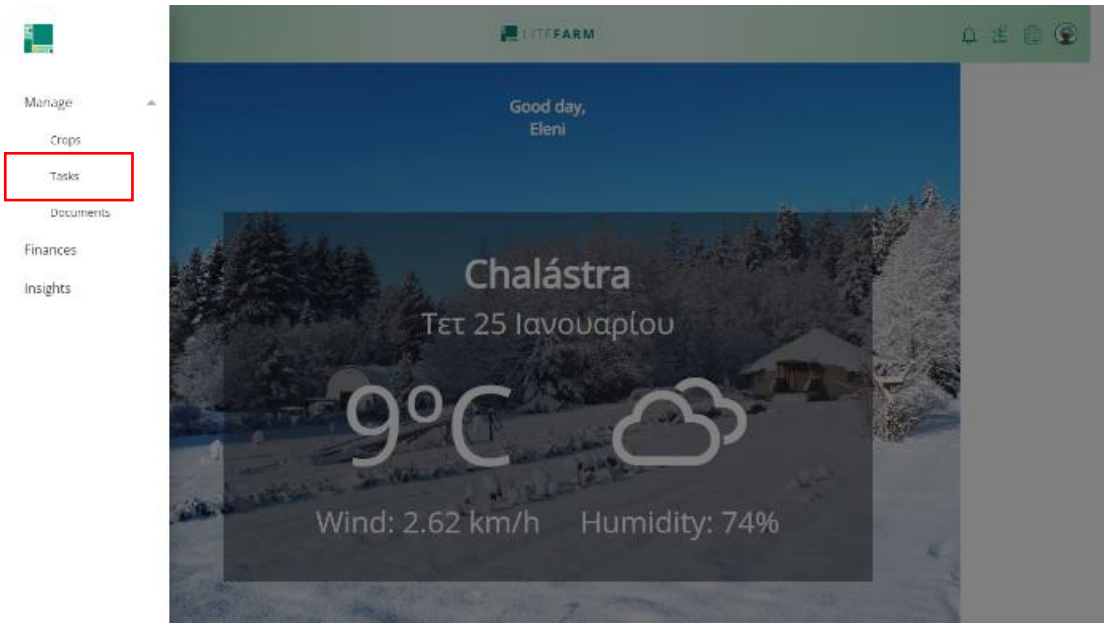
The user provides the crop's details and presses the "Save" button.



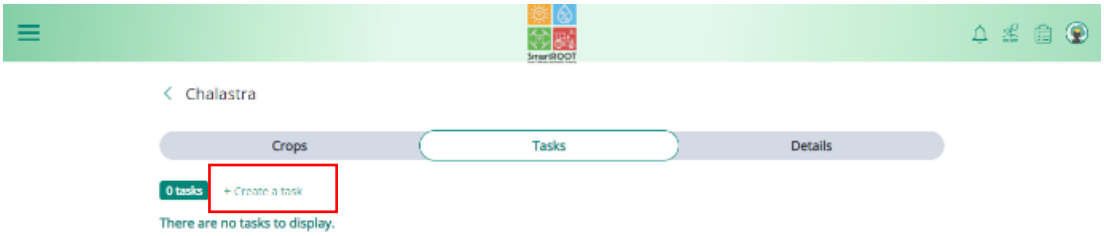
After clicking on the “Save” button, the below page is presented.

4.3.5 Add a task for a crop in a farm

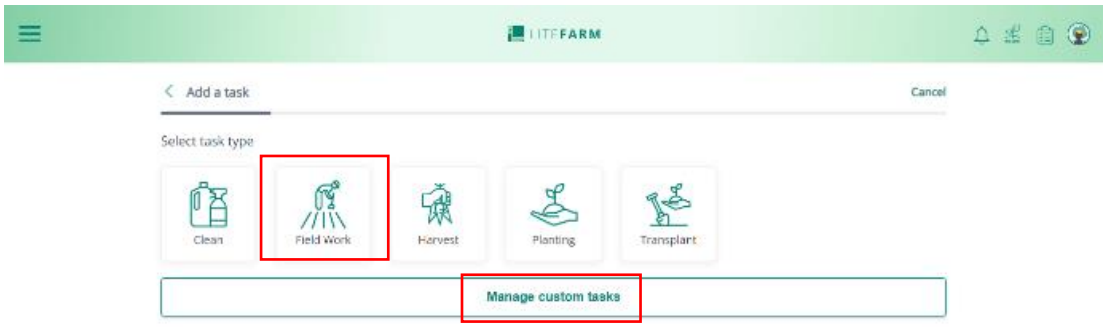
Similar to the addition of a new crop is the addition of a new task. More specifically, this functionality can be accessed through the left side’s menu button and the “Task” option.



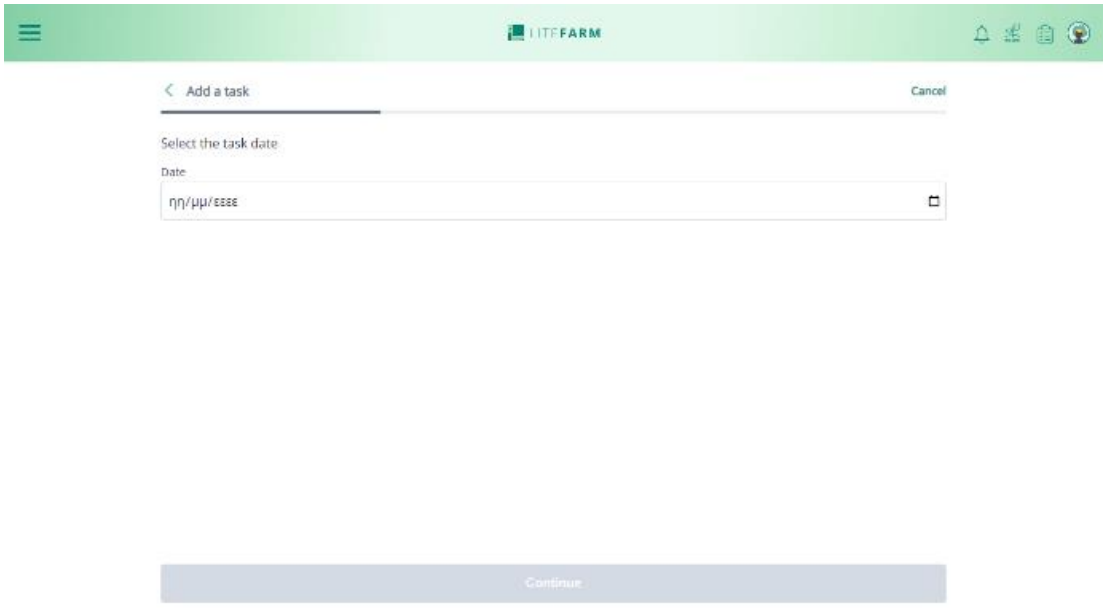
Alternatively, this functionality can be accessed through the “My farm” and the “Farm map” option and then by clicking on the farm’s field and selecting the addition of a task under the “Tasks” tab.



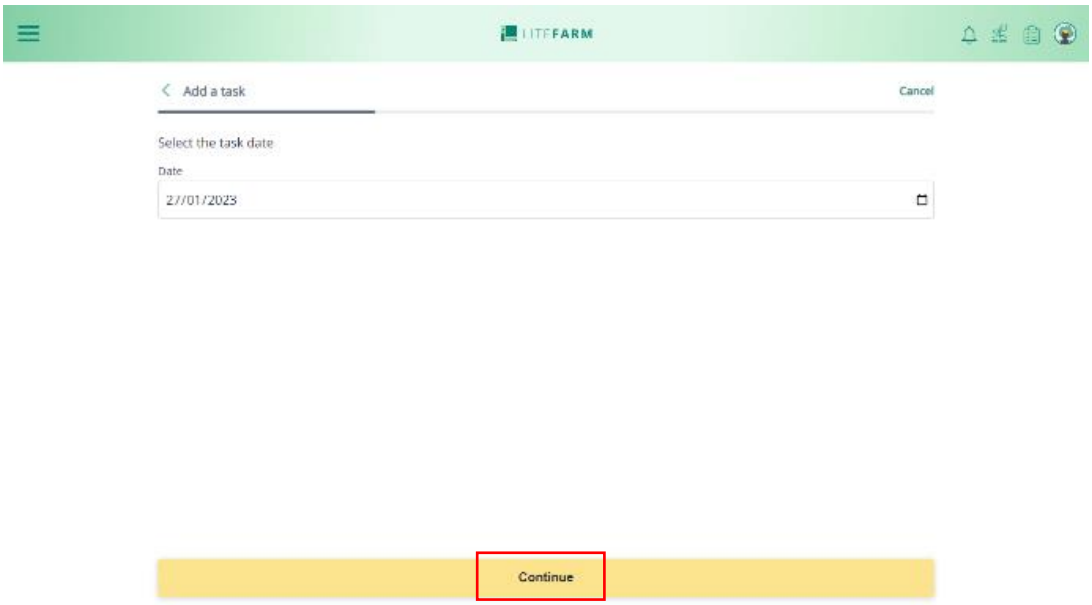
Then, the below page is presented asking the user to select the task type among five available options, including “Clean”, “Field Work”, “Harvest”, “Planting” and “Transplant”. Let assume that the user selects a “Field work” task.



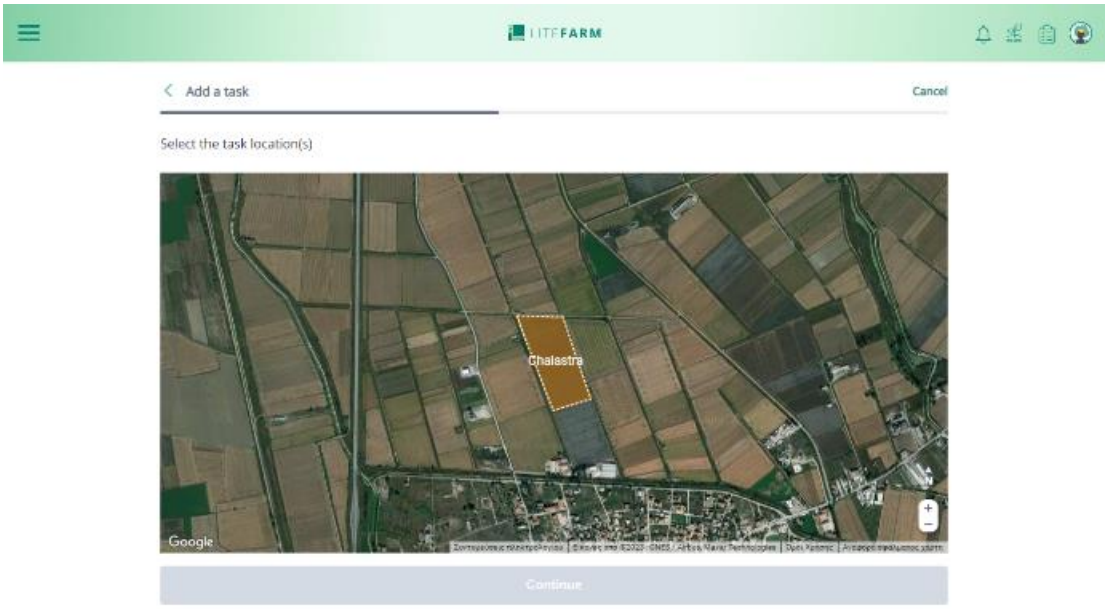
Then, the user is requested to select the task date.



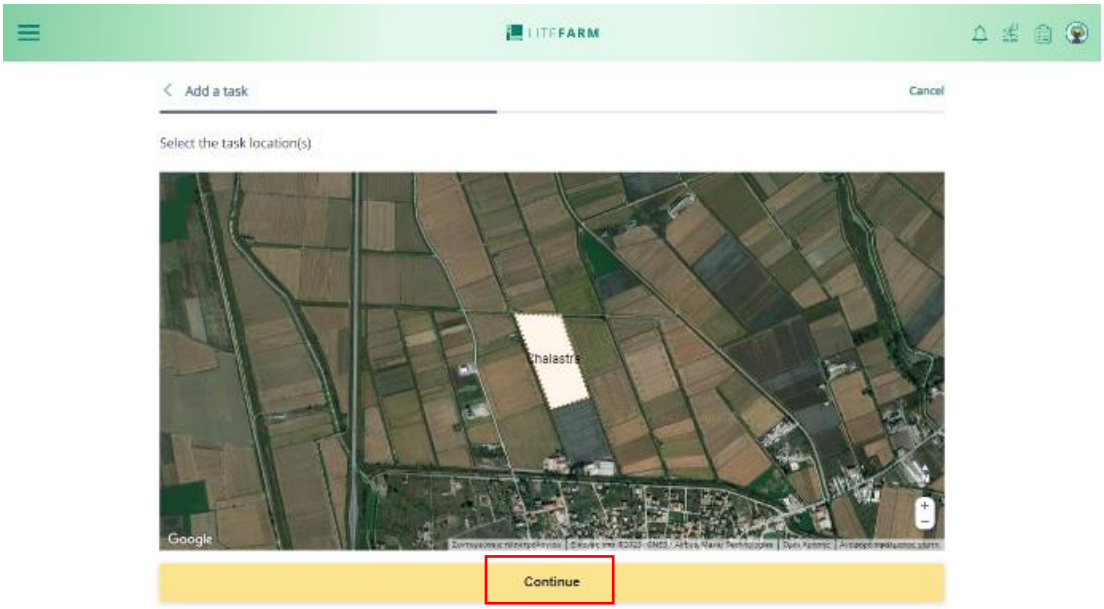
After selecting the date, the user clicks on the “Continue” button.



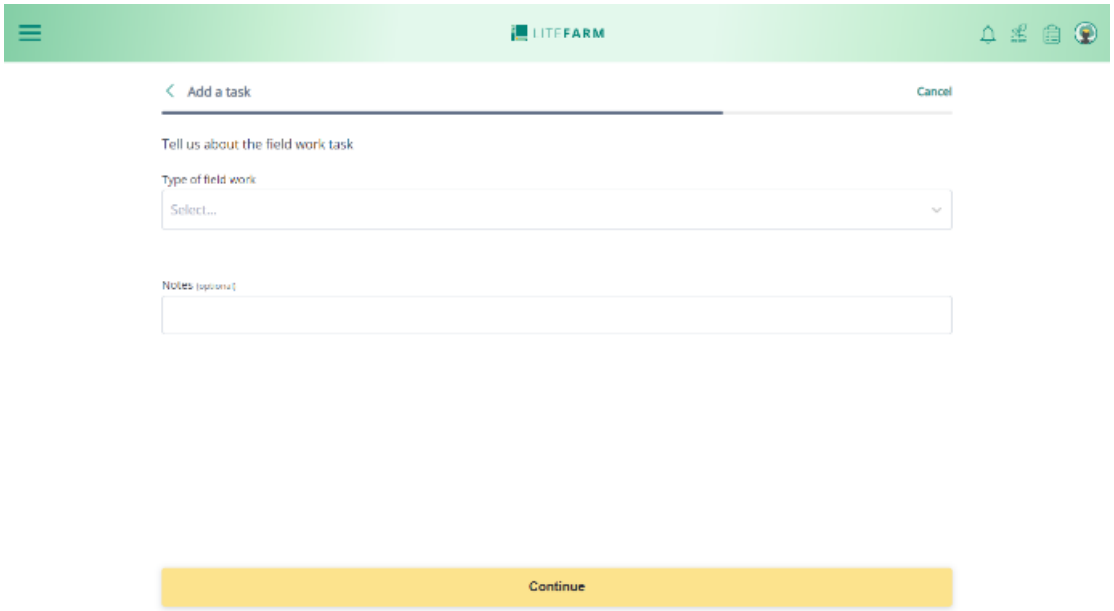
Then, the user is requested to select the task location.



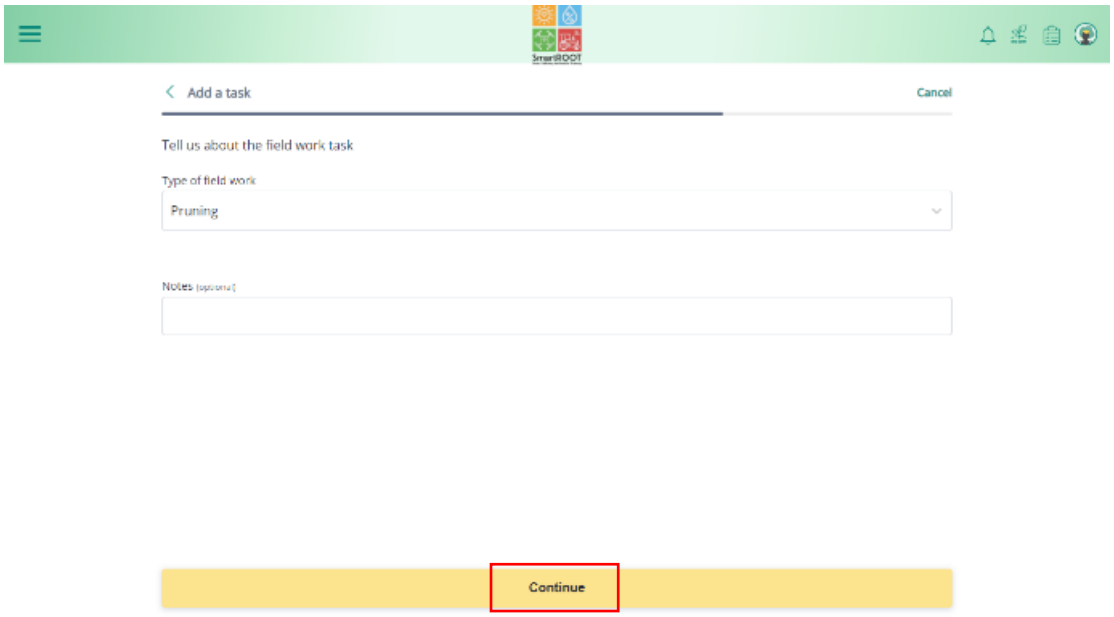
The user checks on the field and presses the “Continue” button”.



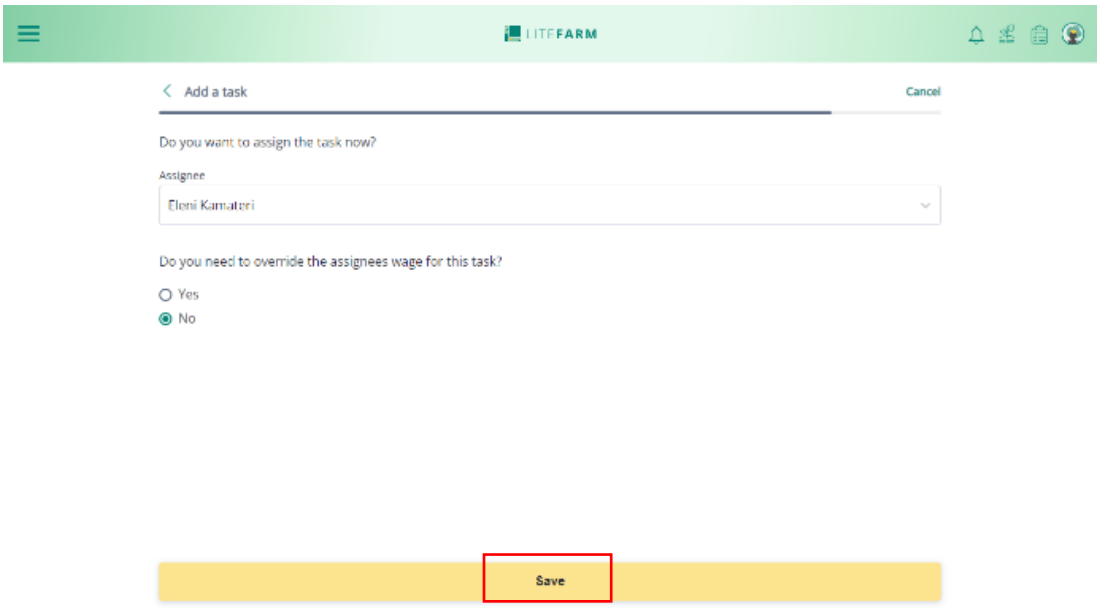
Then, the user is requested to give details about the task, including the type of the field work.



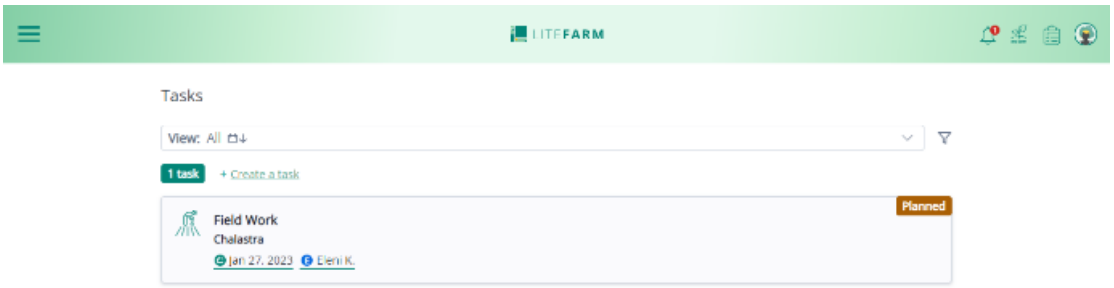
The user selects the pruning type and presses the “Continue” button.



Then, the user is requested to assign the task to an assignee and check whether (or not) to override the assignees wage for this task (whether this task is included or not in the assignee's wage).

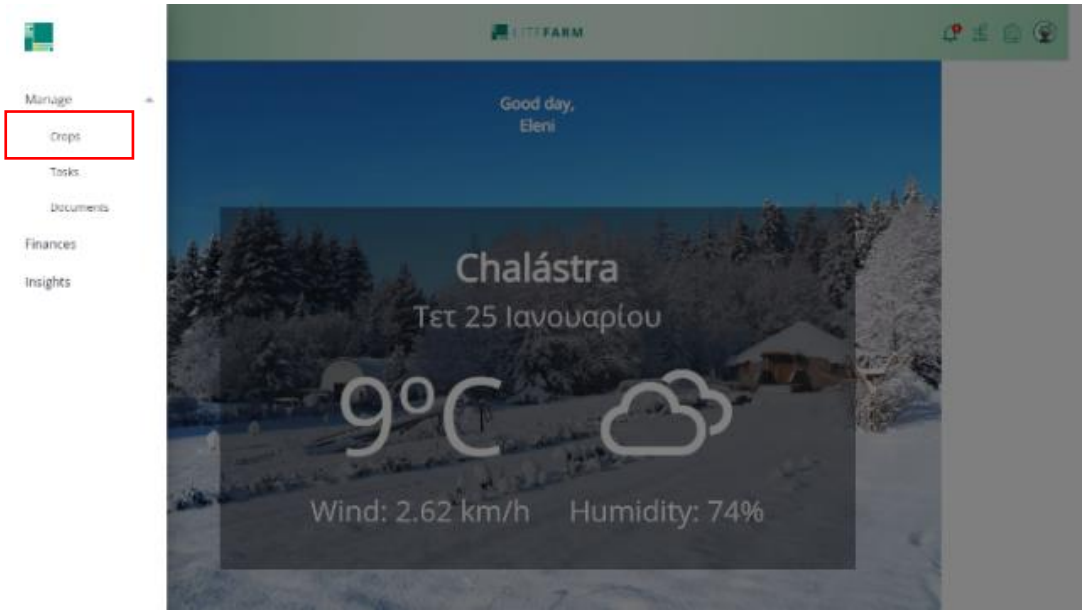


The user selects the assignee and the override option, presses the "Save" button and the below page is presented.

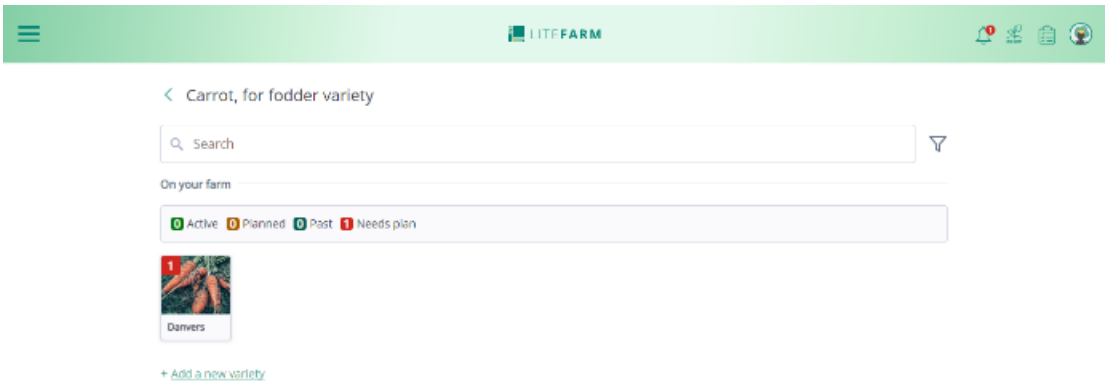


4.3.6 Add a crop plan

A functionality provided by the tool after the addition of a new crop is the addition of a crop plan. Let consider that the user has entered the Chalastra's farm. Then, the user clicks on the left side's menu button and selects the "Crop" option from the drop-down list.

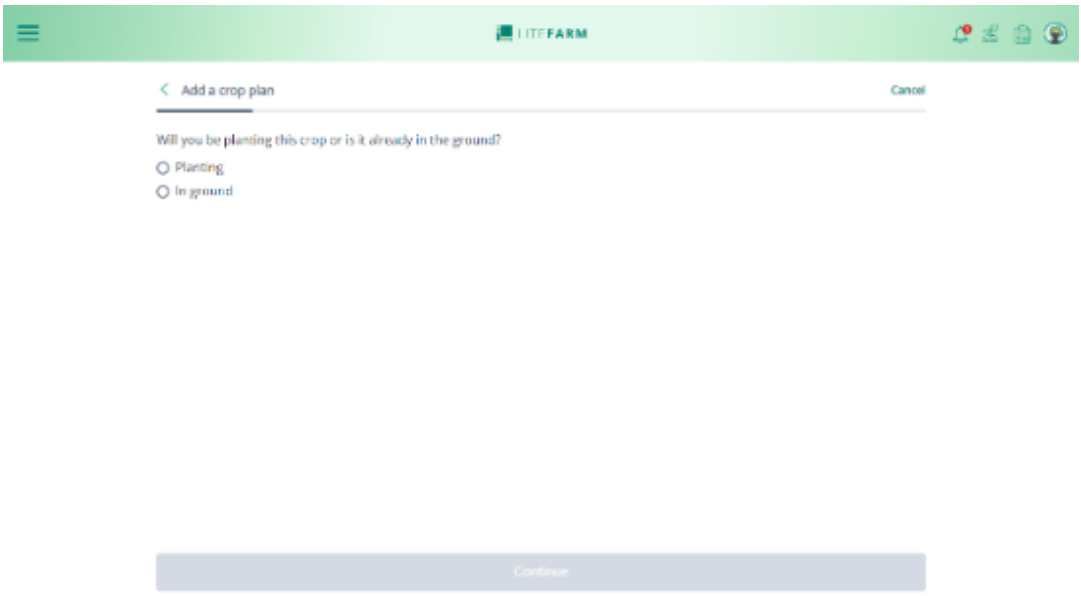


Then, the user is requested to select a crop on his/her farm.

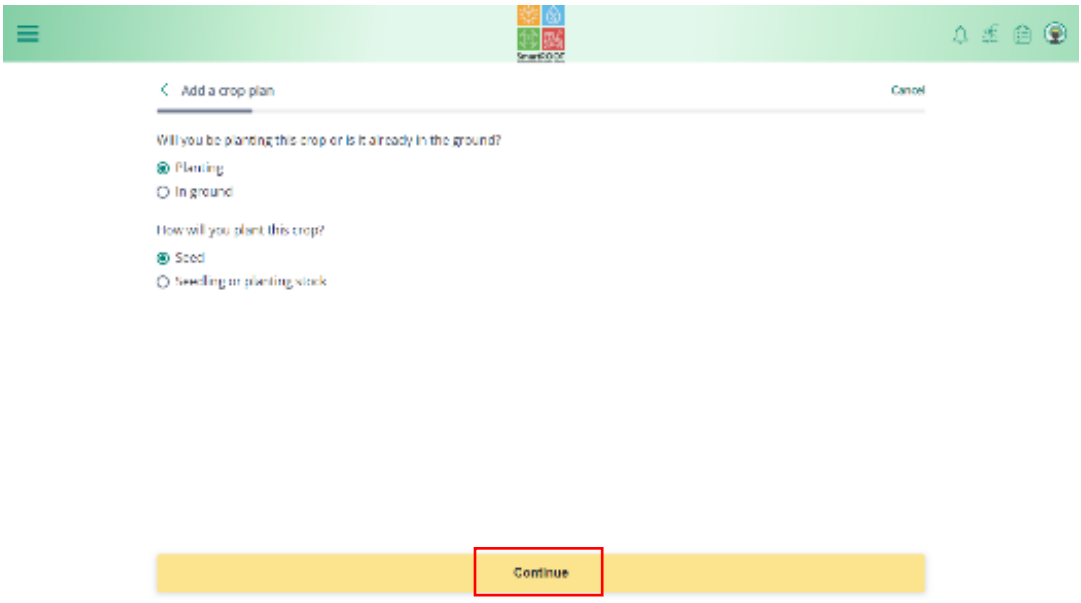


Let assume that the user selects the “Carrot” crop. Then, the below page is presented providing the user two options, the management option and the details preview option. By clicking on the “Management” tab and then on the addition of a crop plan, the user is able to define a crop plan for the selected crop.

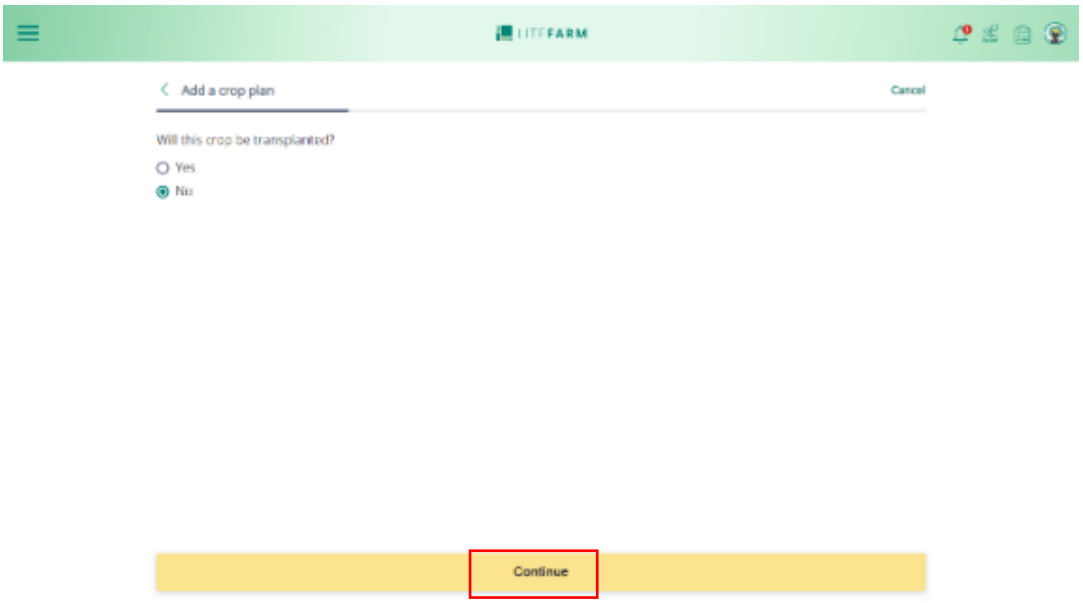
Then, the user is requested whether the crop will be planted or is already in the ground.



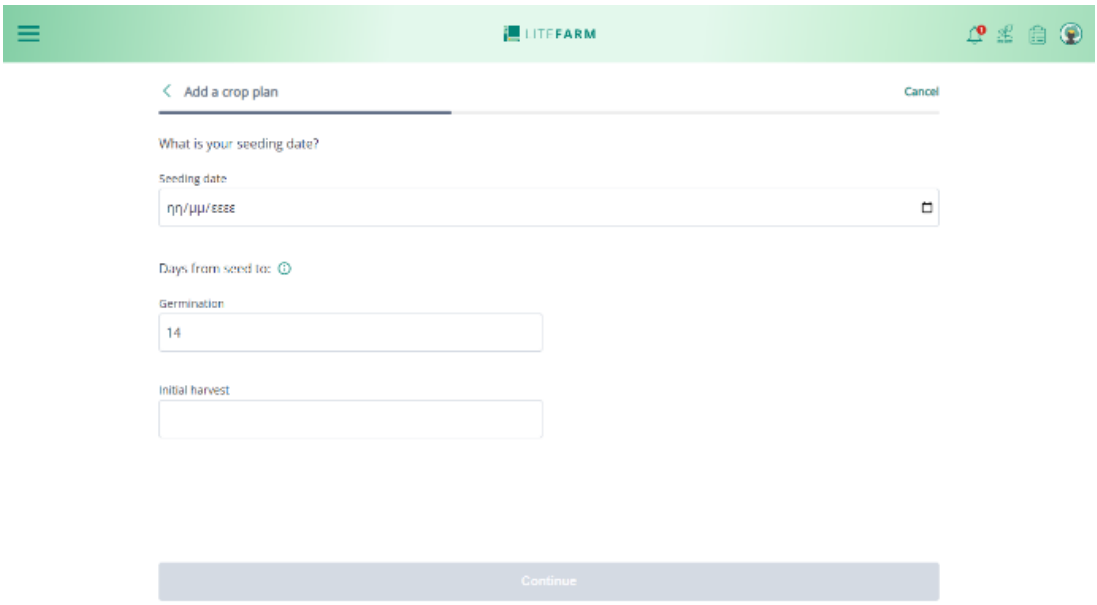
Let assume that the user selects the planting. Then, the user is requested how he/she plans to plant this crop. The user selects the seed answer and presses the “Continue” button.



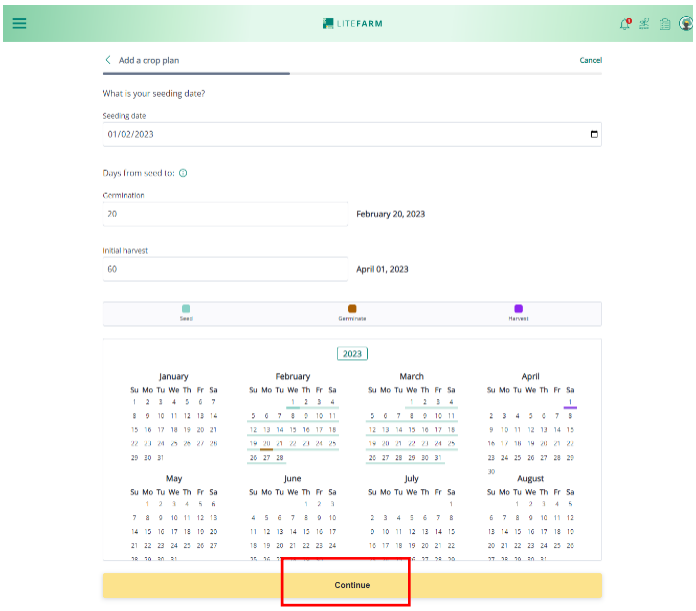
Then, the user is requested whether (or not) this crop will be transplanted. The user selects the “No” answer and presses the “Continue” button.



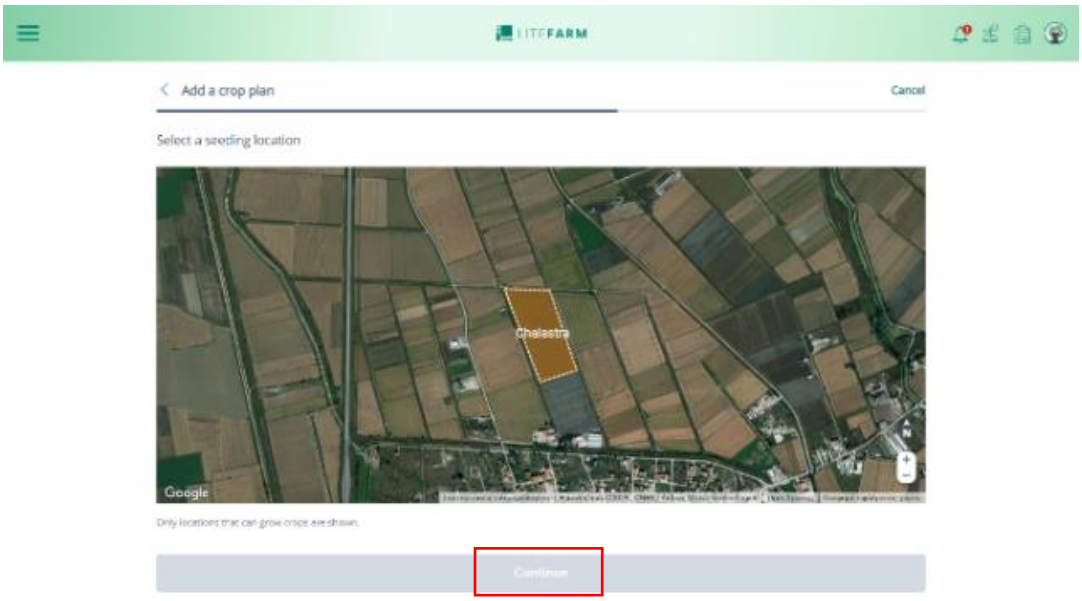
Then, the user is requested to define the seeding date, the days from seed to germination and the days from seed to initial harvest.



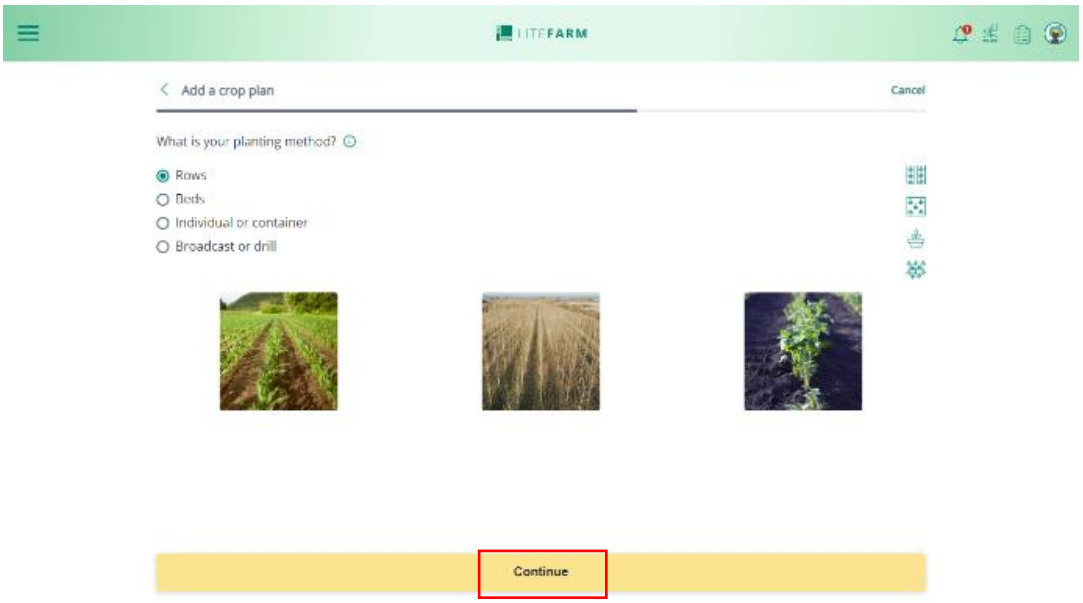
The user provides the requested details and presses the “Continue” button.



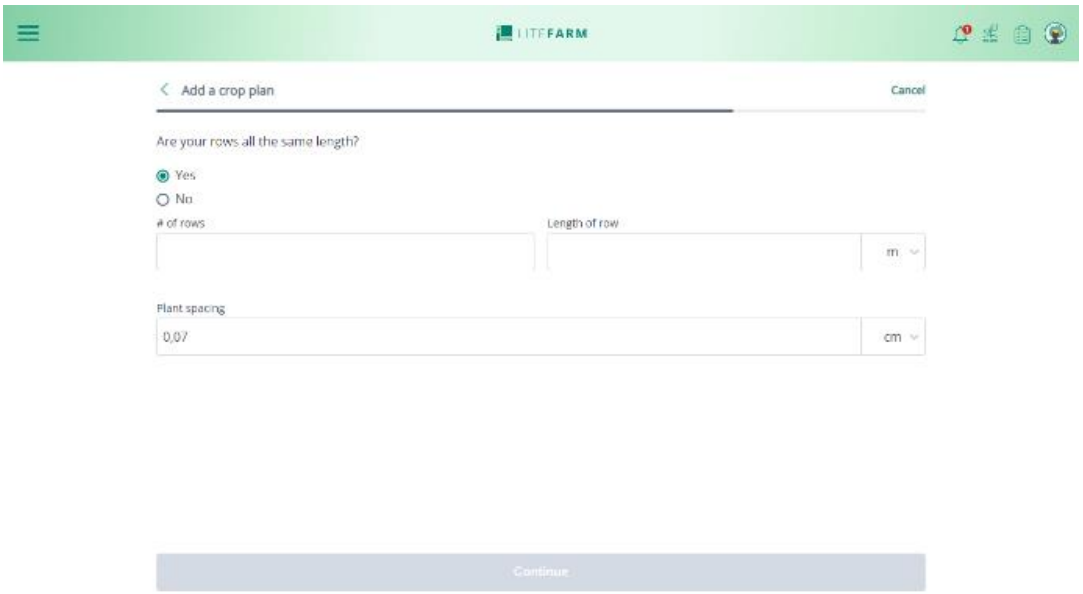
Then, the user is requested to select the seeding location. The user selects the seeding location and presses the “Continue” button.



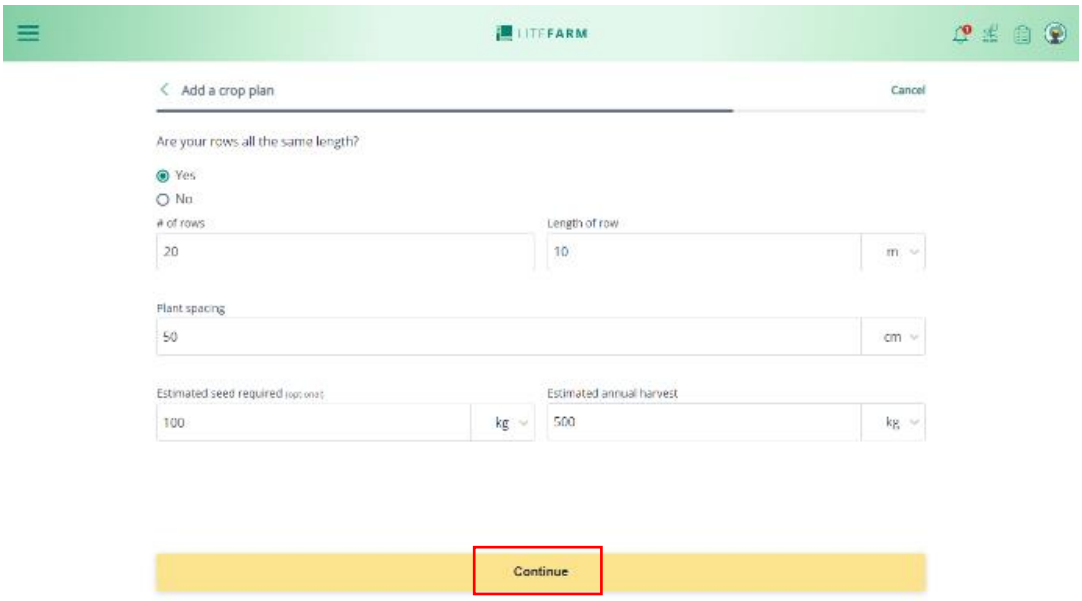
Then, the user is requested to select the seeding method. The user selects the “Rows” answer and presses the “Continue” button.



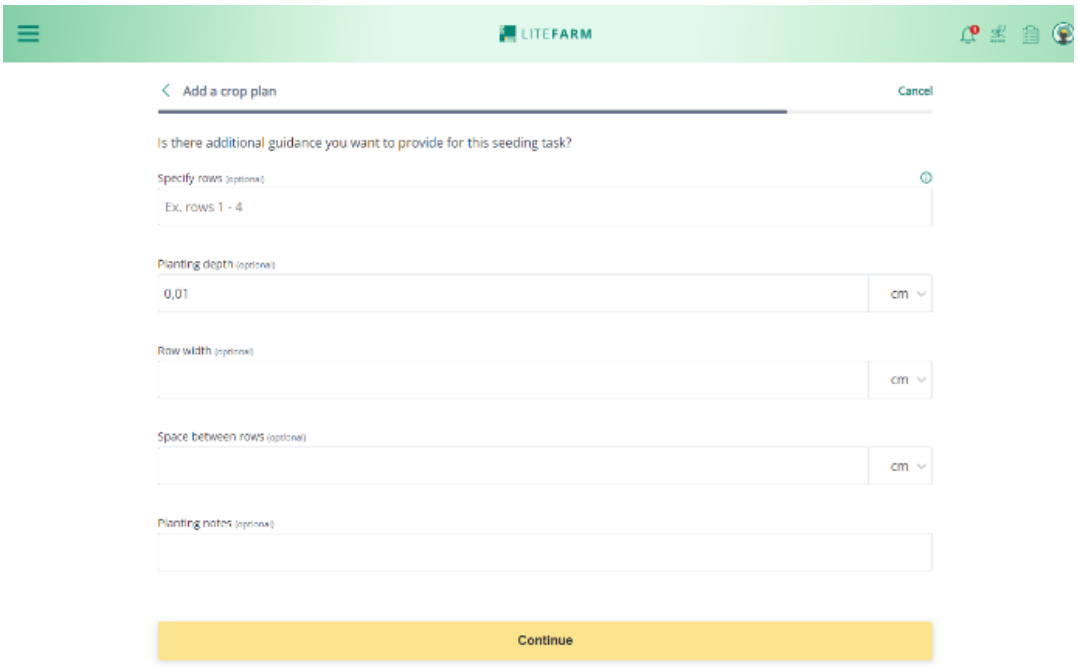
Then, the user is requested to provide some details about the seeding method, which is the “Rows”.



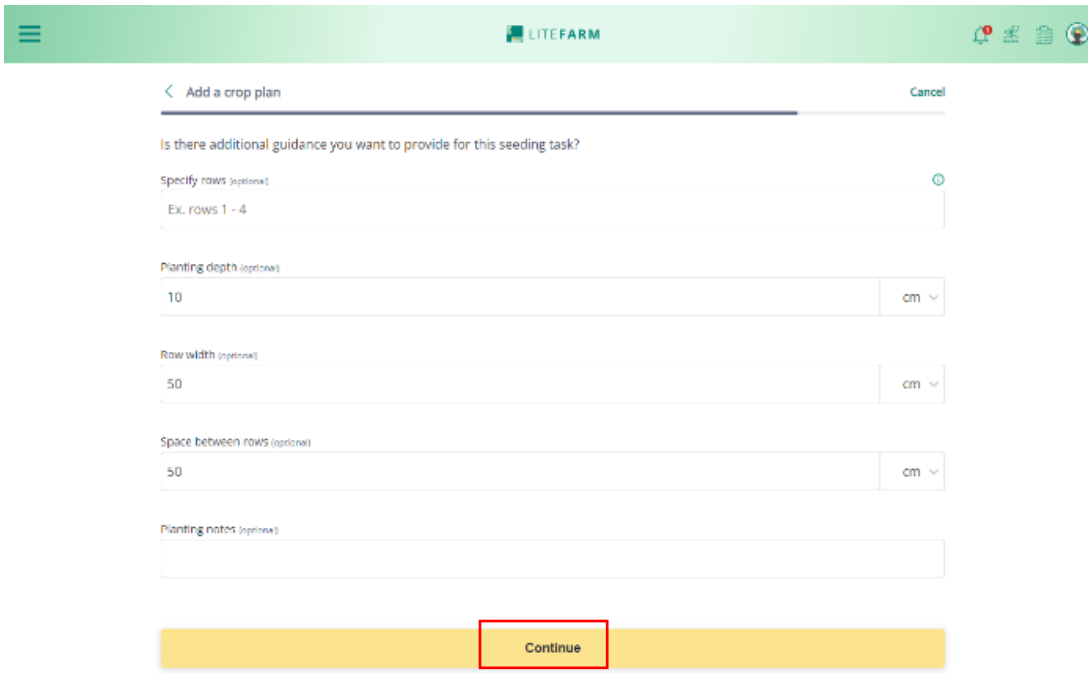
The user provides the seeding method’s details and presses the “Continue” button.



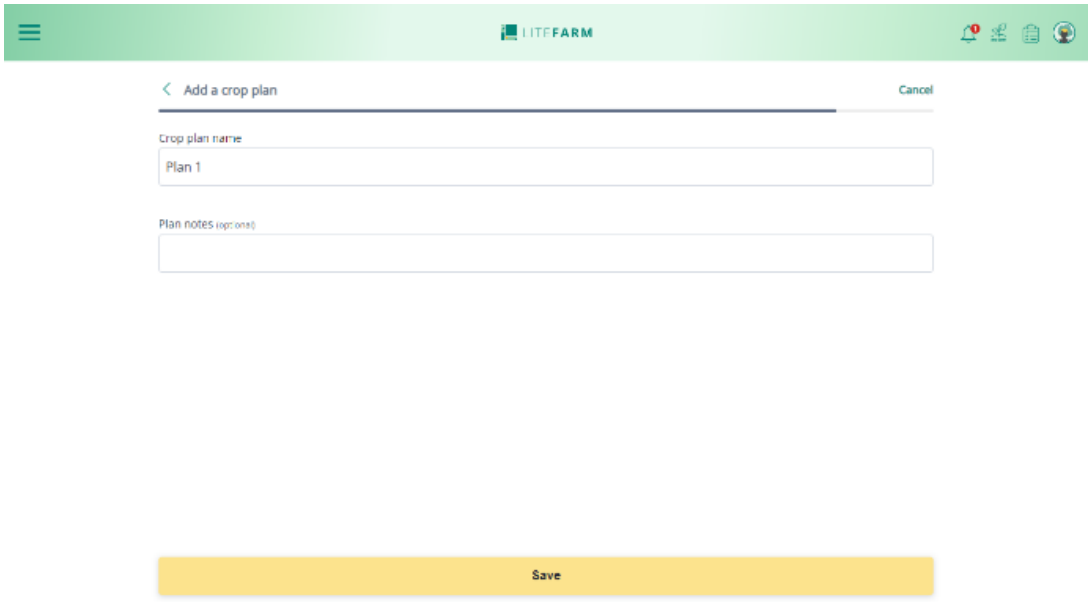
Then, the user is requested whether (or not) he/she wants to provide additional guidance for this seeding task.



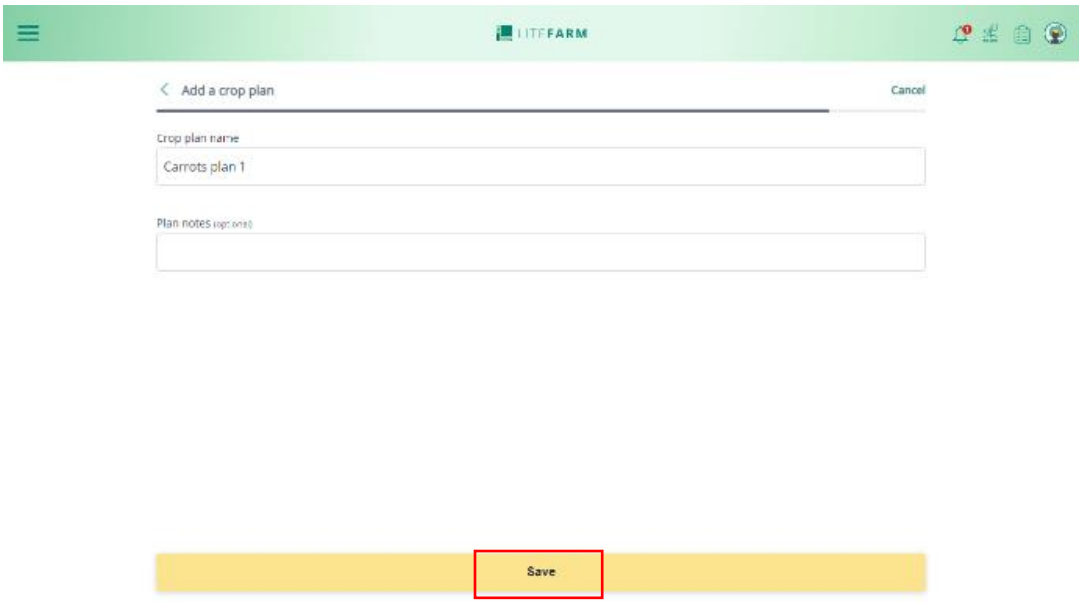
The user provides the additional guidance details and presses the “Continue” button.



Finally, the user is requested to provide a name for the crop plan.

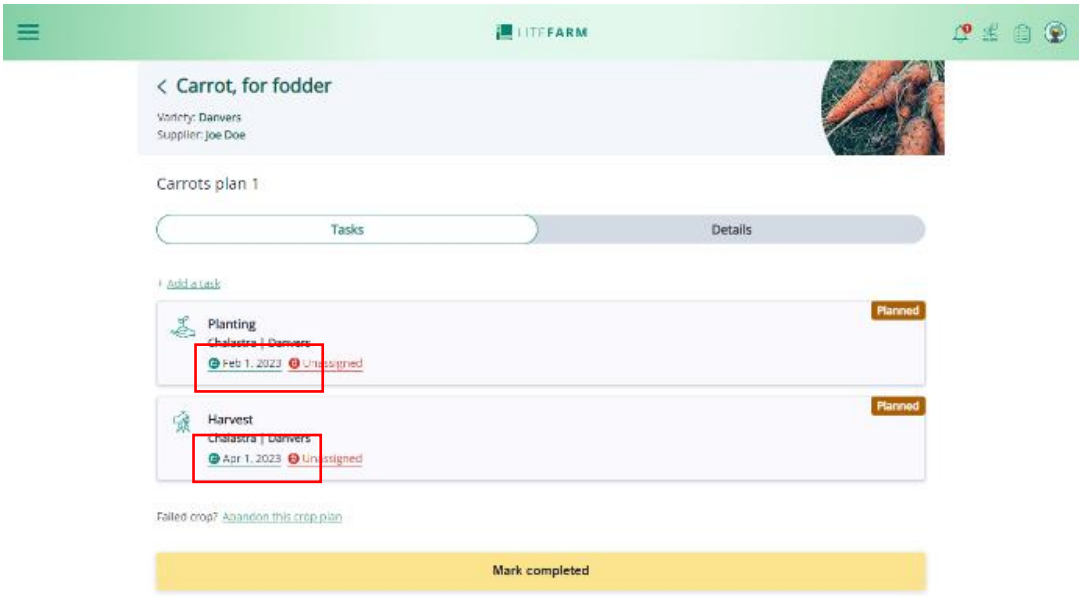


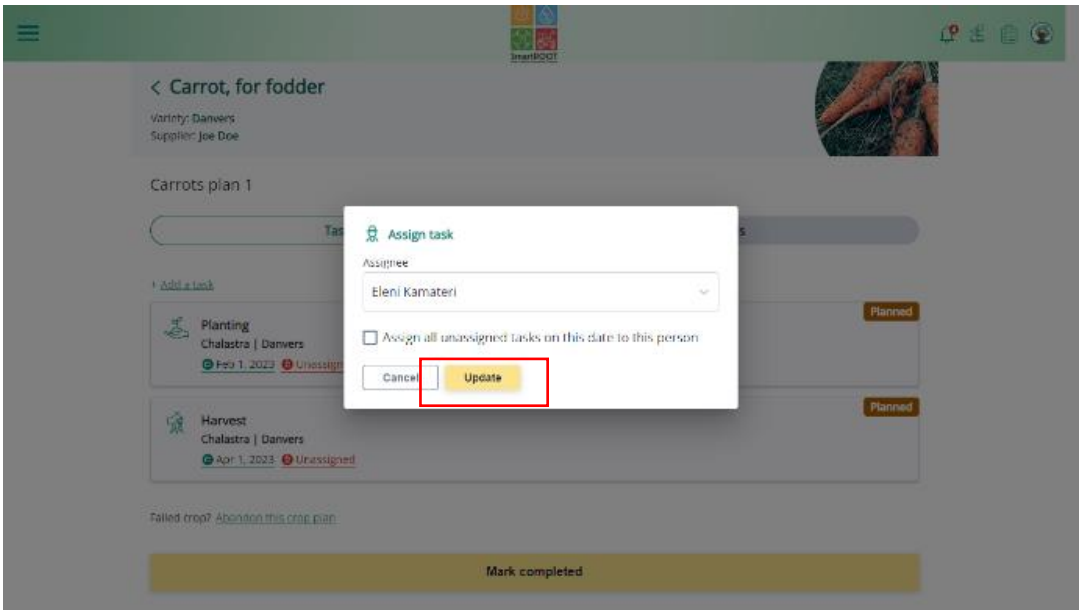
The user provides the name of the crop plan and presses the “Save” button.



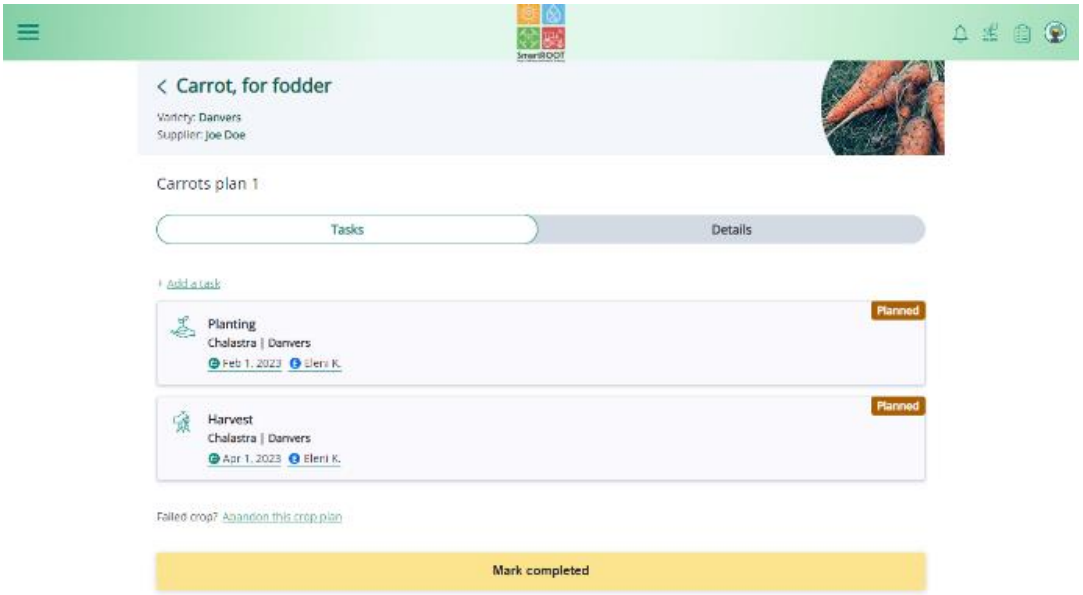
After clicking on the “Save” button, the below page is presented.

As we can see, two tasks have been created, including a planting and a harvesting task. Both of them are unassigned. The user can click on the red link of “unassigned” and assign each task to a person. In our case, the only available person is one. So, we assign both tasks to this person.



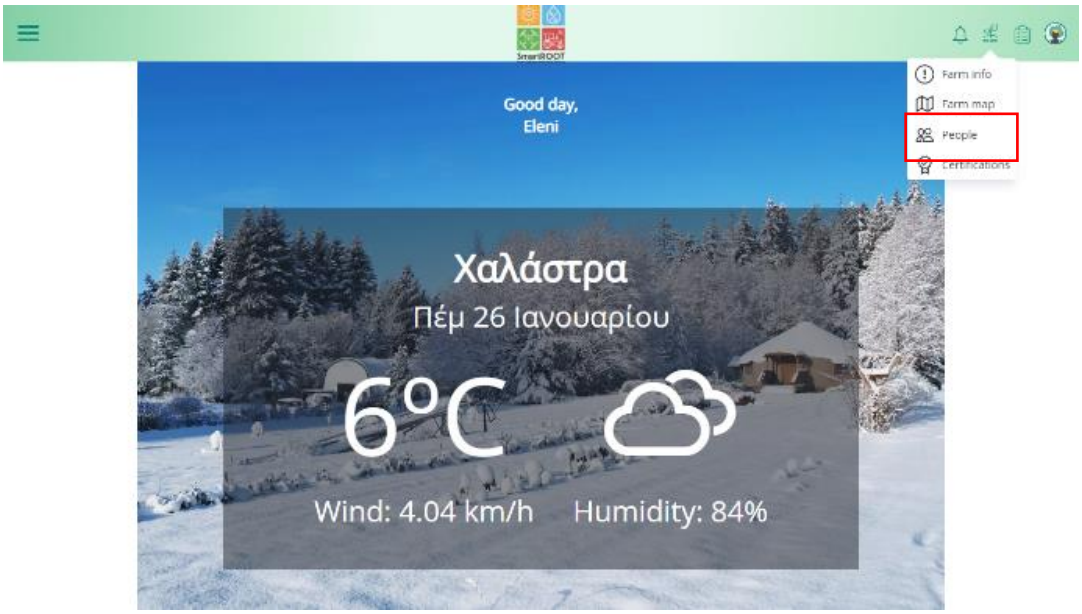


After finishing the assigning process, the below page is presented.

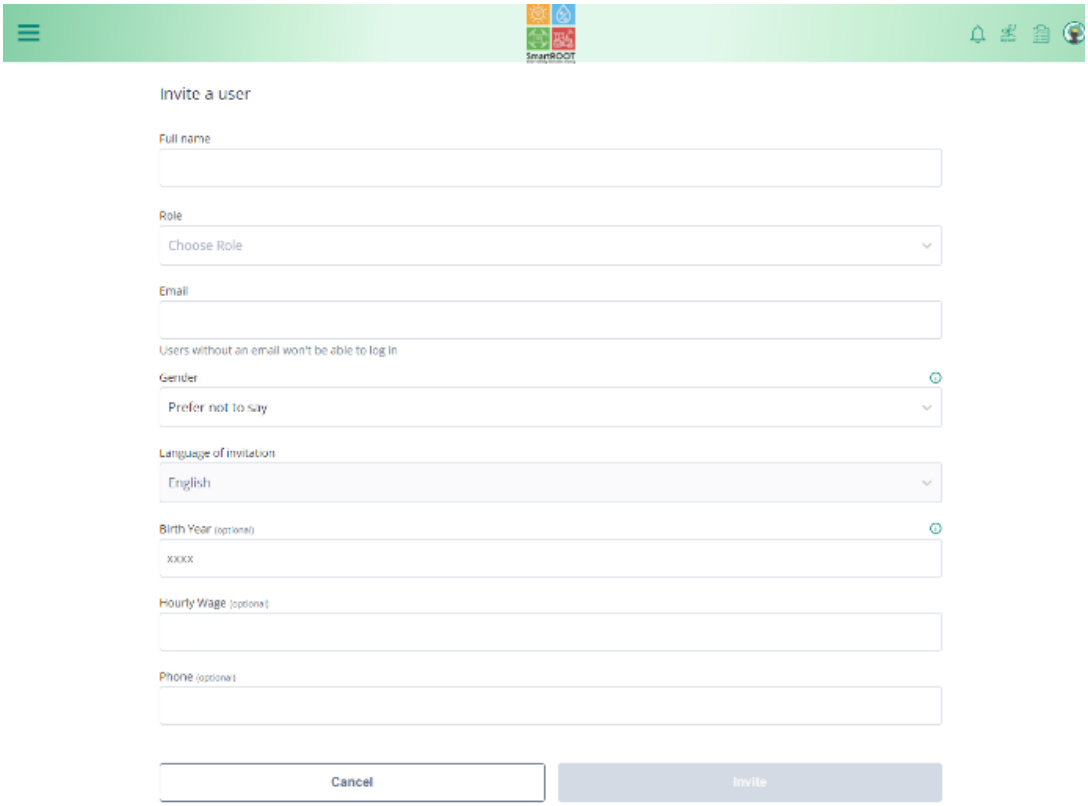


4.3.7 Add a person

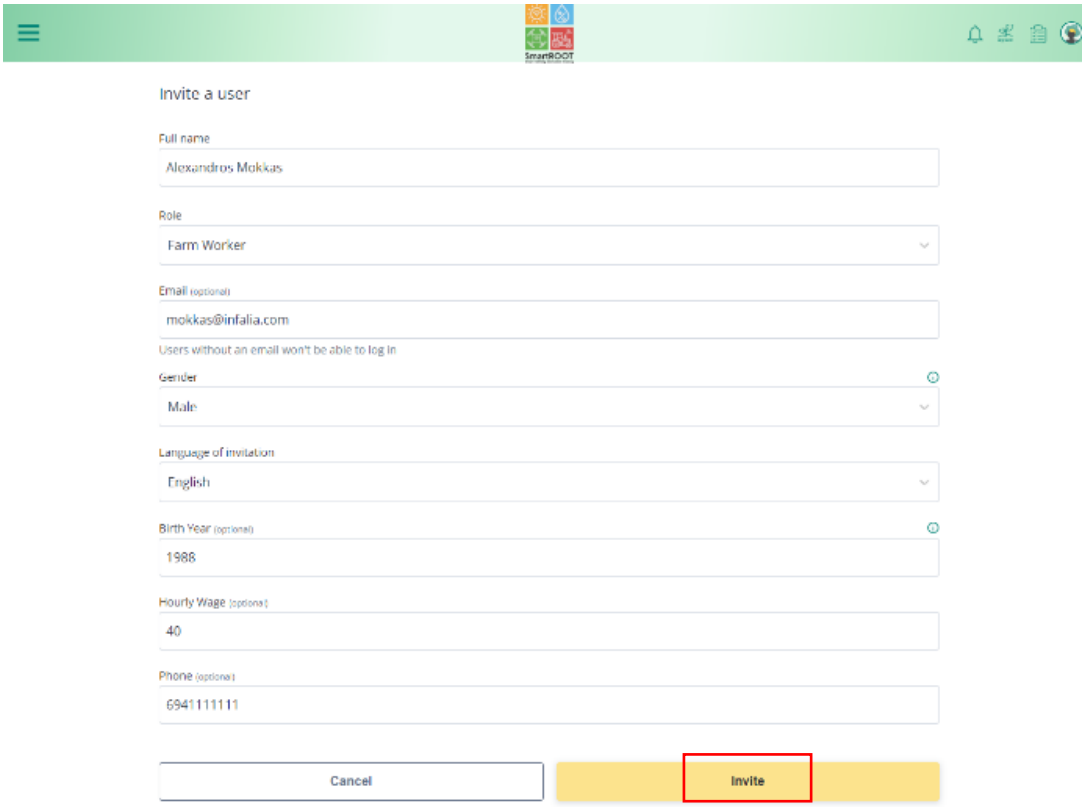
Another functionality provided by the tool is the addition of new persons associated with the farm. This functionality is available through the “My farm” button and the “People” option.



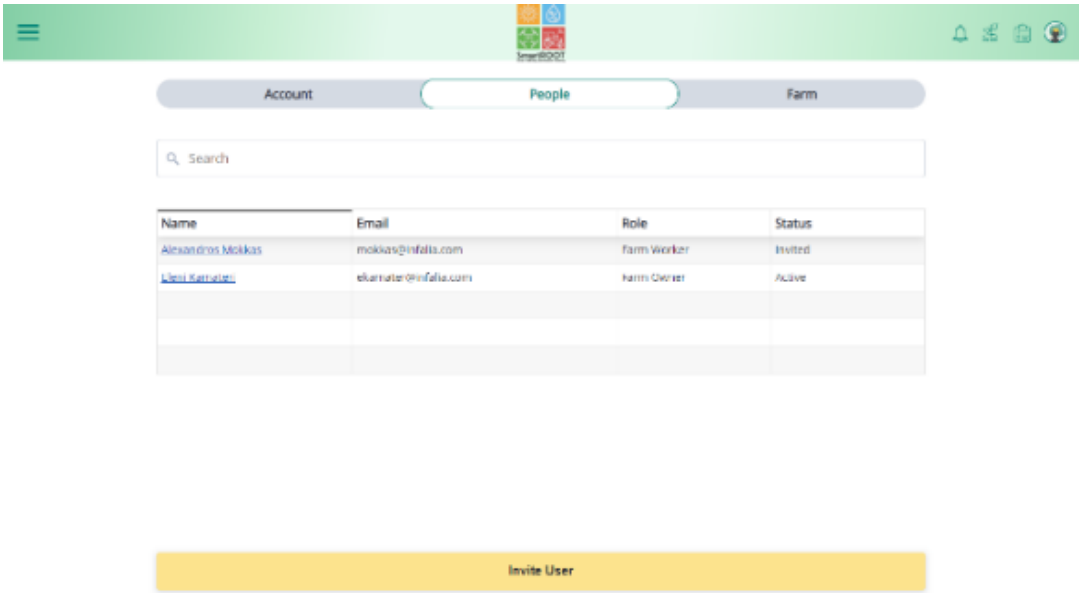
After clicking on the "People" option, the below page is presented asking the user to provide the details of a person and invite him/her. Among the details that need to be defined is the person's role. Four options are available: Farm Owner, Farm Manager, Farm Worker and Extension Officer.



The user provides these details for the new person and presses on the “Invite” button.

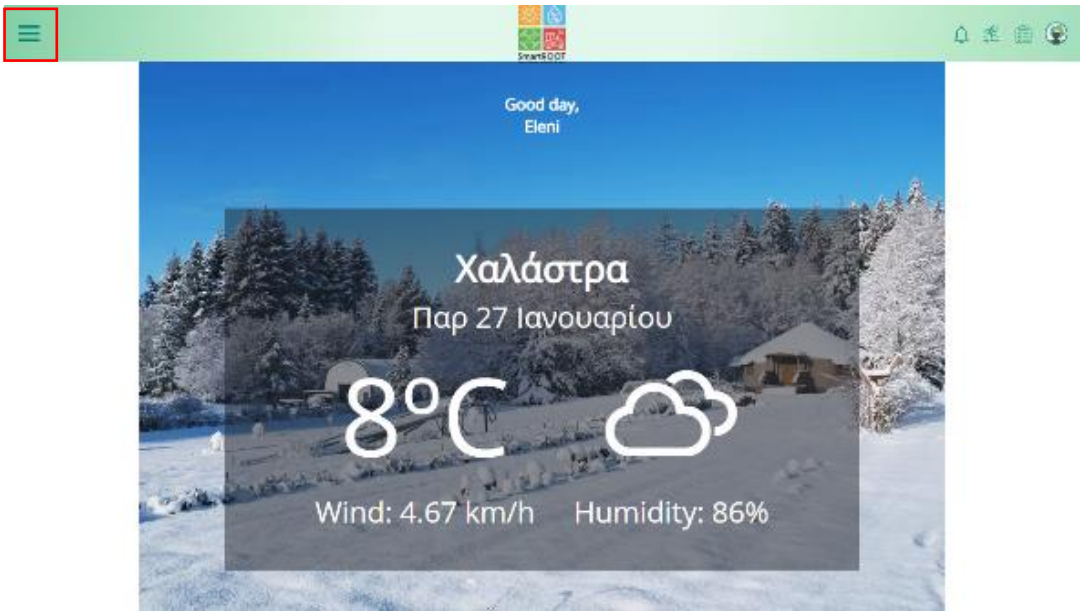


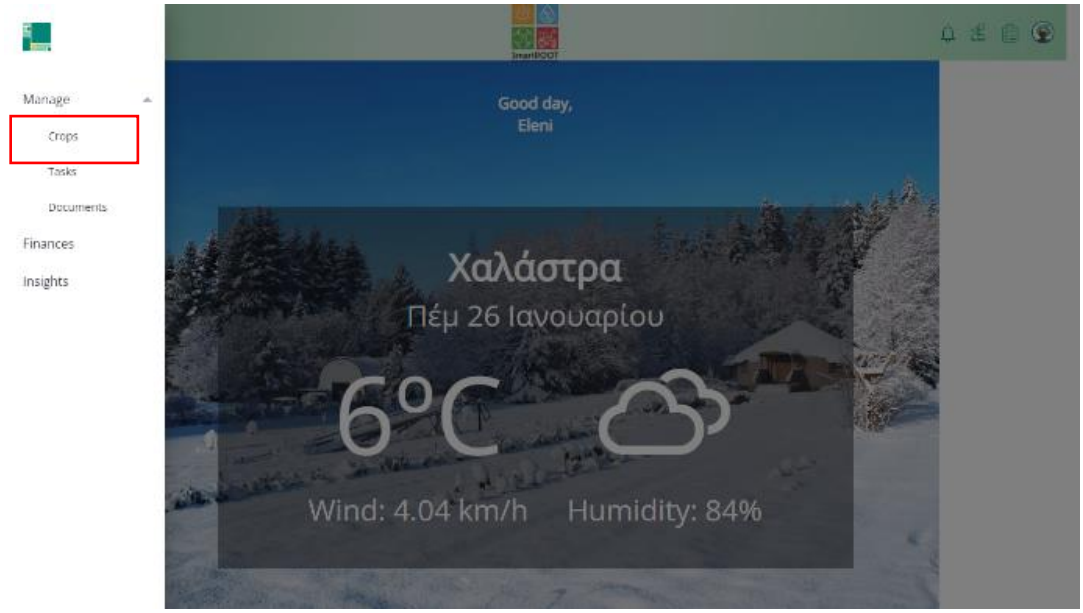
After clicking on the “Invite” button, the below page is presented.



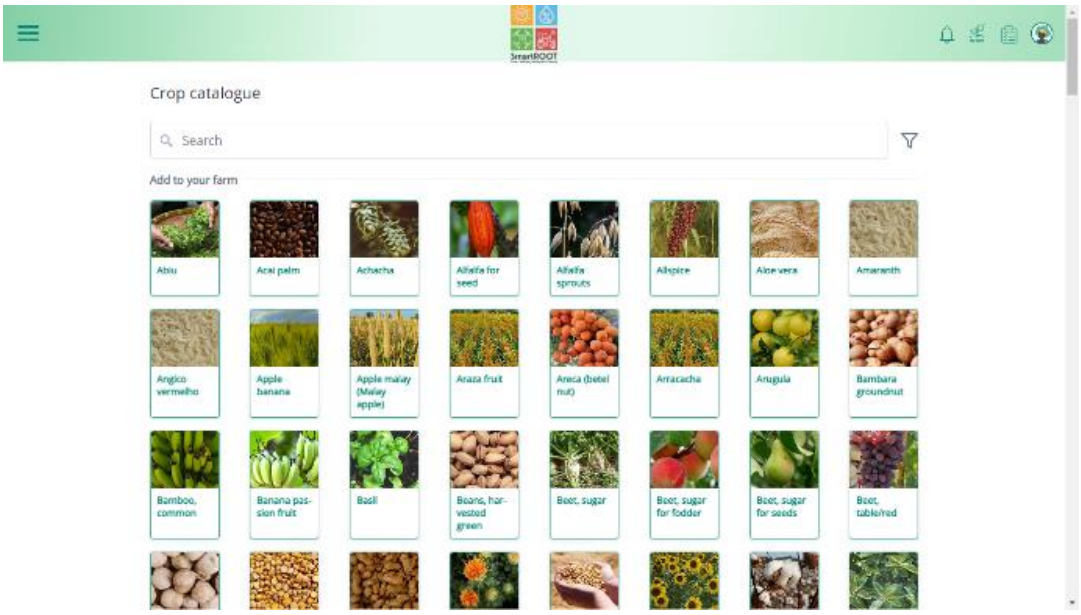
4.3.8 Add a new crop or a new crop variety

Another functionality provided by the tool regarding the crops is the addition of a new crop or a new crop variety. Let consider that the user has entered the Chalastra's farm and the below page has been showed. Then, the user clicks on the left side's menu button and selects the "Crop" option from the drop-down list.

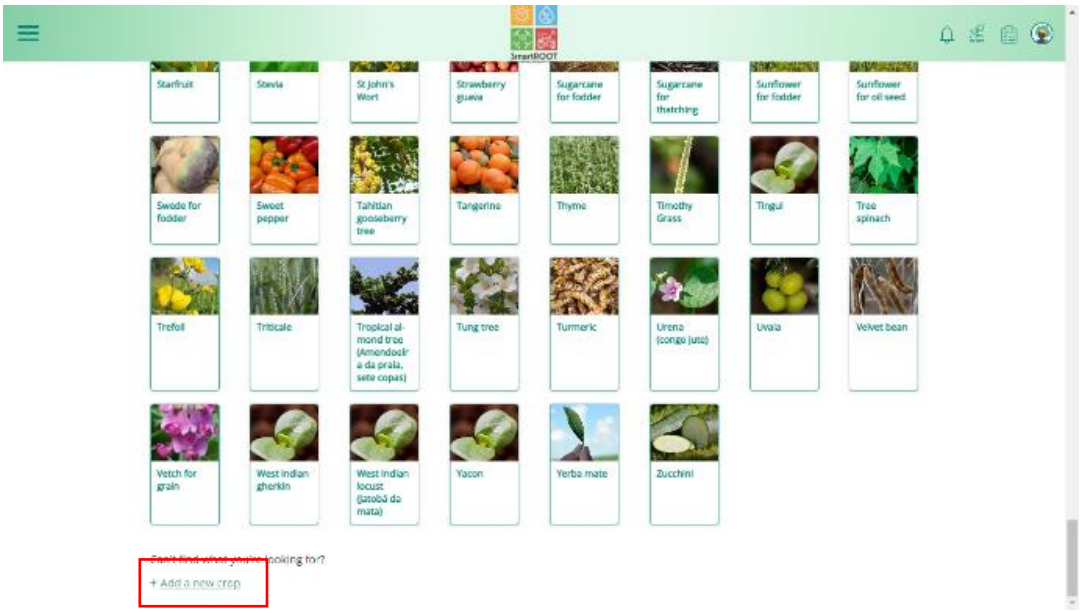




Then, the below page is presented where the user can scroll down the big list of crops and select a crop to add to his/her farm.

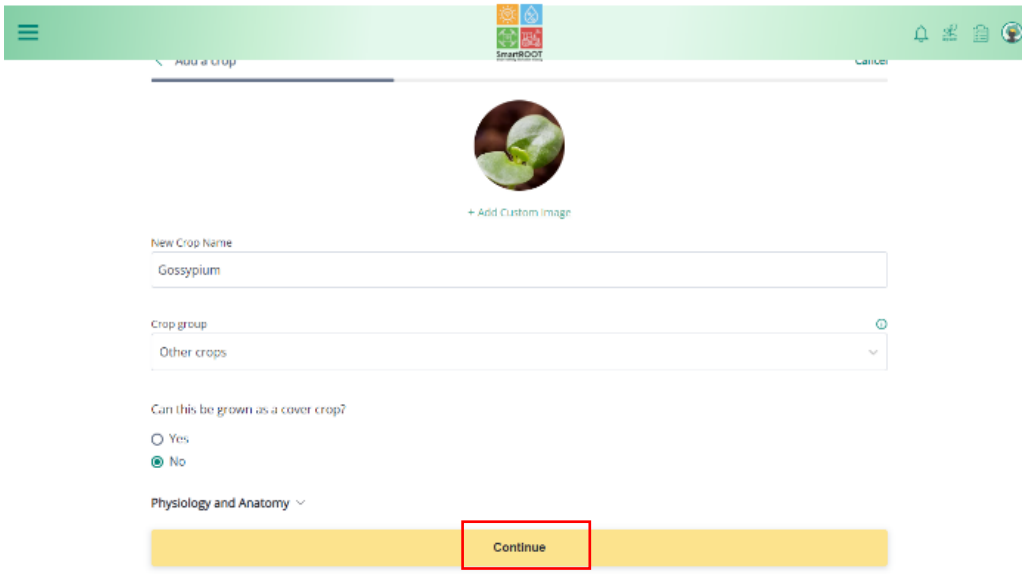


At the bottom of the previous page, the user can find the option to add a new crop.

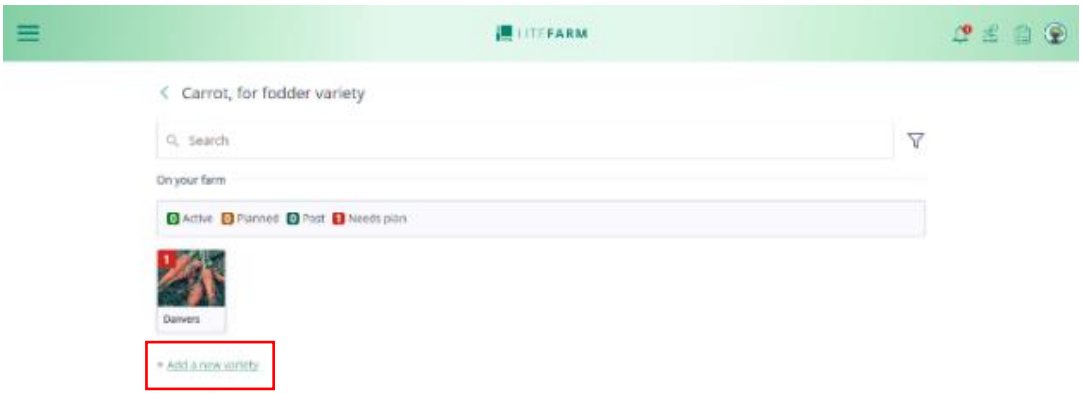


When clicking on the “Add a new crop” option, the below page is presented asking the user to provide the new crop’s details, such as its name, its group, whether or not it can be grown as a cover crop, and other physiology and anatomy details about this new crop.

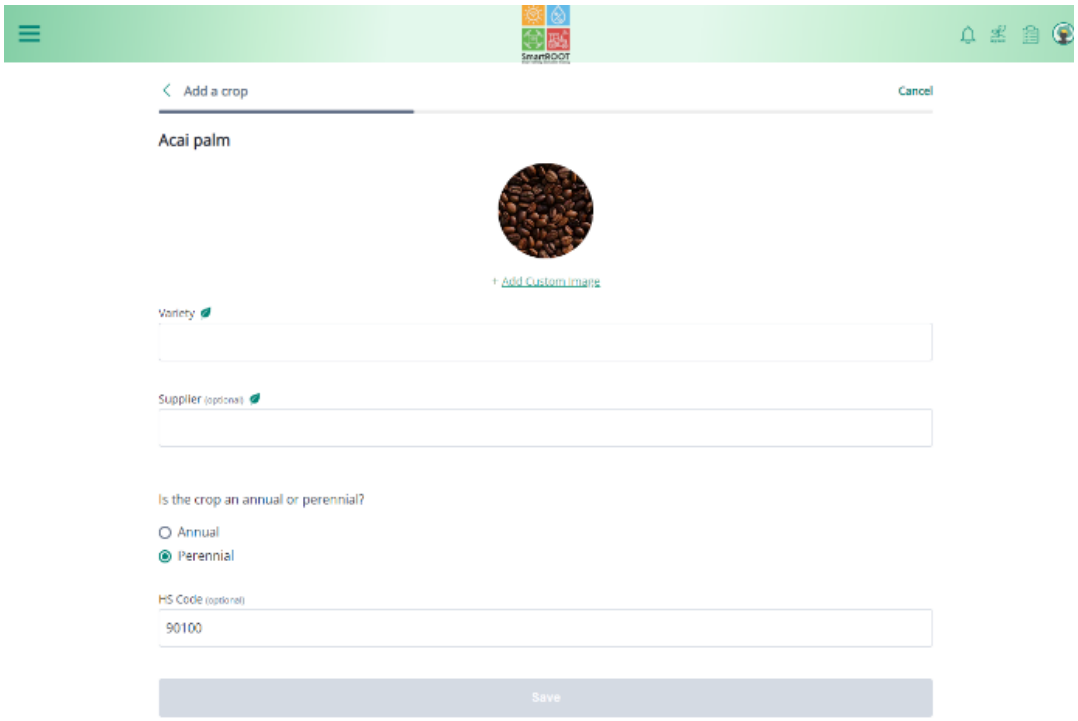
The user provides the details of the new crop and presses the “Continue” button.



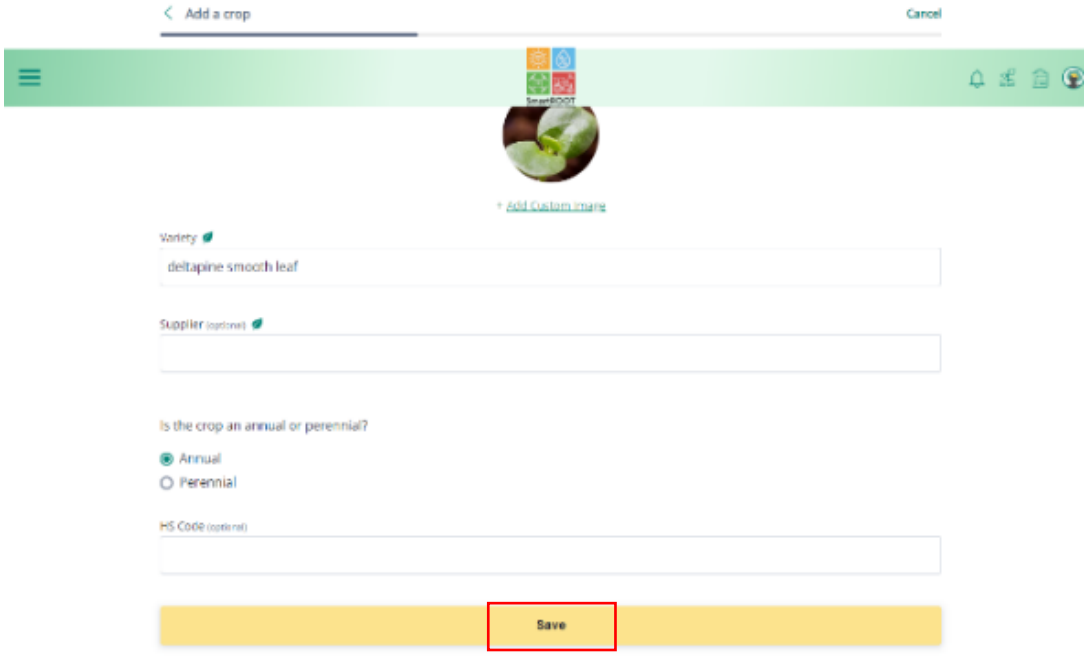
Then, the below page is presented where the user can further add a new crop variety.



The user clicks on the “Add a new variety” option and the below page is presented asking the user to define the crop variety’s name, the supplier, whether the crop is annual or perennial, and its code.



The user provides the requested details about the specific variety of the crop and presses the “Save” button.

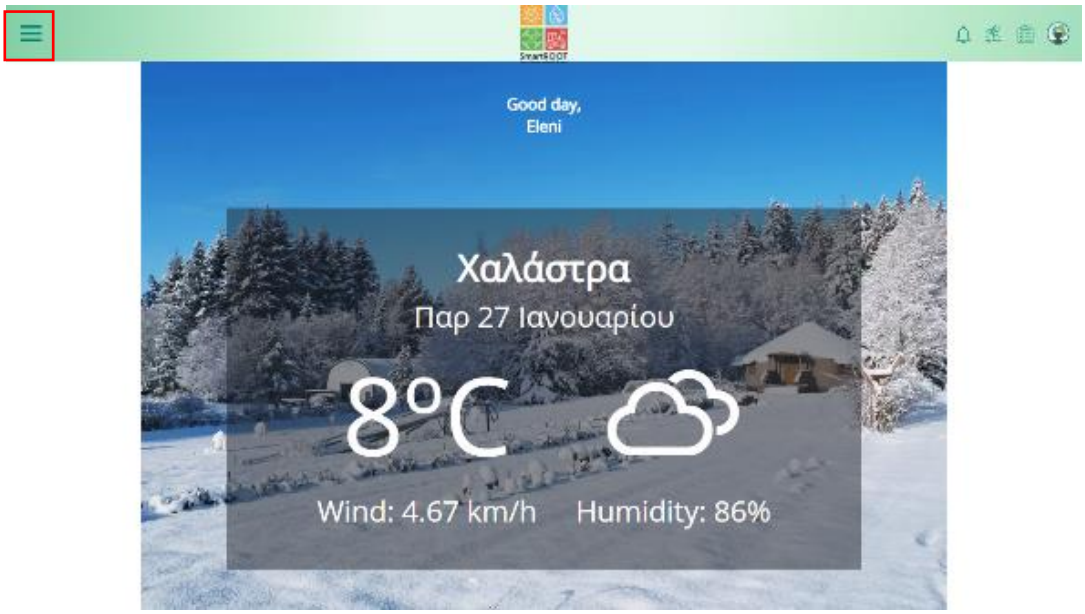


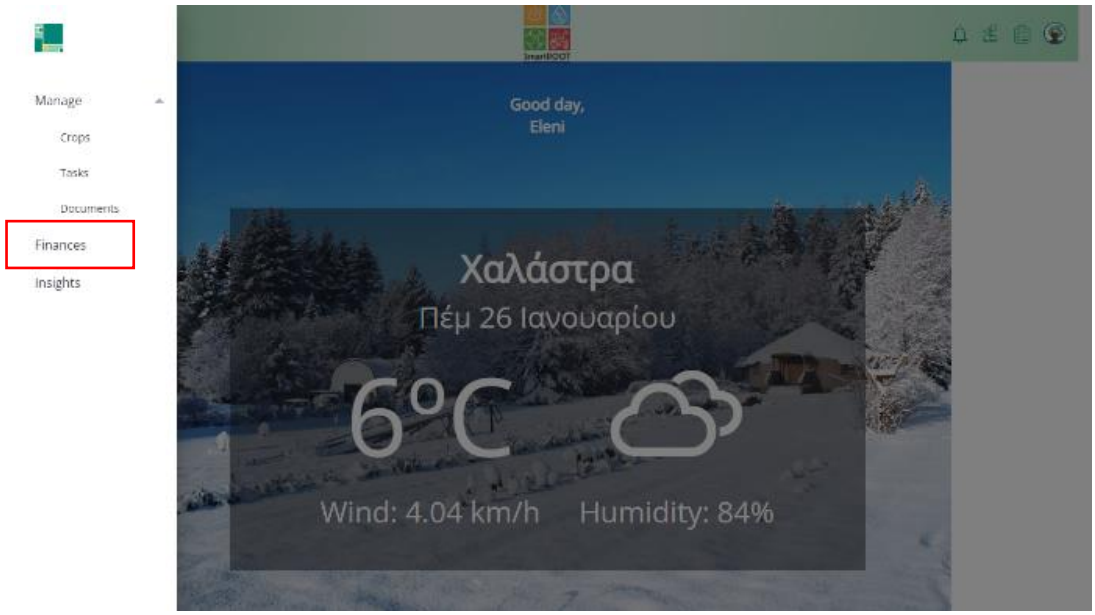
After clicking on the “Save” button, the below page is presented.

4.3.9 Add an expense or a sale

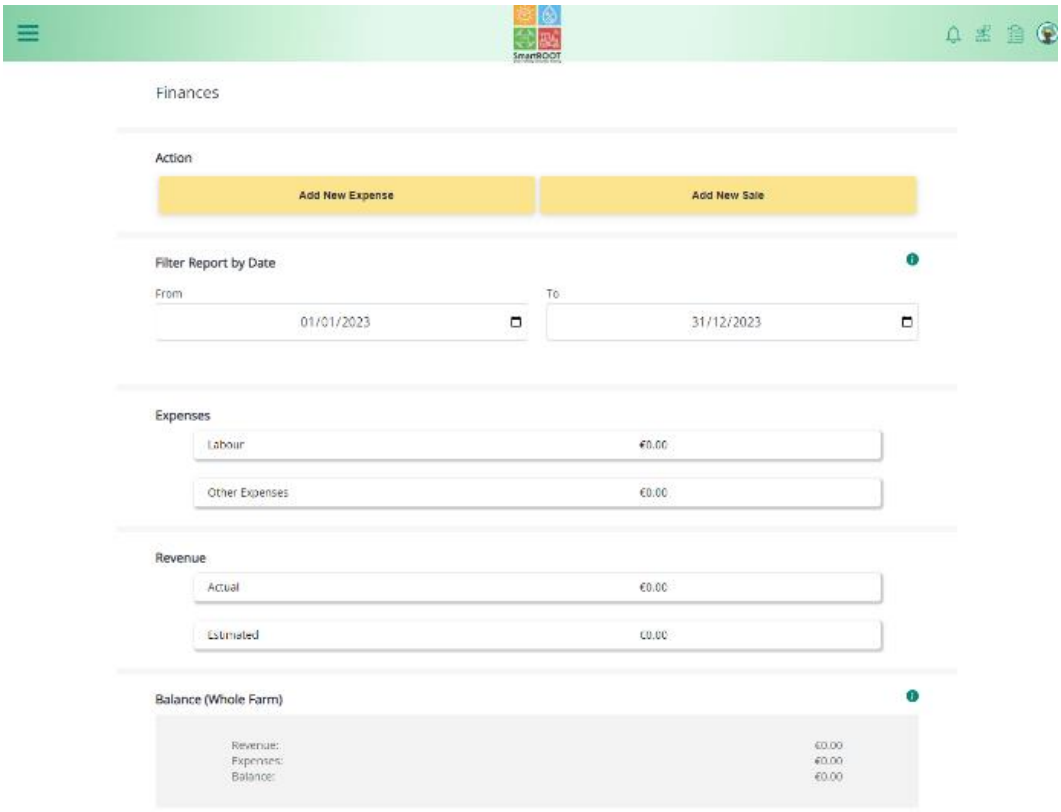
Another interesting functionality provided by the tool is the addition of expenses and sales and the calculation of the balance amount remained at the end for the specific farm.

Let consider that the user has entered the Chalastra's farm and the below page has been showed. Then, the user clicks on the left side's menu button and selects the "Finances" option from the drop-down list.

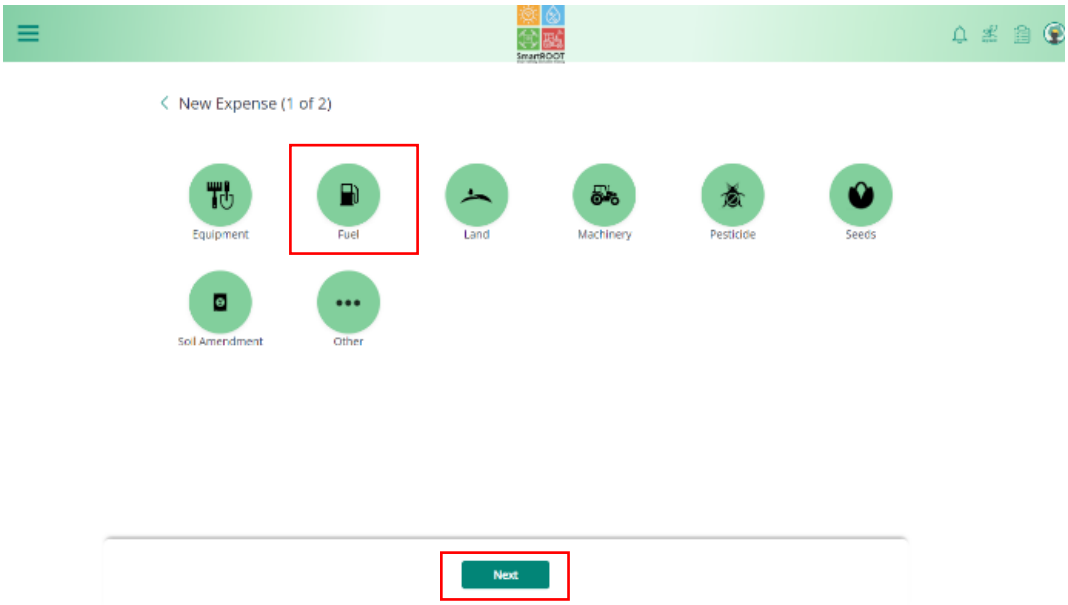




Then, the below page is presented where the user can add a new expense or a new sale by clicking the respective button.

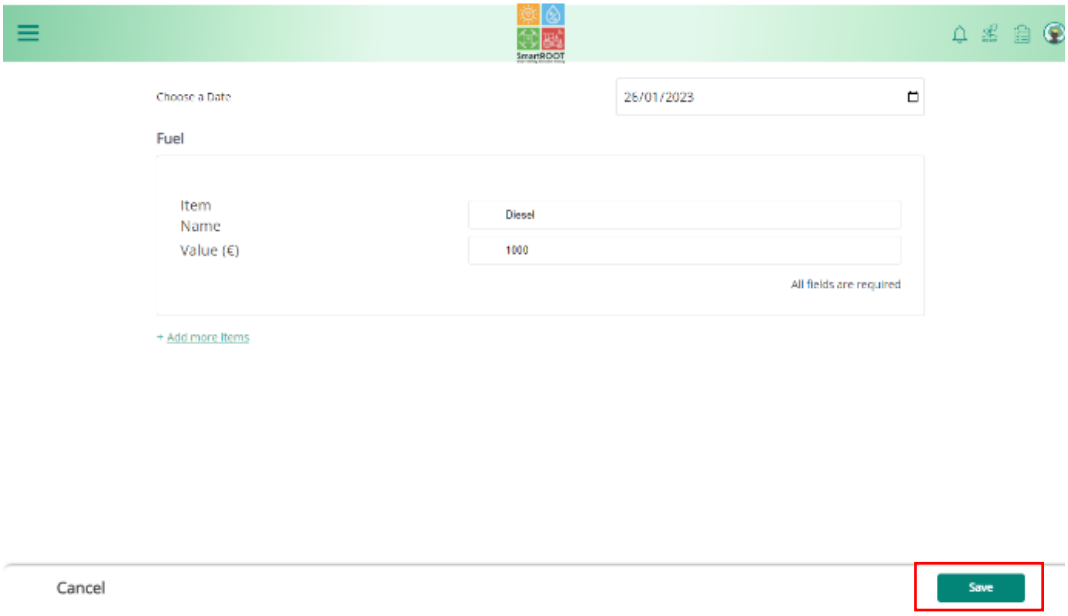


Let assume that the user selects to add a new expense and the below page is presented asking the user to define the type of the expense.

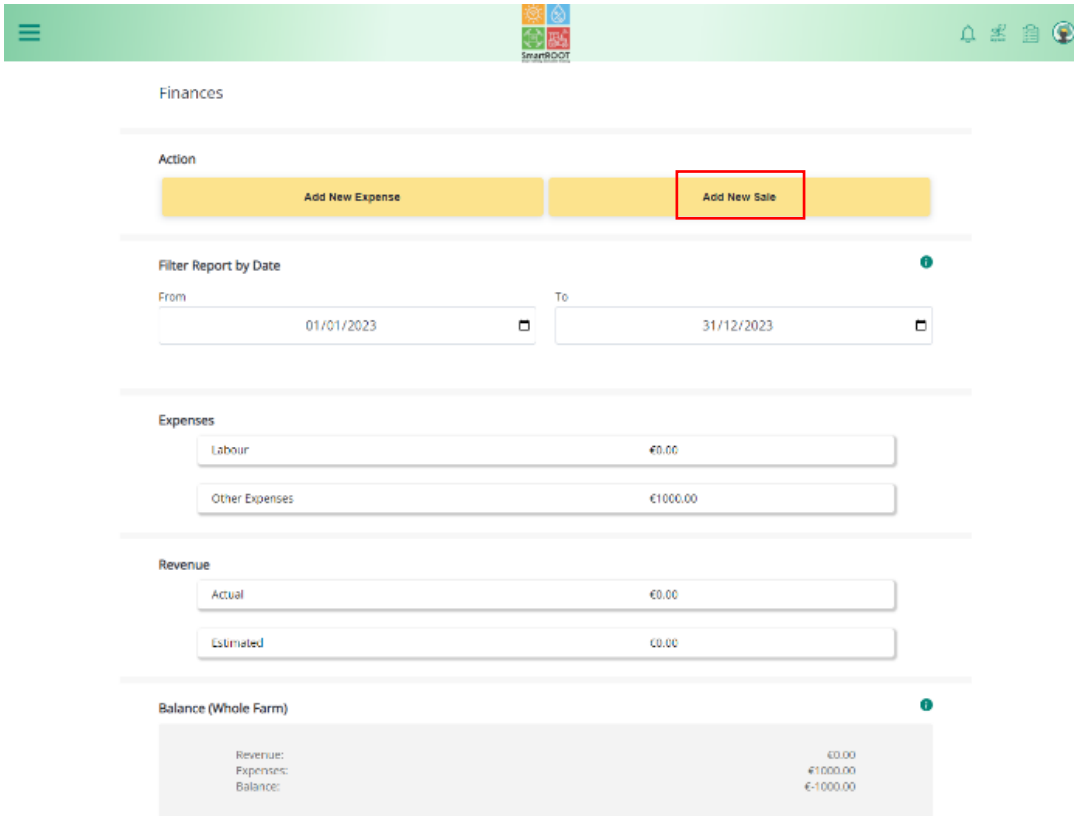


Let assume that the user selects the “Fuel” answer and presses the “Next” button. Then, the below page is presented asking the user to provide more information about this fuel expense.

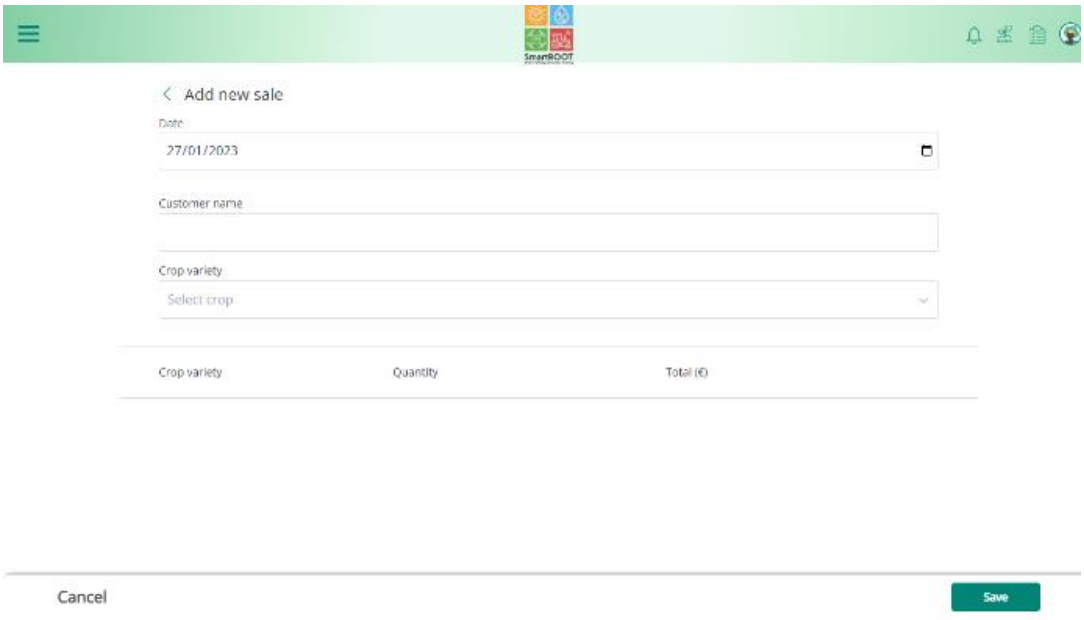
The user provides the additional information and presses the “Save” button.



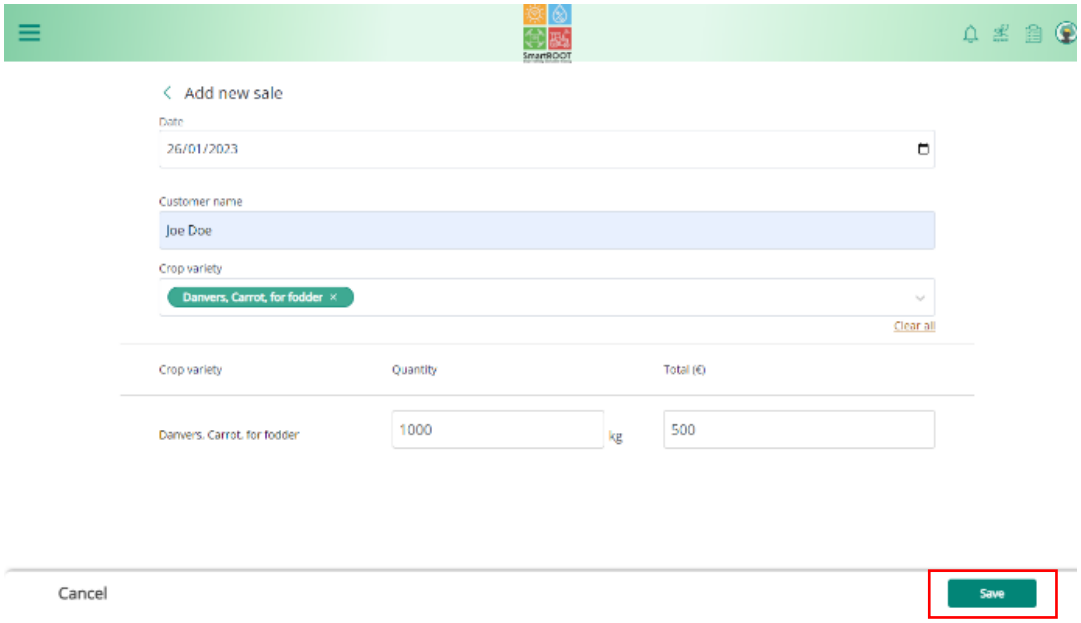
Let assume that the user now selects to add a new sale by clicking on the “Add New Sale” option.



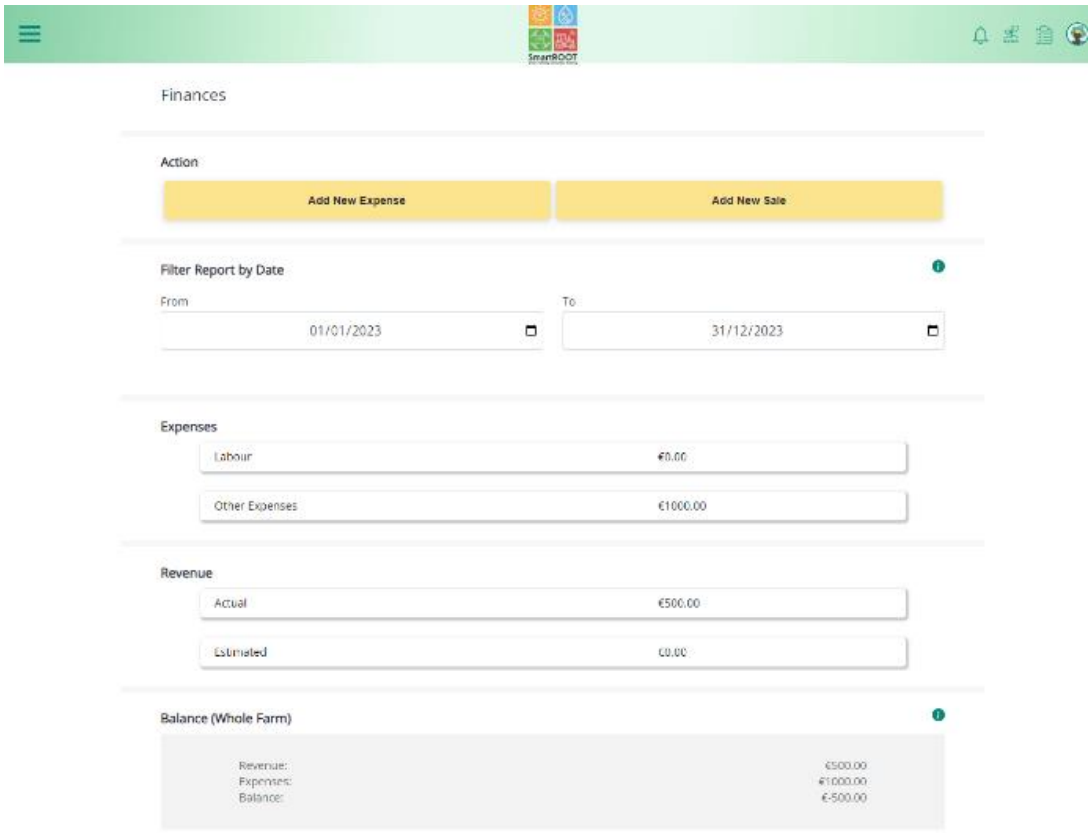
By clicking on this button, the below page is presented asking the user to define several details about the sale, including the date, the customer name, the crop variety, the quantity and the total amount of money.



The user provides these details and presses the “Save” button.



Last, from the main page of the “Finances” option the user can see the total revenues, the total expenses and the balance for the specific farm.

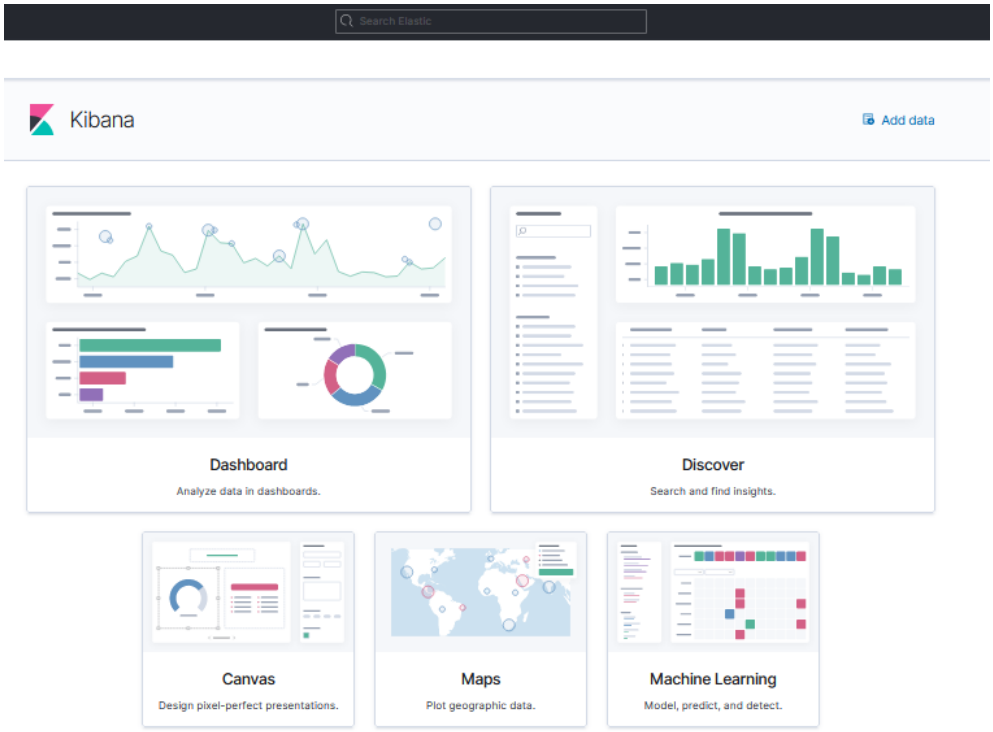

Finances
Action
Add New Expense
Add New Sale
Filter Report by Date
From
01/01/2023
To
31/12/2023
Expenses
Labour
€0.00
Other Expenses
€1000.00
Revenue
Actual
€500.00
Estimated
€0.00
Balance (Whole Farm)
Revenue:
Expenses:
Balance:
€500.00
€1000.00
€-500.00

5 Data Visualization

5.1 Overview

The Data Visualization tool is a web-based application that enables users to visualize their data. The Data Visualization tool can be used as a collaborative environment for the insightful presentation and monitoring of the sustainable farming data.

The tool has been built in the context of the SmartROOT project for educational purposes.



5.2 Background Knowledge

5.2.1 Technology behind the tool

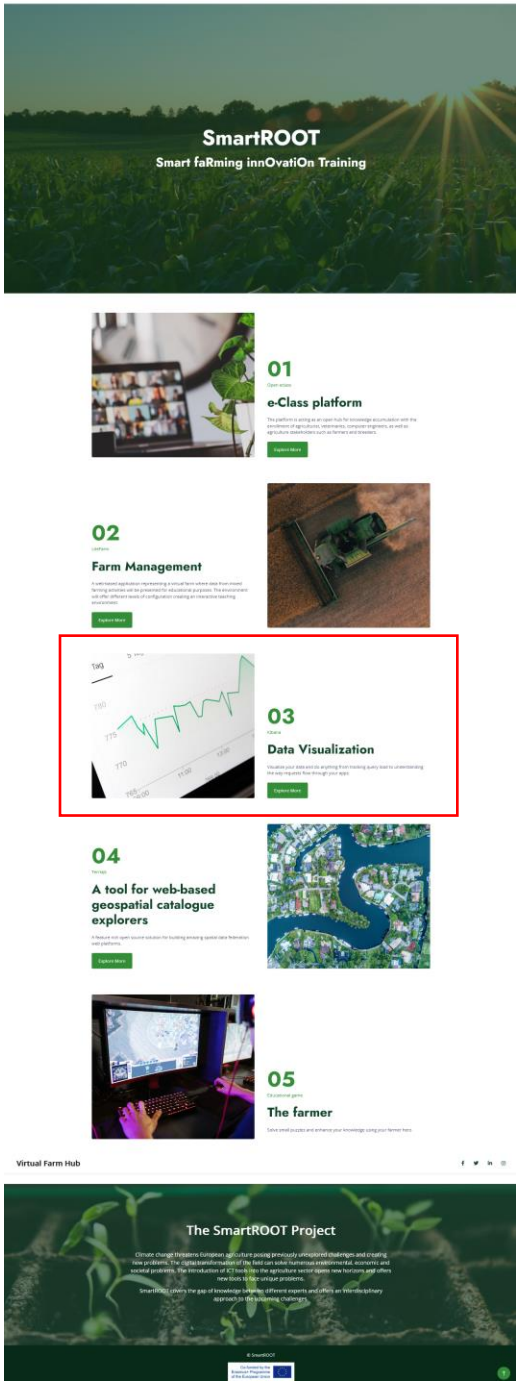
The tool has been built by means of the open-source Kibana software[5]. The Kibana is a free and open frontend application that sits on top of the Elastic Stack, providing search and data visualization capabilities for data indexed in Elasticsearch. Commonly known as the charting tool for the Elastic Stack, Kibana also acts as the user interface for monitoring, managing, and securing an Elastic Stack cluster — as well as the centralized hub for built-in solutions developed on the Elastic Stack. Developed in 2013 from

[5] https://www.elastic.co/kibana/

within the Elasticsearch community, Kibana has grown to become the window into the Elastic Stack itself, offering a portal for users and companies.

5.3 Walkthrough the Farm Management tool

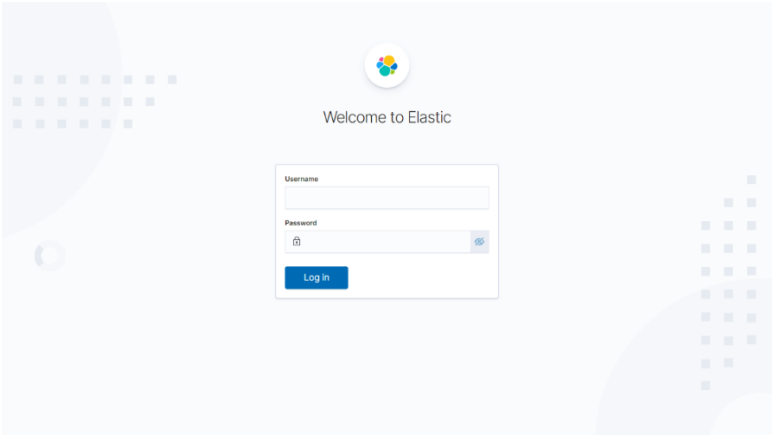
From the navigation page of the Virtual Farm Hub (IO3) https://virtualfarm.infalia.com/, anyone can access the Data Visualization tool https://cattle.infalia.com/, which is the 3rd available tool of the Virtual Farm Hub platform.



The following sections present the main functionality supported by the Data Visualization tool.

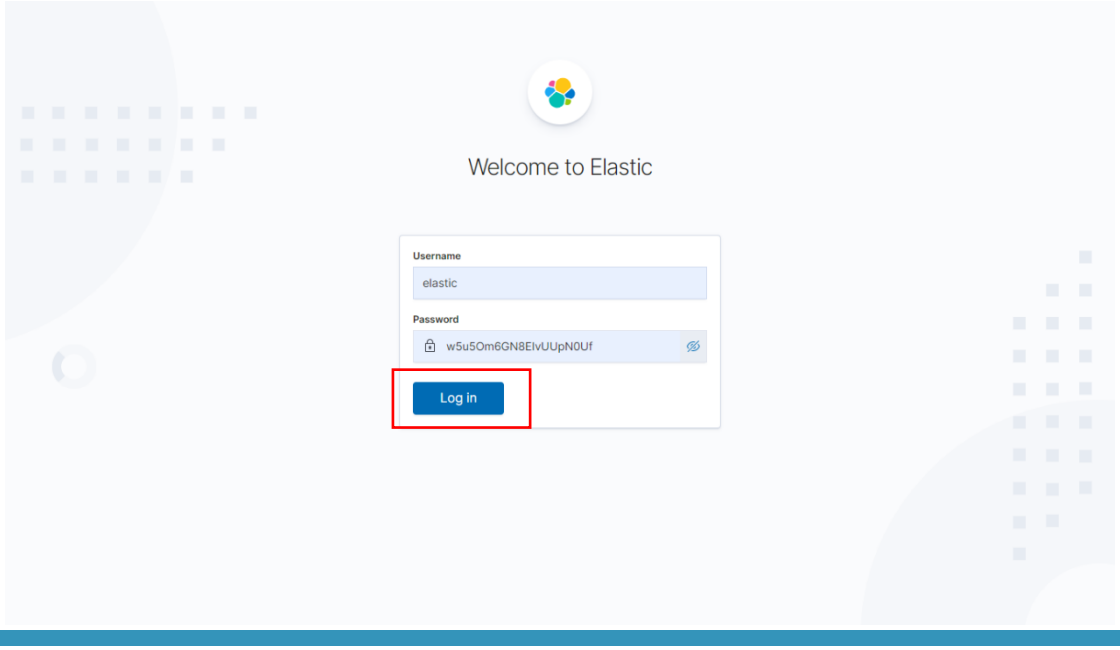
5.4 Log in

After clicking the “Explore More” button from the navigation page of the Virtual Farm Hub, the below page is presented asking the user to provide his/her credentials and log in the tool. Since the tool is the frontend application that sits on top of the Elastic Stack, providing search and data visualization capabilities for data indexed in Elasticsearch, the credentials requested in the log in page are private and refer to the respective Elastic Stack account.

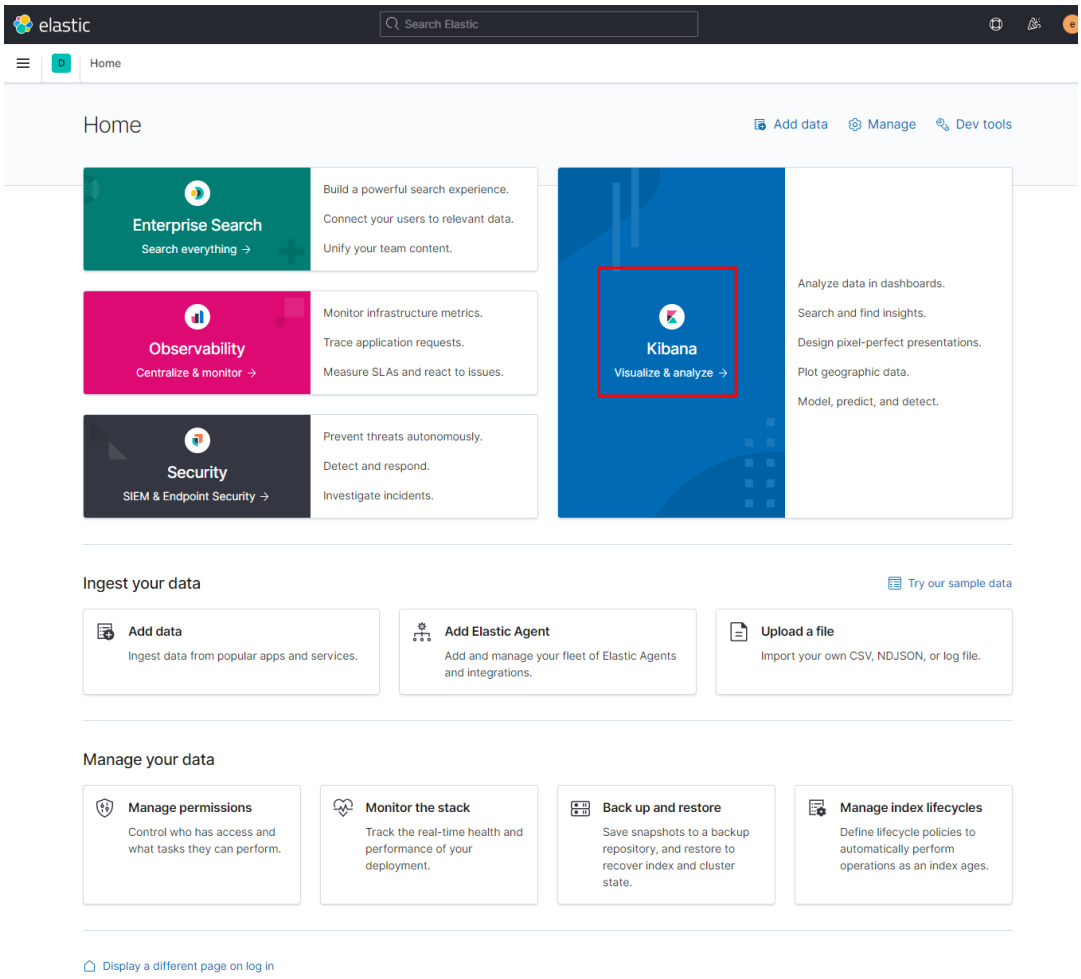


In the context of the SmartROOT project, all users share the following credentials referring to the project’s account in the Elastic Stack:

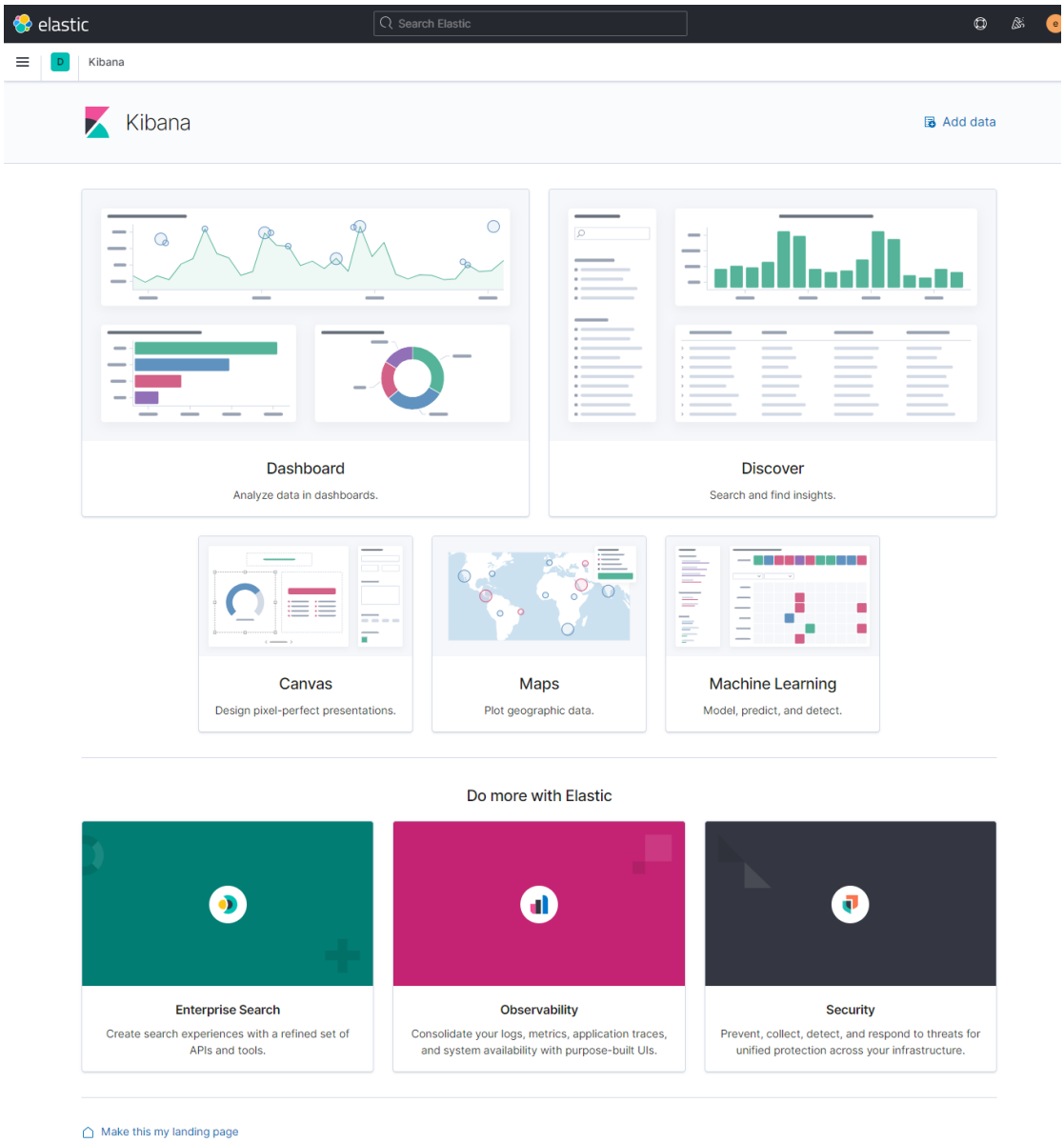
Username: Elastic Stack **Password**: w5u5Om6GN8EIvUUpN0Uf



After clicking on the “Log in” button, the below page is presented where the user clicks on the “Kibana Visualize & analyze” button and enters the tool’s main page.

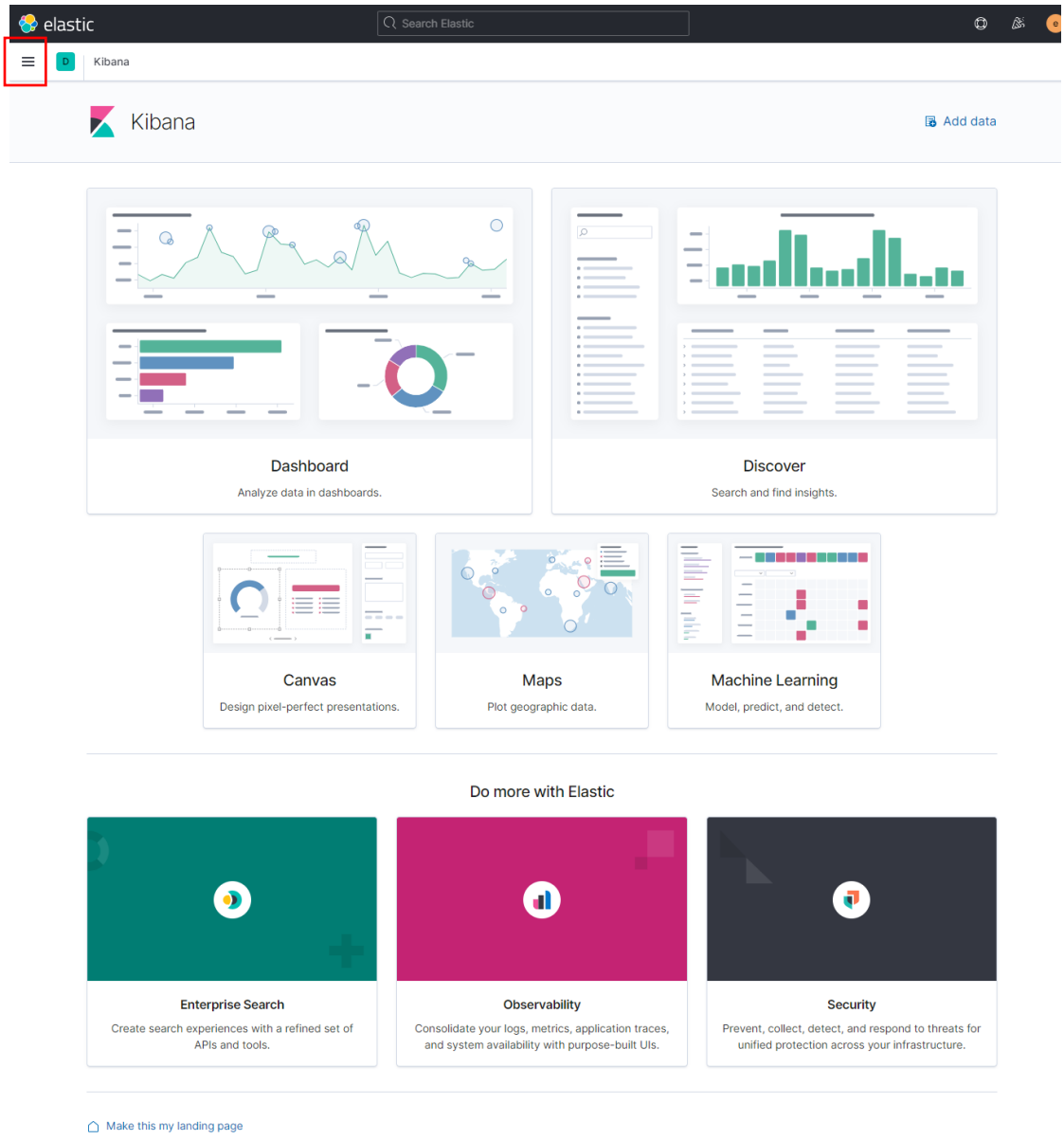


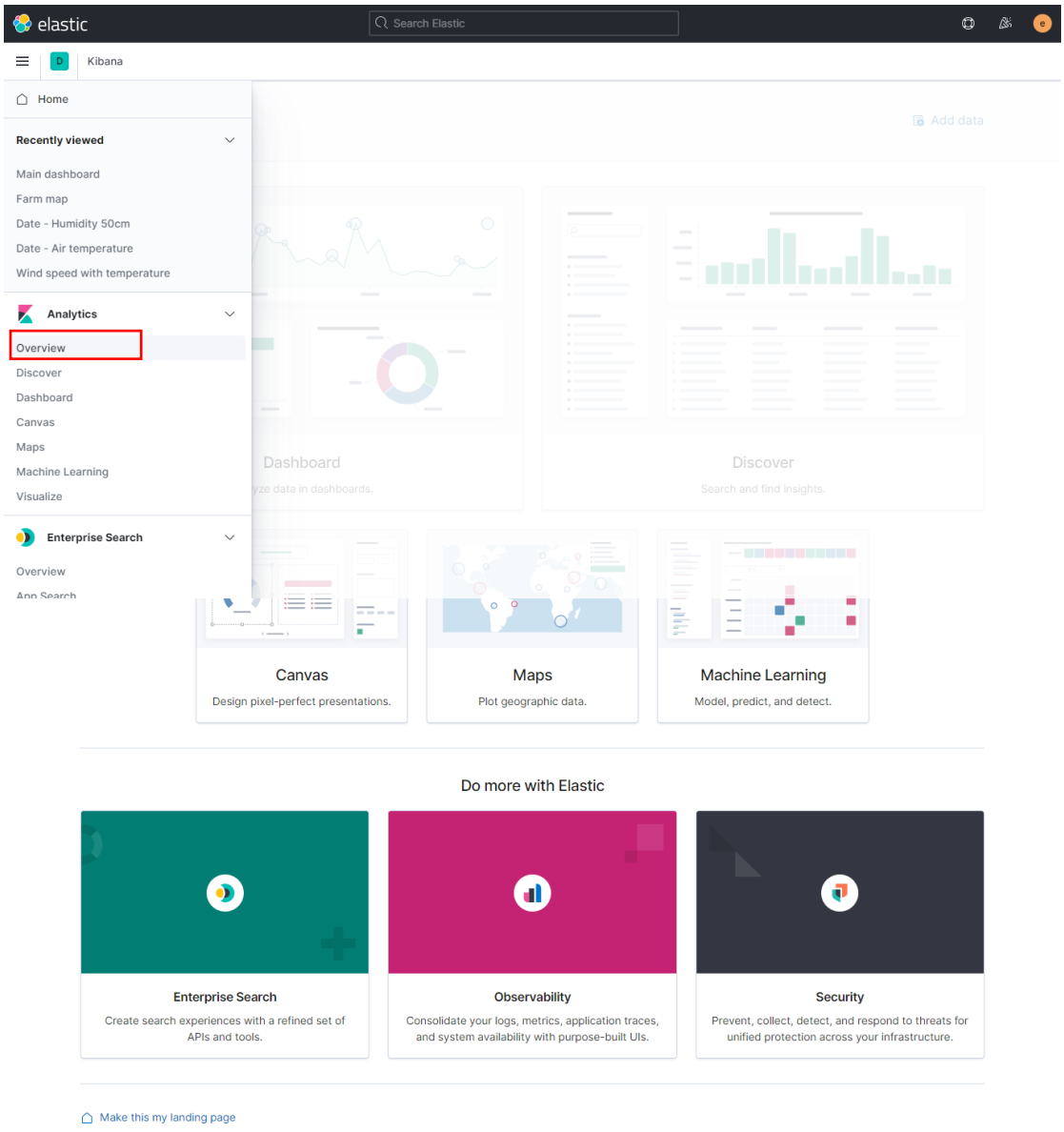
The below page is the main page of the Data Visualization tool.



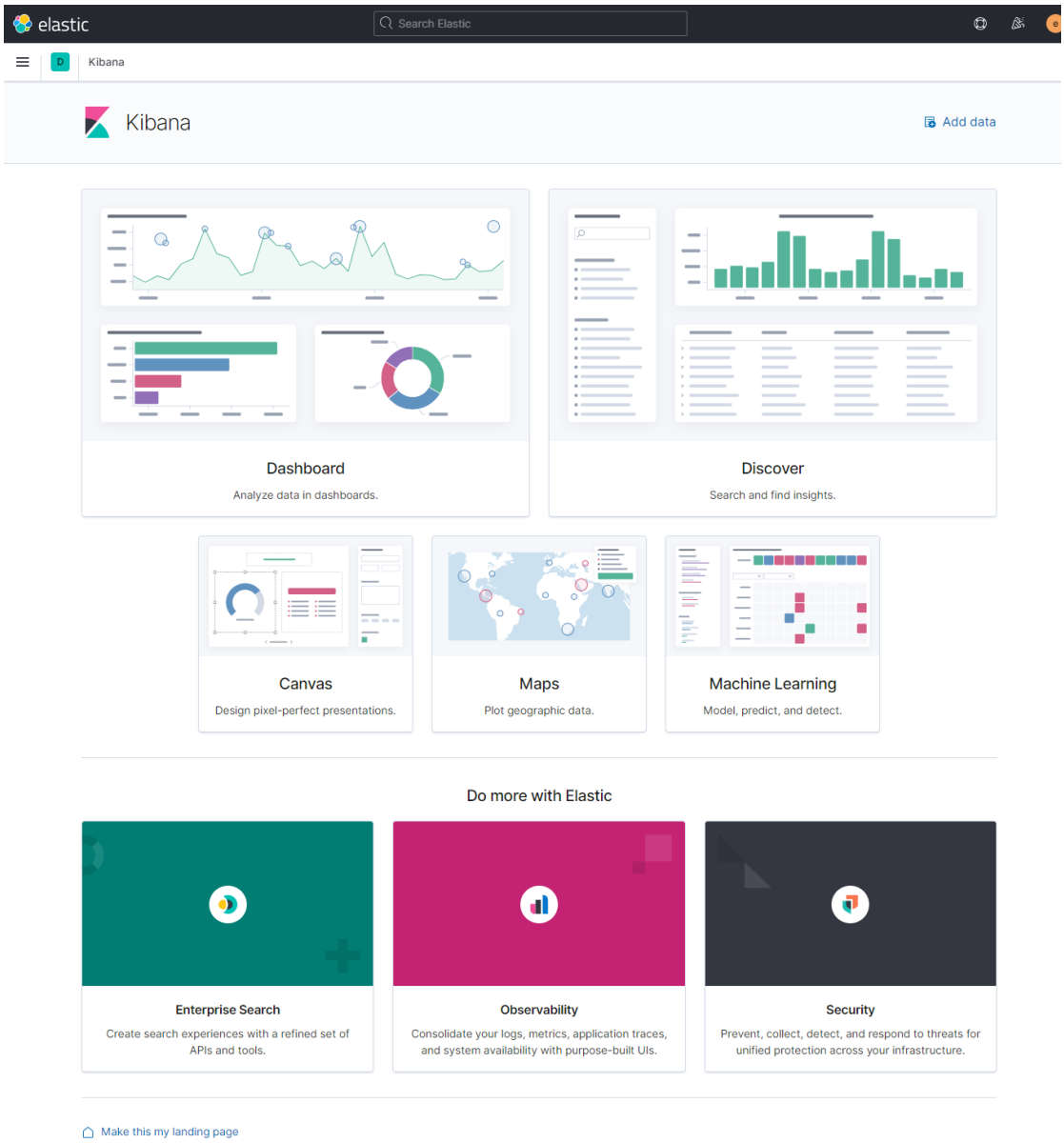
5.5 Overview

The initial functionality supported by the Data Visualization tool is the “Overview” functionality. To access this functionality, the user needs to click on the main menu button and then selects the first button of the “Analytics” tools, under the main menu.


elastic
Search Elastic
Kibana
Kibana
Add data
Dashboard
Analyze data in dashboards.
Discover
Search and find insights.
Canvas
Design pixel-perfect presentations.
Maps
Plot geographic data.
Machine Learning
Model, predict, and detect.
Do more with Elastic
Enterprise Search
Create search experiences with a refined set of APIs and tools.
Observability
Consolidate your logs, metrics, application traces, and system availability with purpose-built UIs.
Security
Prevent, collect, detect, and respond to threats for unified protection across your infrastructure.
Make this my landing page

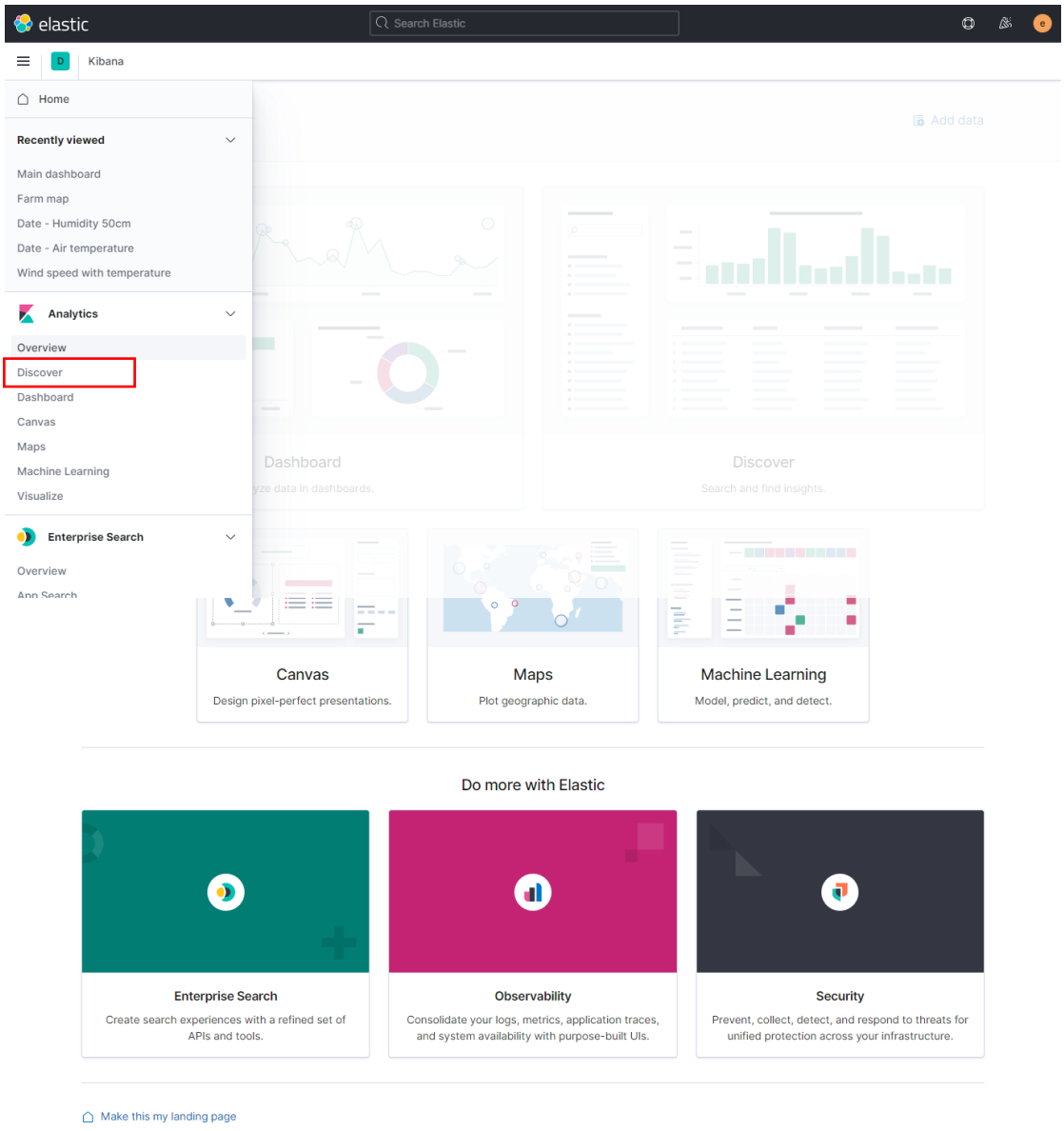


By clicking on the "Overview" button, the tool presents an overview of the most important functionalities/features supported and provides to the user the option to include data from online open databases.

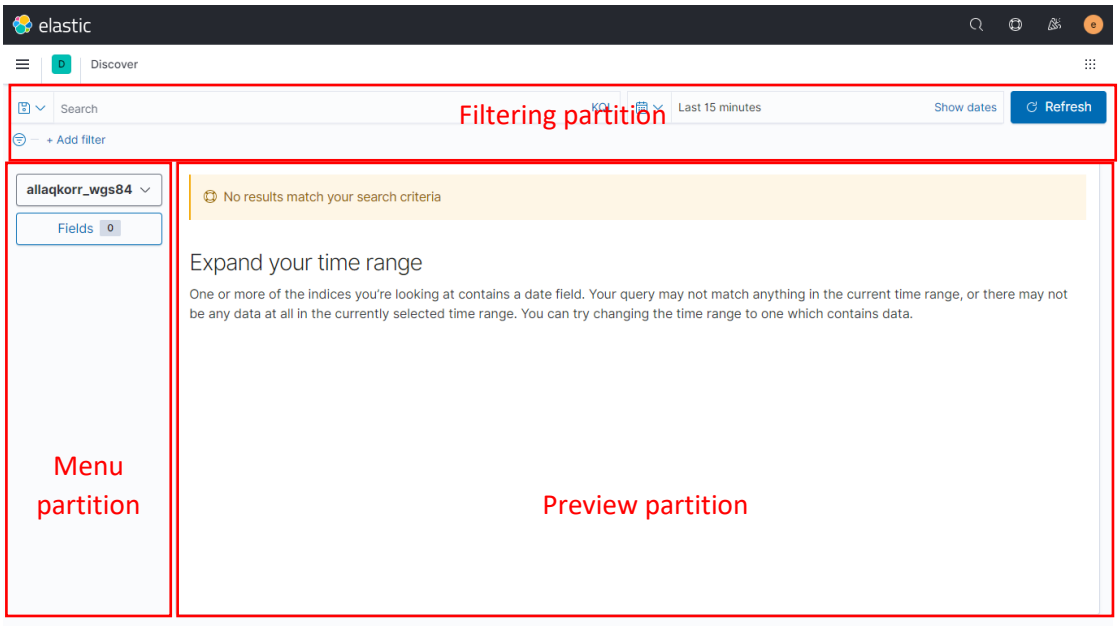


5.6 Discover

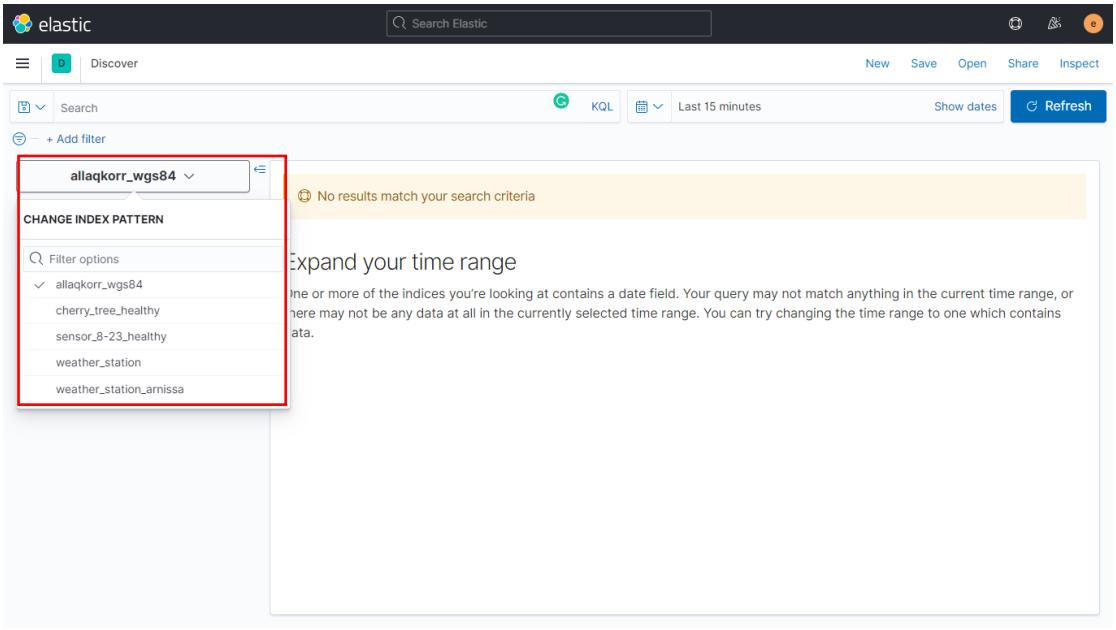
The second functionality supported by the Data Visualization tool is the “Display” functionality. To access this functionality, the user needs to click on the second button of the “Analytics” tools, under the main menu.



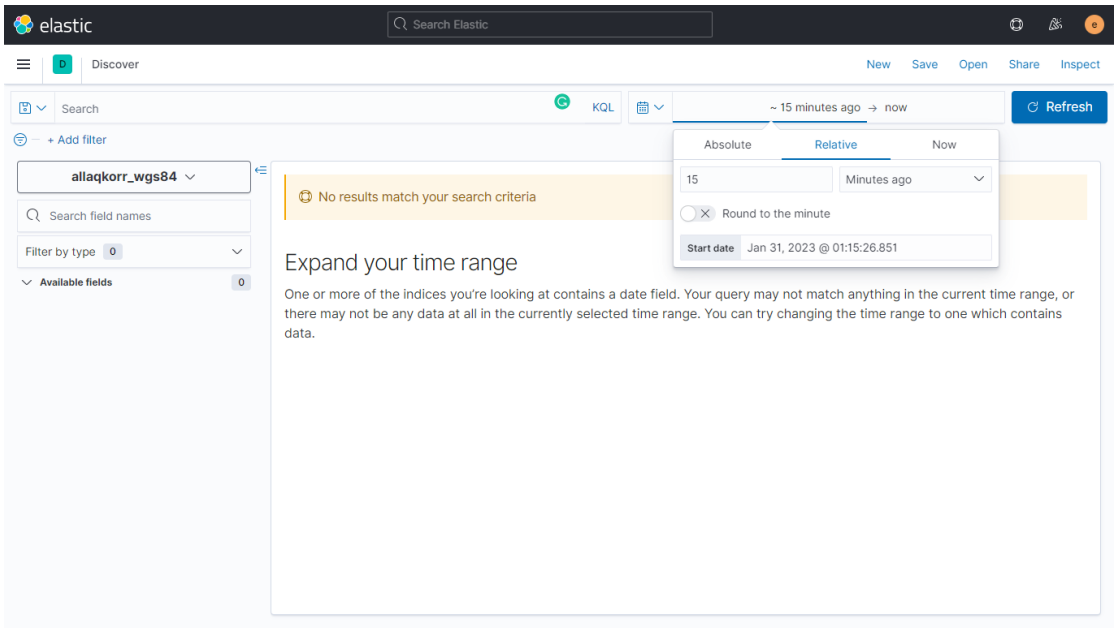
By clicking on the “Display” button, the page is divided into three partitions. The first is the filtering partition, the second is the preview partition and the third is the menu partition.



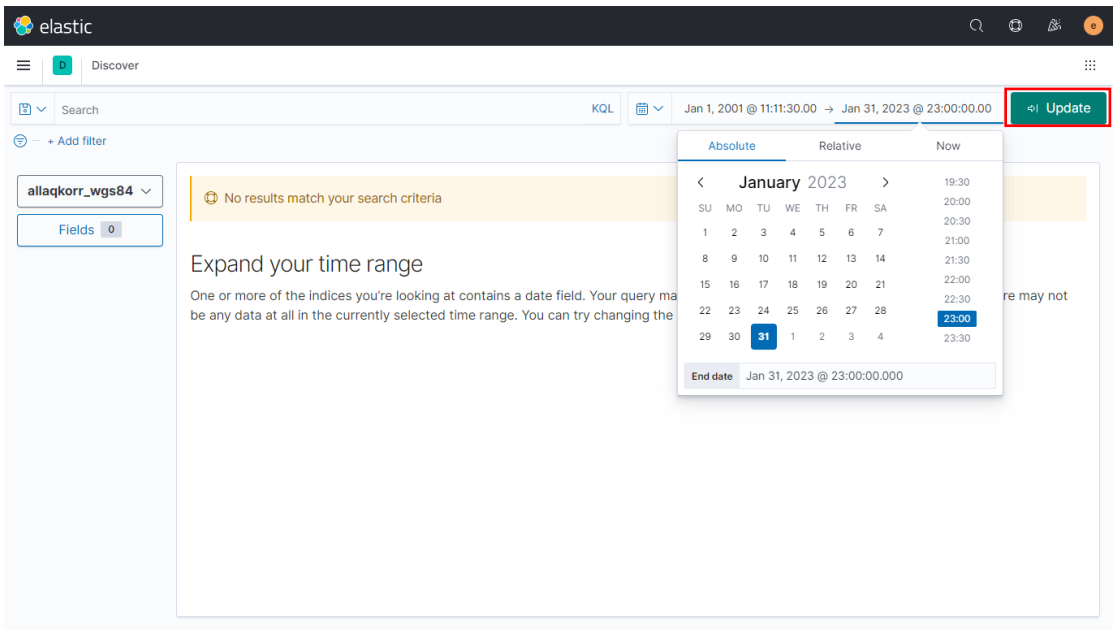
From the menu partition, the user can select a data collection to display. In the example below, there are five available data collections to select from and the user has selected to preview the “allaqkorr_wgs85” data collection that contains data about cattle.



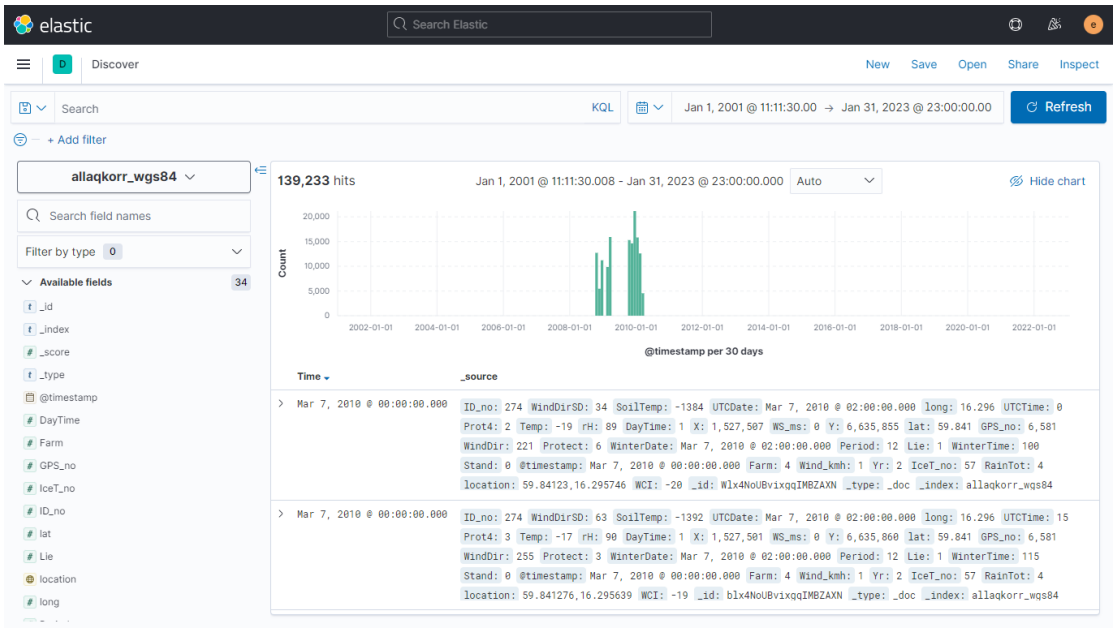
Then, the user defines the time range from the filtering partition to cover the time period of the data collection.



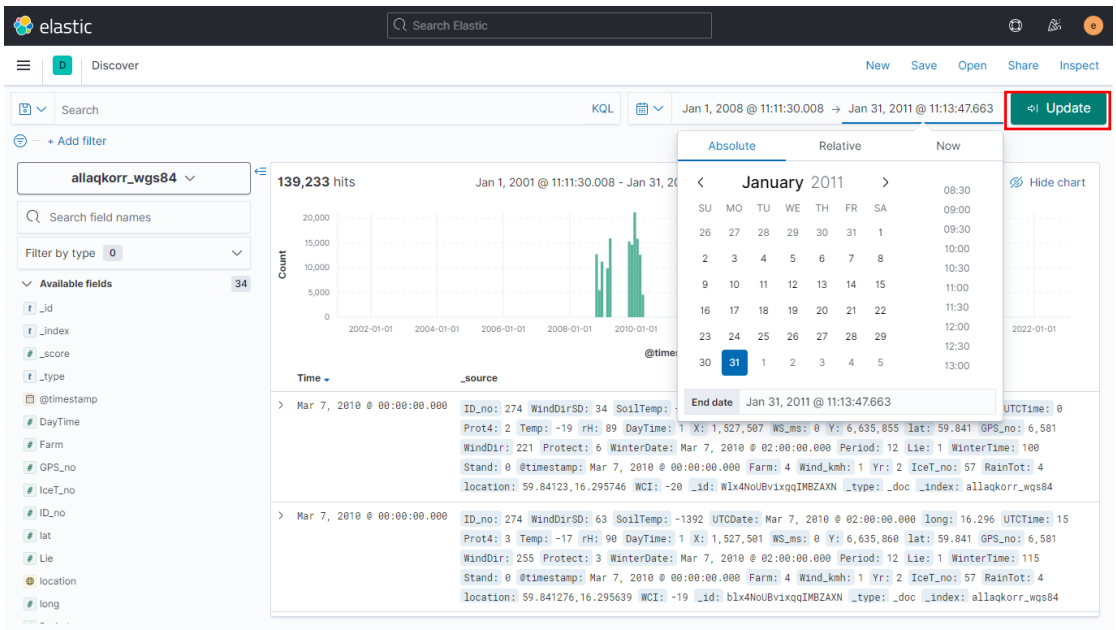
Initially, the user can set an extended time range e.g., from January 2001 to January 2023 and press the "Update" button.



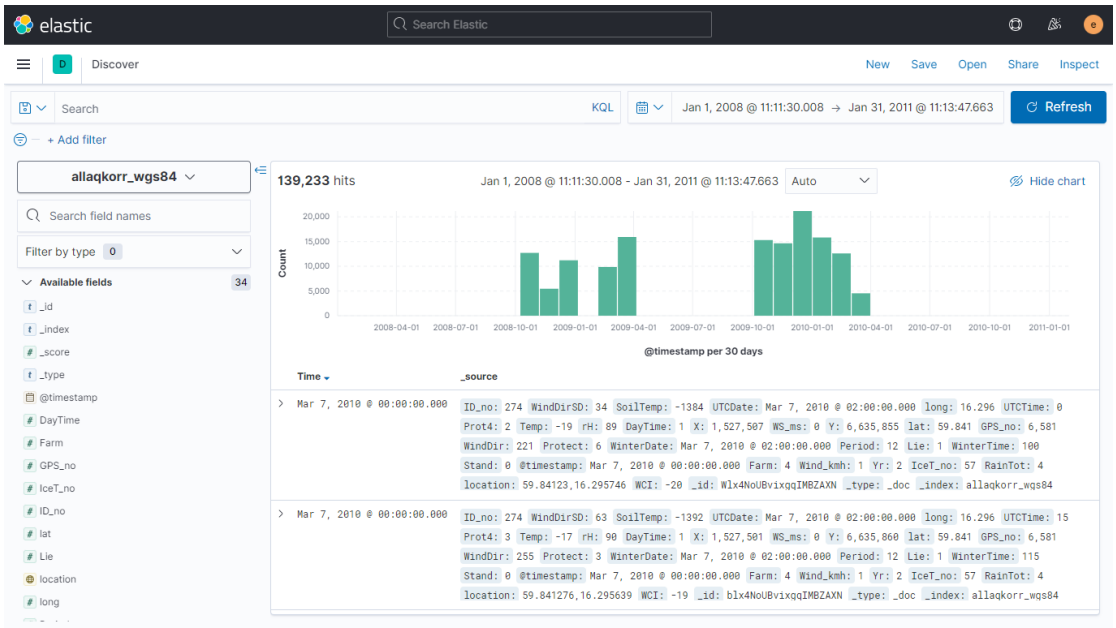
From the preview presented below, the user can understand that his/her data ranging from 2008 to 2010.



Thus, the user needs to re-set the time range from January 2008 to January 2011 and again press the "Refresh" button.



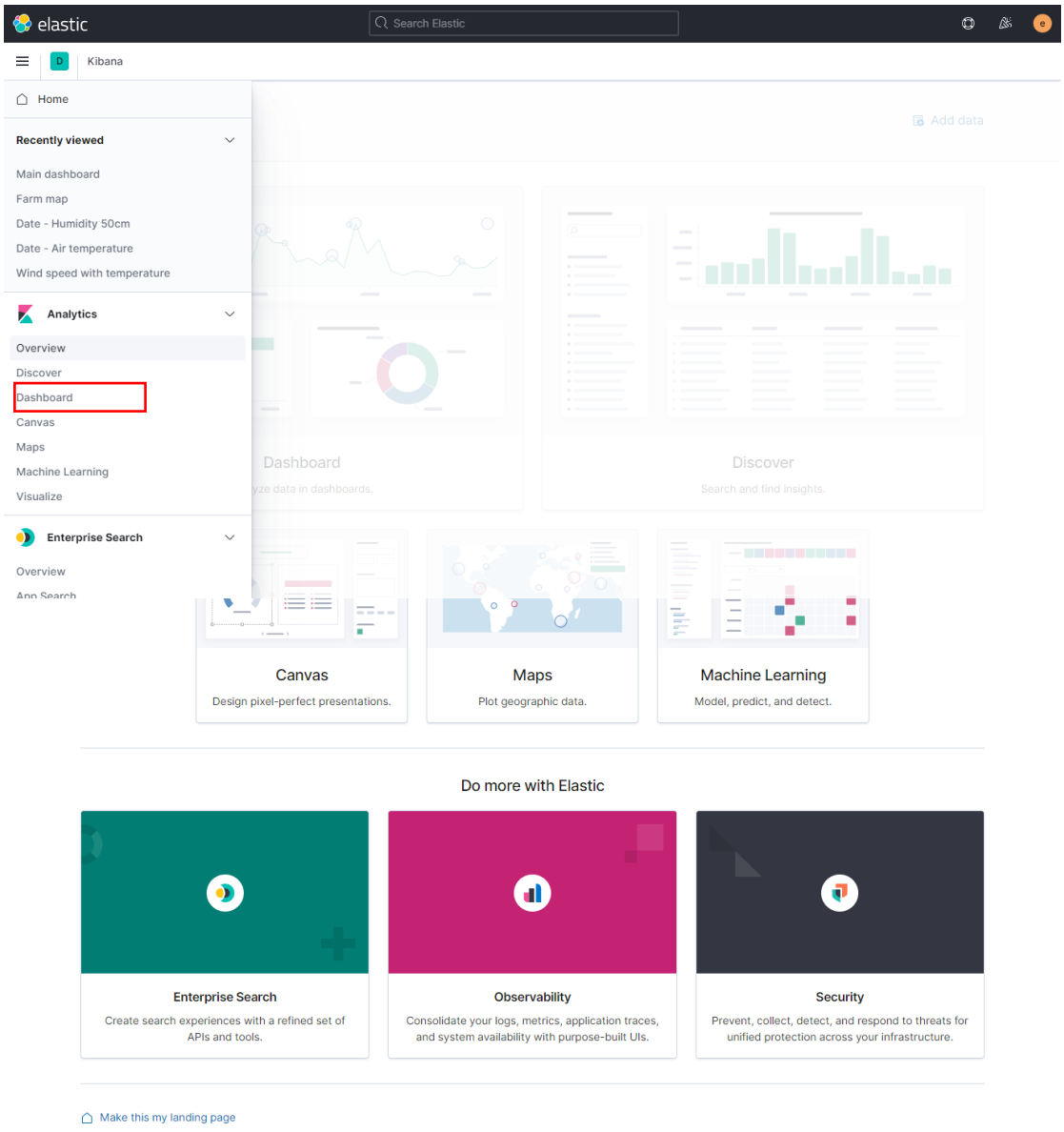
From the preview presented below, the user can see his/her data in the correct time range.



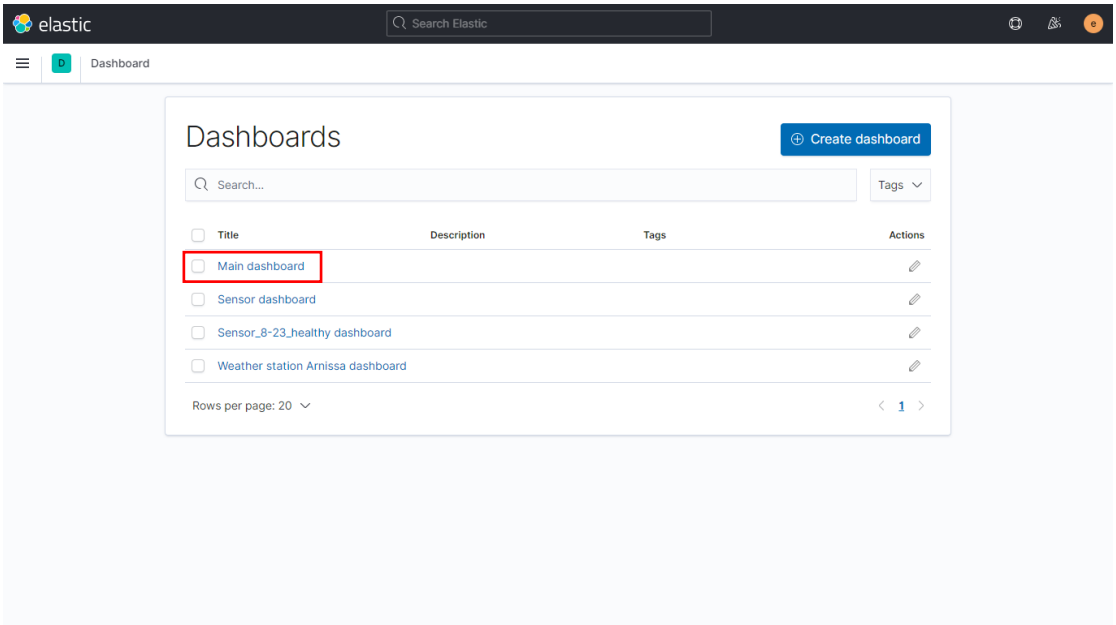
By displaying the data in this way, the user can explore interesting insights and decide which fields or time periods he need to further investigate.

5.7 Dashboard

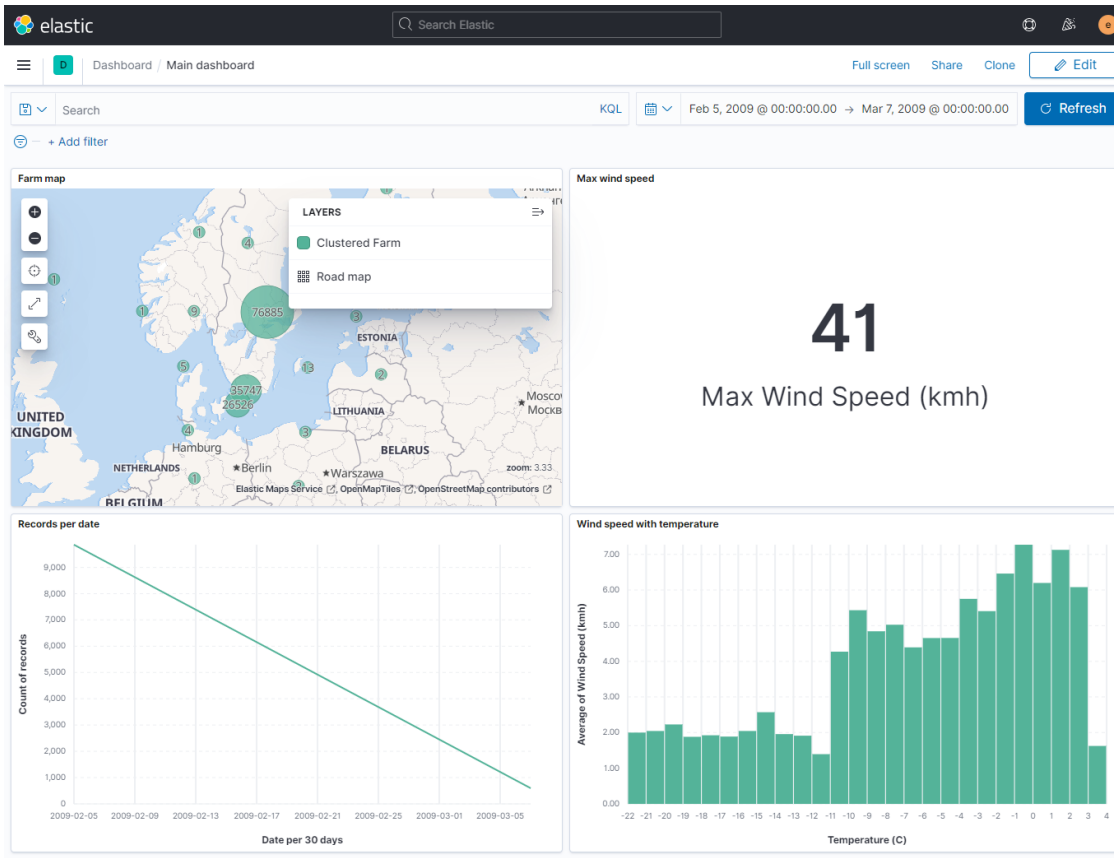
The most important functionality supported by the Data Visualization tool is the “Dashboard” functionality. To access this functionality, the user needs to click on the third button of the “Analytics” tools, under the main menu.



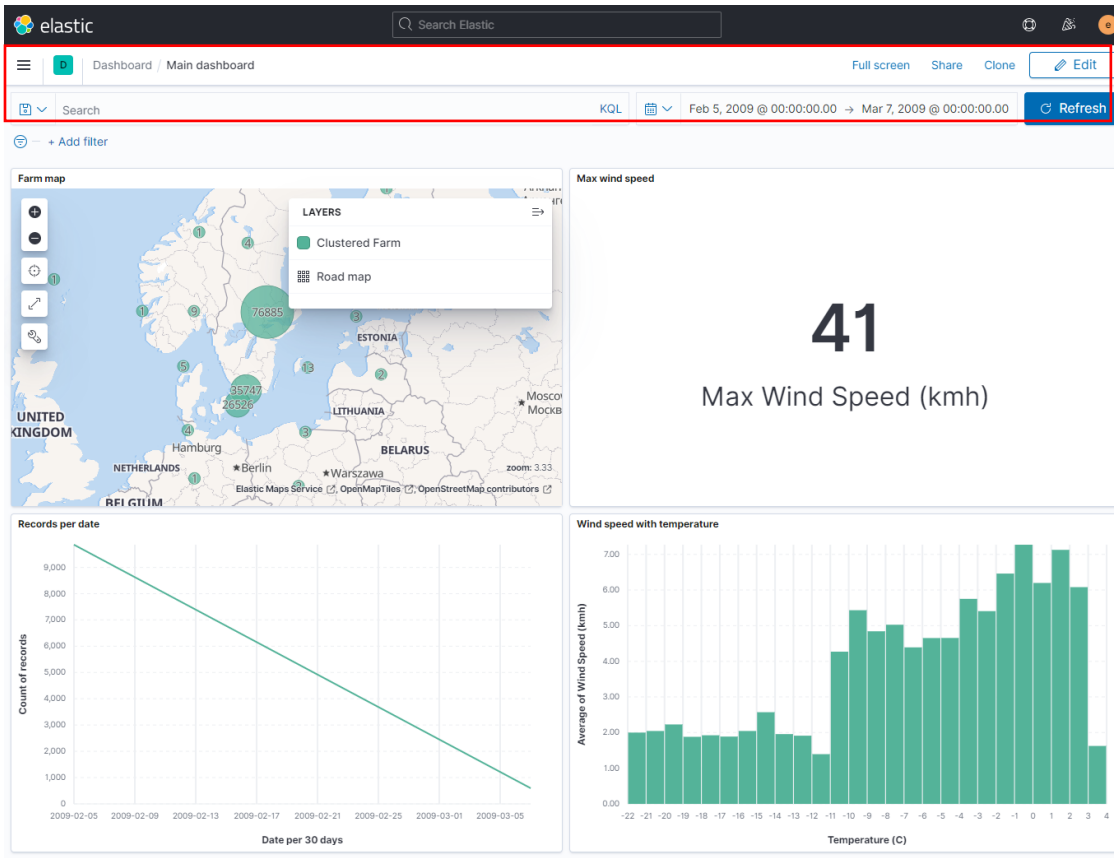
By clicking on the “Dashboard” button, the following page is presented asking the user to select an existing dashboard from the Dashboards list or to add a new one by clicking on the “Create dashboard” button.



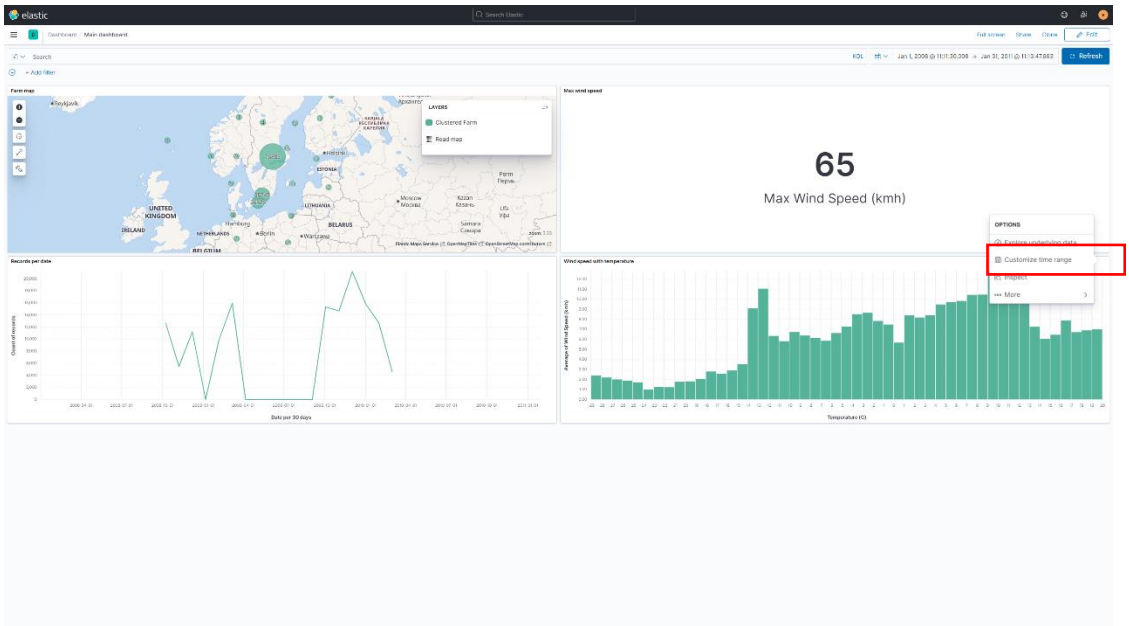
Let assume that the user selects to preview the “Main dashboard”. Here, the user can preview several visualizations coming from all available data collections gathered in a board named “Main dashboard”. These visualizations have been created in a previous time for educational, training, monitoring or other purposes.



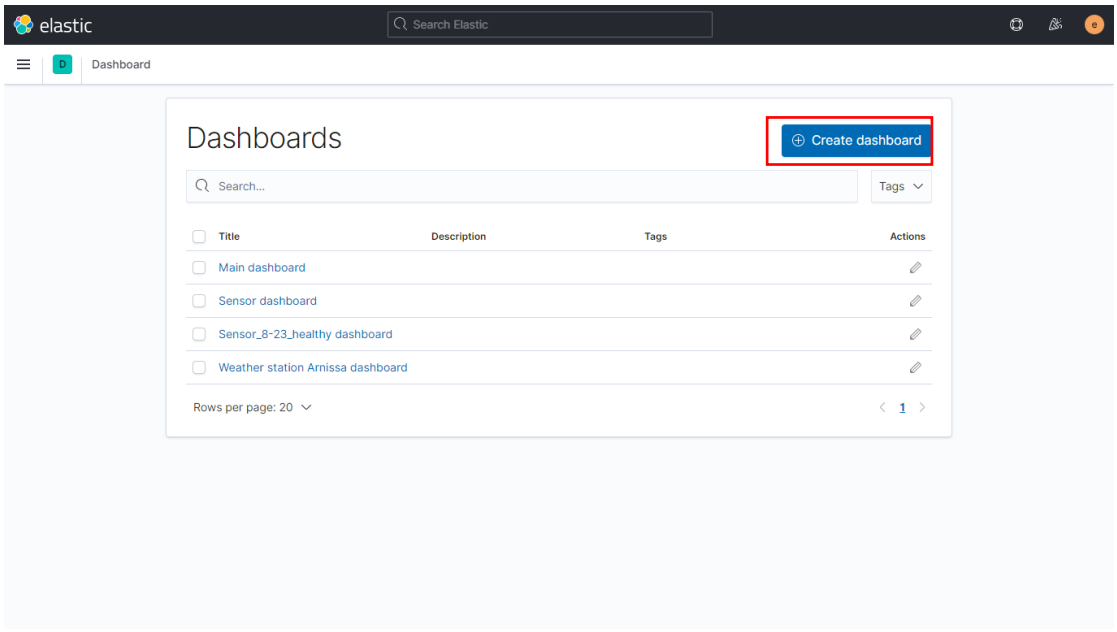
The user can dynamically change the time range of the visualizations. More specifically, the user has two options: first the user can select and change the time range in the filtering partition. By this way, all visualizations are updated based on the new time range.



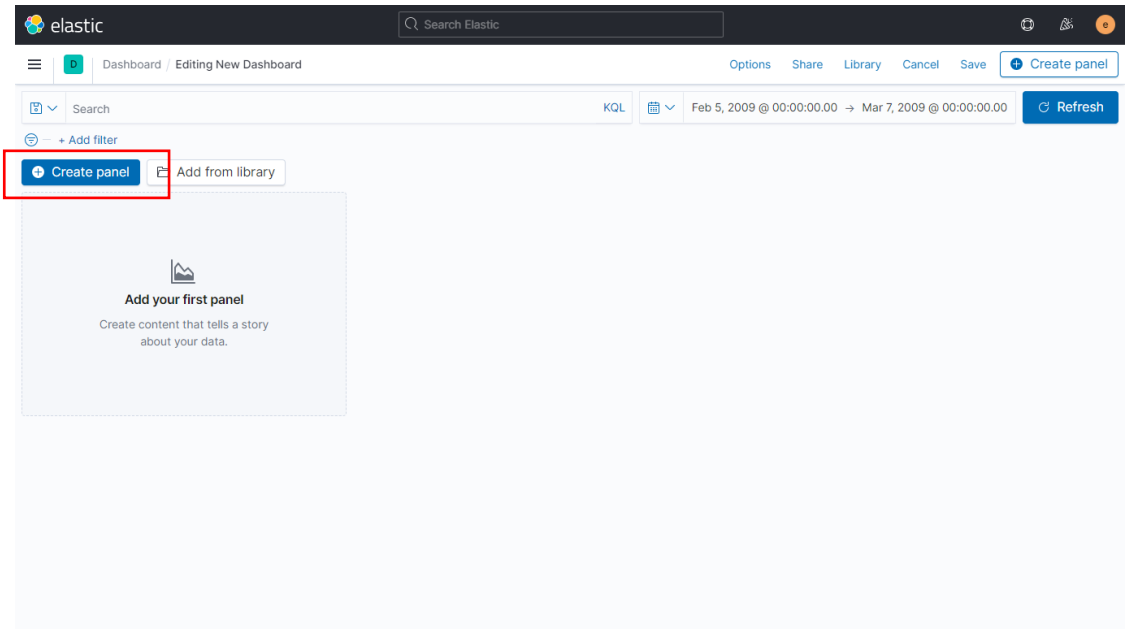
In the second option, the user can check on a menu button at the right corner of each visualization and change the time range from a specific visualization.



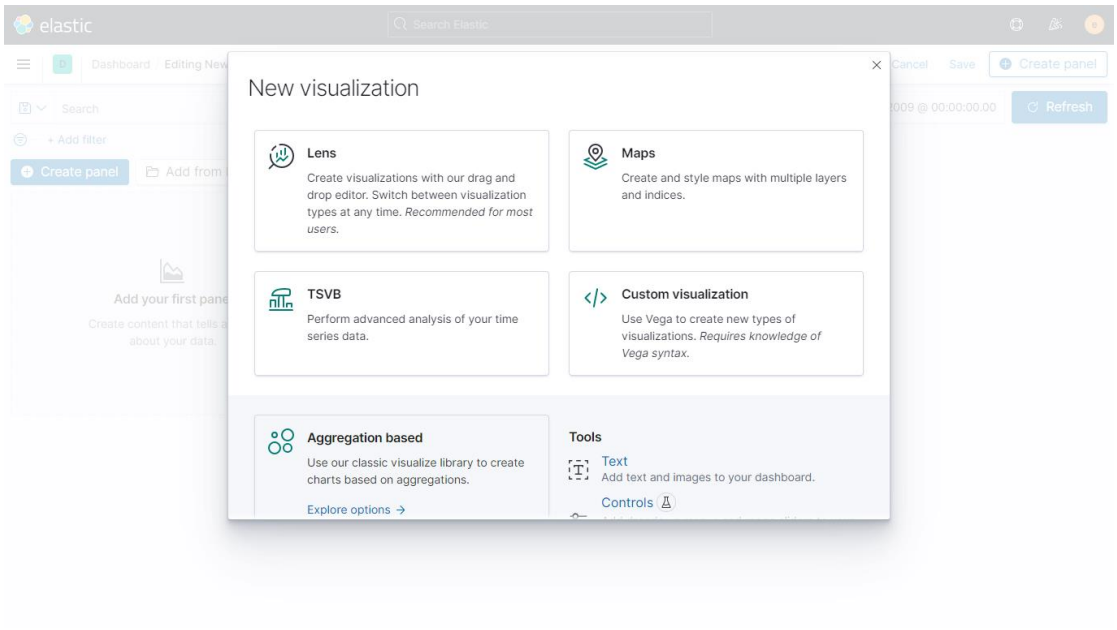
Another option of the user under the “Dashboard” button is to add a new dashboard by clicking on the “Create dashboard” button.



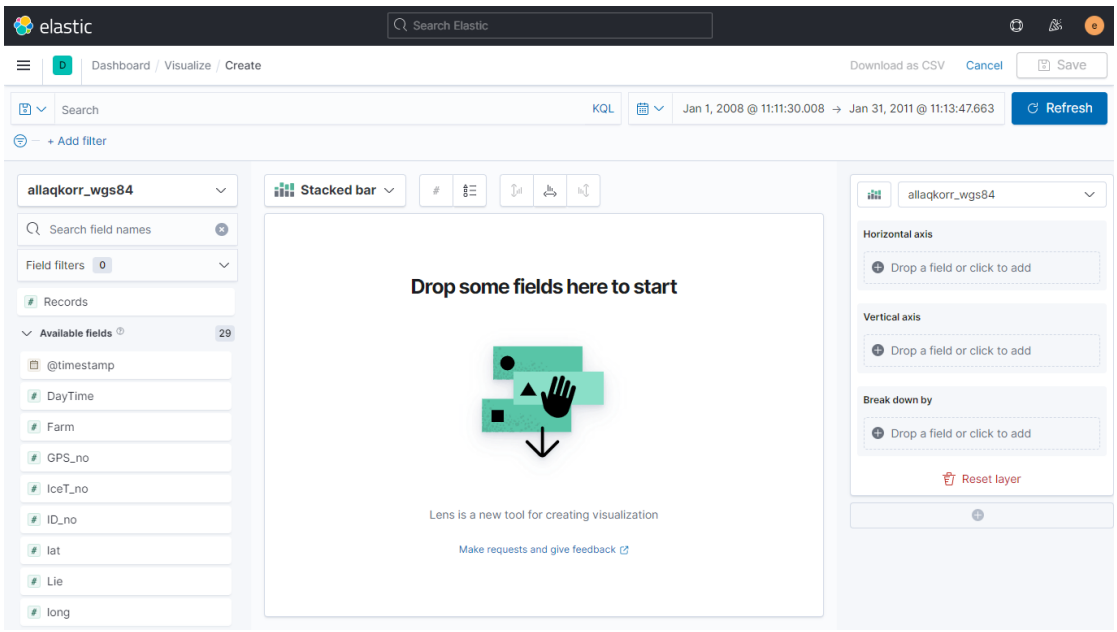
Here, the user can either create a new visualization/panel and incorporate this new panel in the dashboard or add an existing visualization/panel from the library. Let assume that the user selects the “Create panel” button.



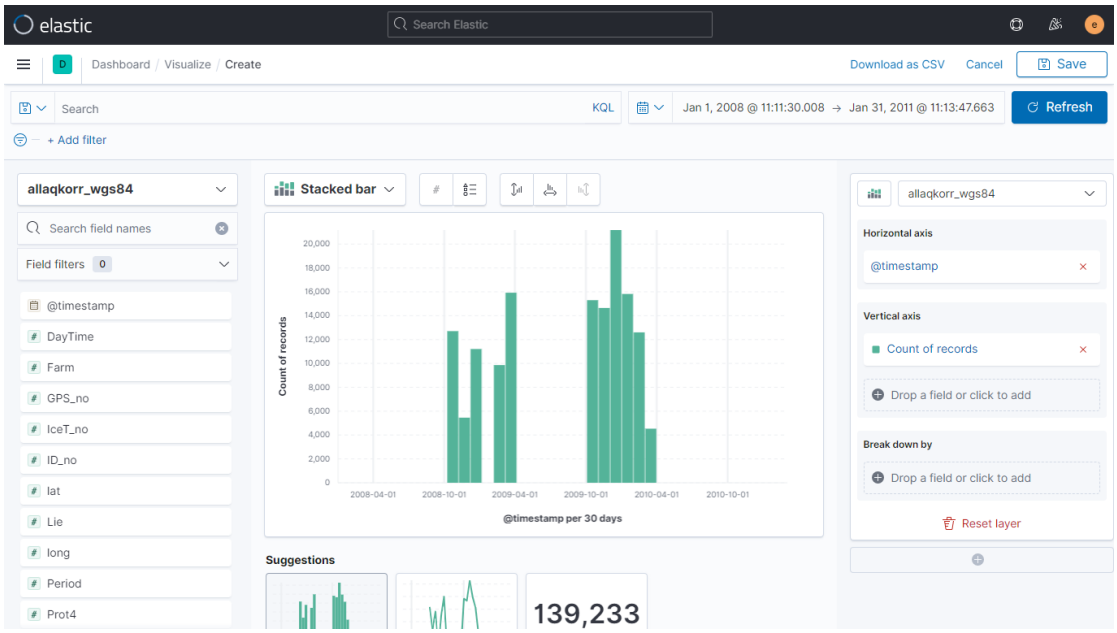
By clicking on the “Create panel” button, the user is requested to select the method for creating the new visualization.



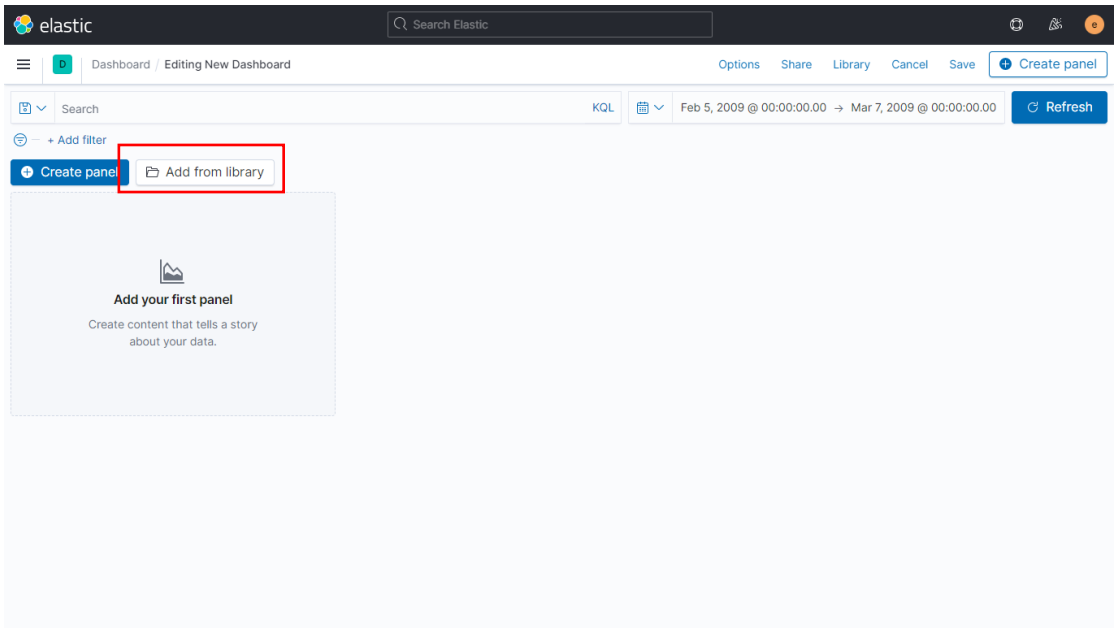
Let assume that the user selects the "Lens" option. By clicking on this option, the following page is displayed asking the user to drag and drop from available fields.



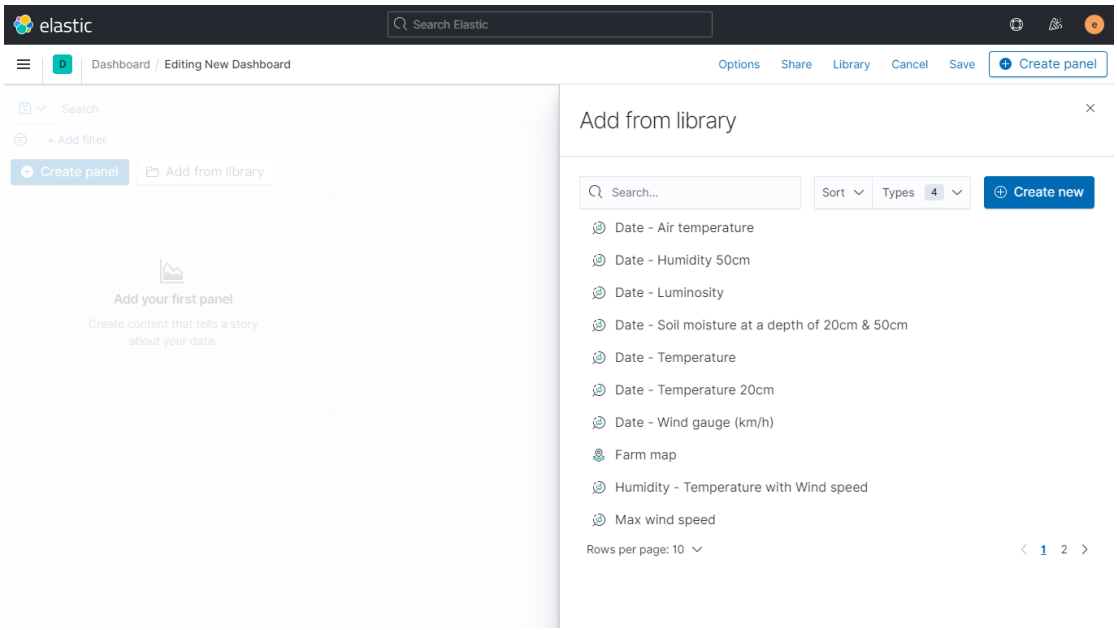
Let assume that the user needs to create a visualization presenting the counts per date. To do this, he drags and drops the "@timestamp" field. By doing that, the following visualization is presented showing the counts per date.



Now, let assume that the user checks on the “Add from library” button.

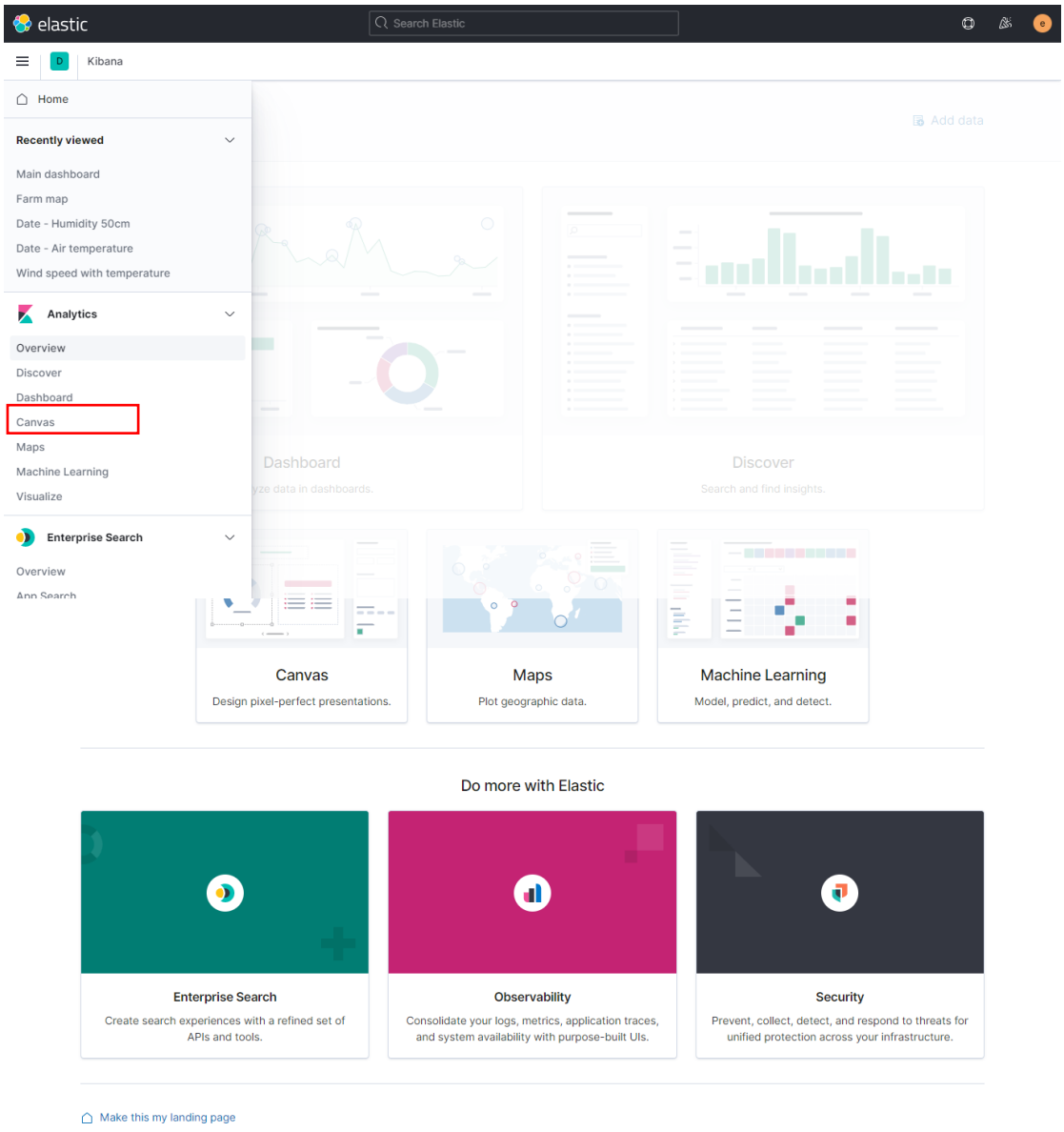


By clicking on this, the below page is presented asking the user to select an existing panel from the library. The library consists of the standalone visualizations that a user has already created from the “Visualize” button of the “Analytics” tools.

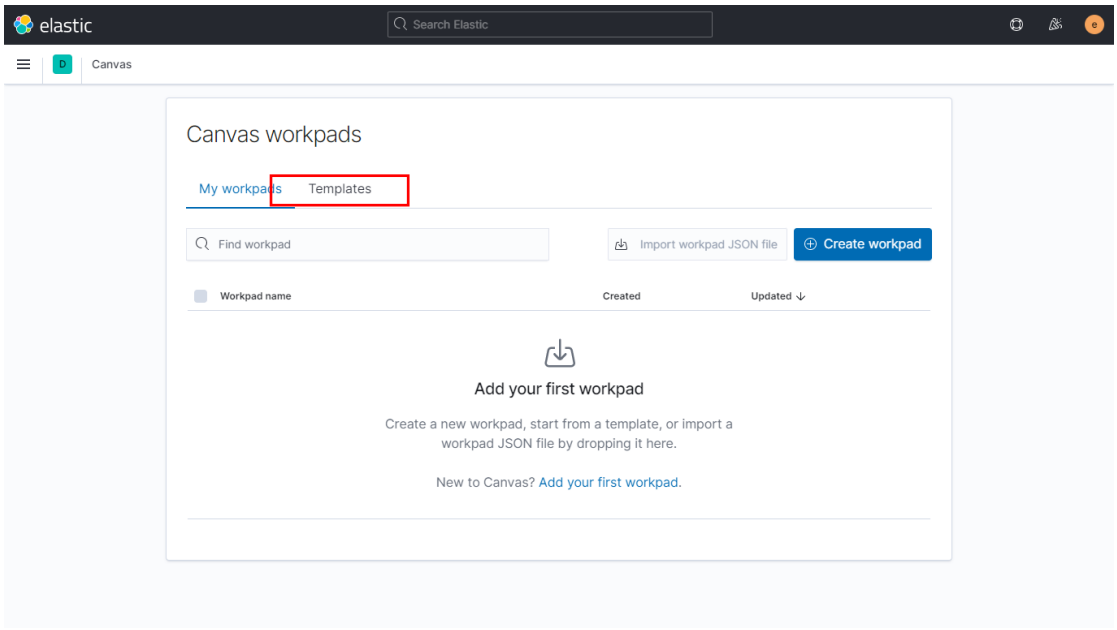


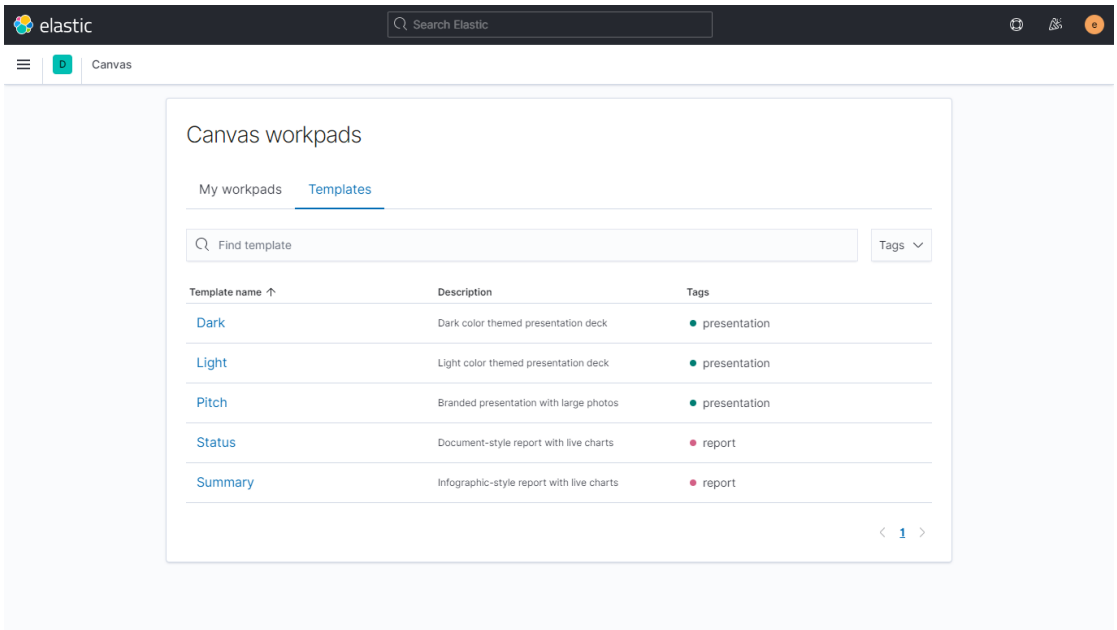
5.8 Canvas

Another functionality supported by the Data Visualization tool is the “Canvas” functionality. To access this functionality, the user needs to click on the second option of the “Canvas” button under the “Analytics” tools from the main menu.



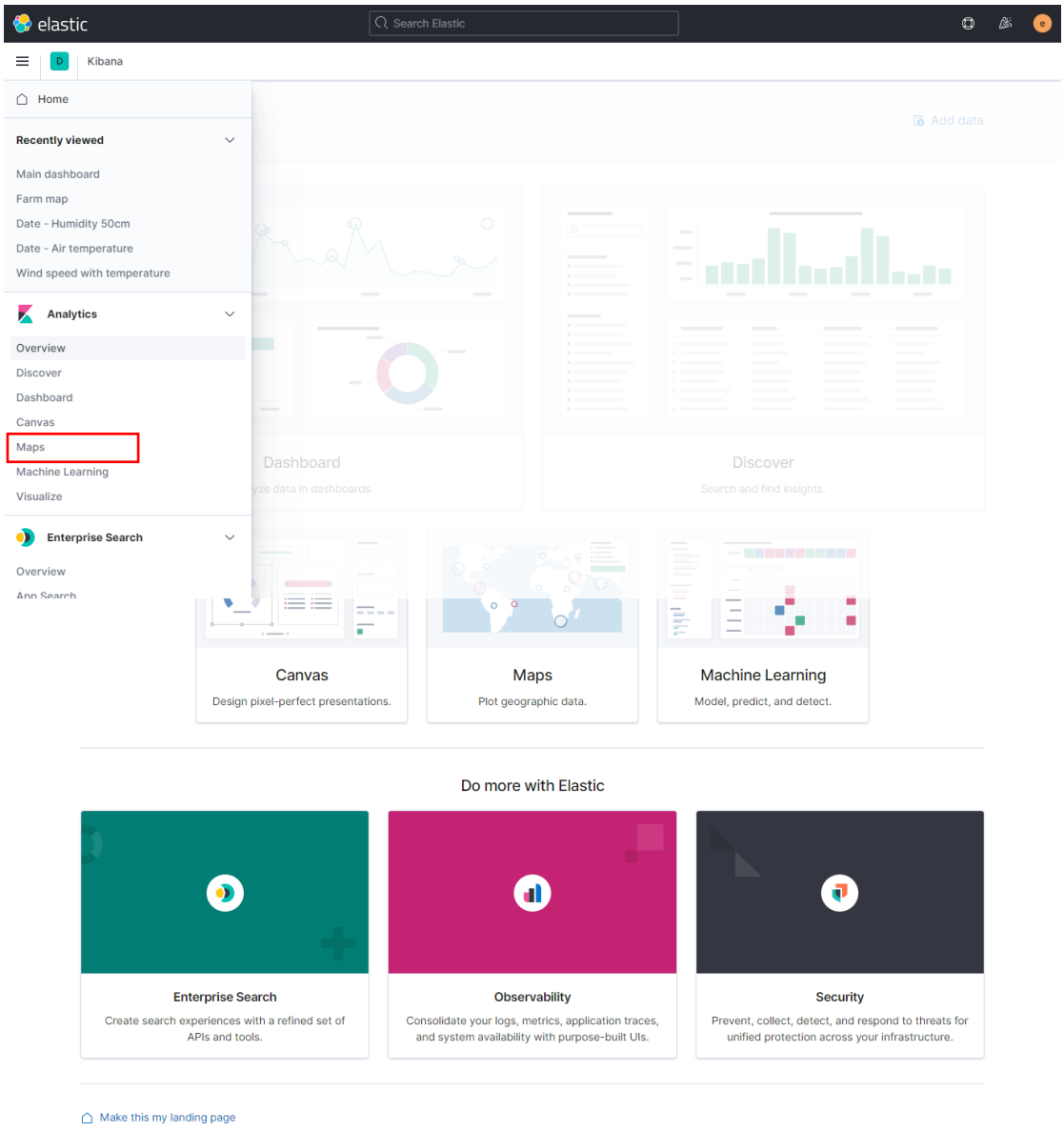
Here, the user can select one of the available Templates and create a presentation or a report using the visualizations.



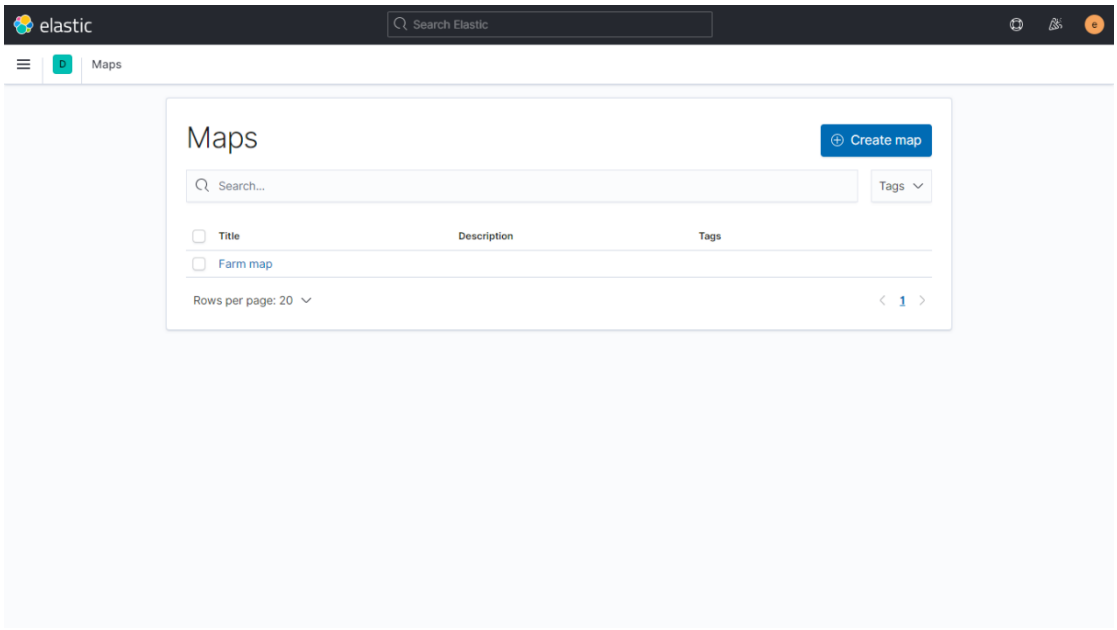


5.9 Map

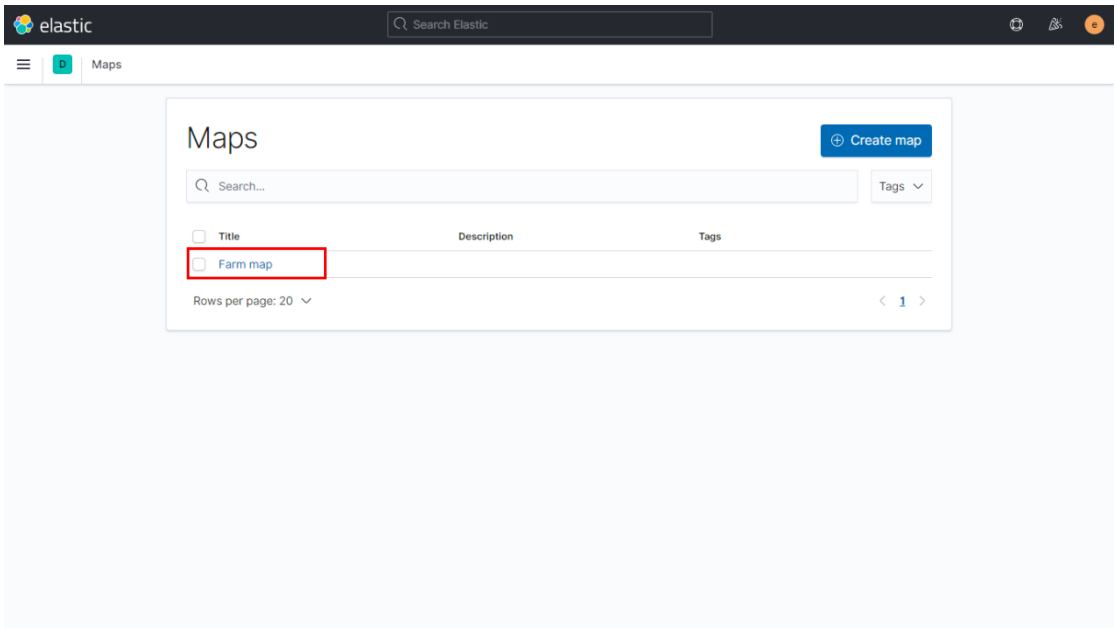
Another functionality supported by the Data Visualization tool is the “Maps” functionality. To access this functionality, the user needs to click on the second option of the “Maps” button under the “Analytics” tools from the main menu.



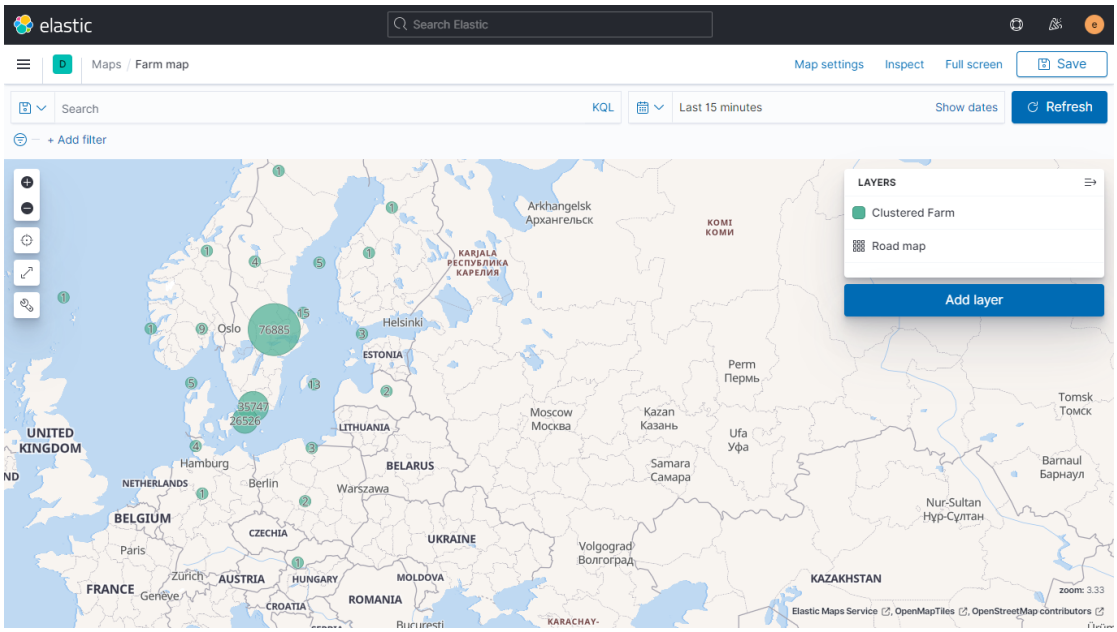
Here, the user can concentrate on the map-oriented visualizations. More specifically, the user can preview one of the existing maps or select to create a new map-oriented visualization by clicking on the “Create map” option.



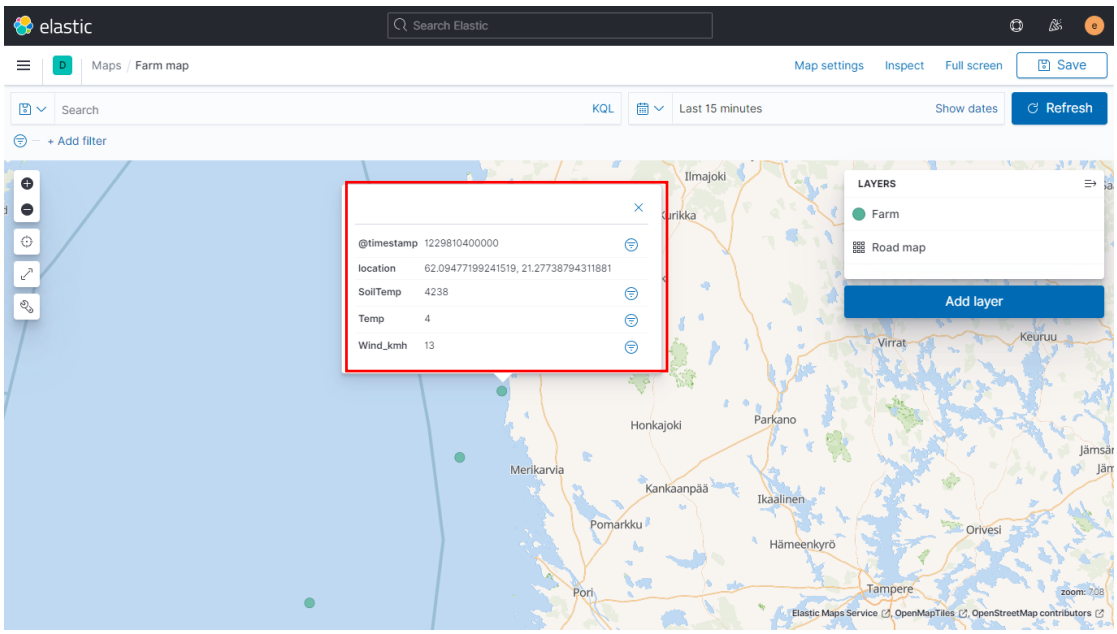
Let assume that the user clicks on the “Farm map” visualization which is one of the existing maps.



Then, the below page is presented displaying the selected visualization.

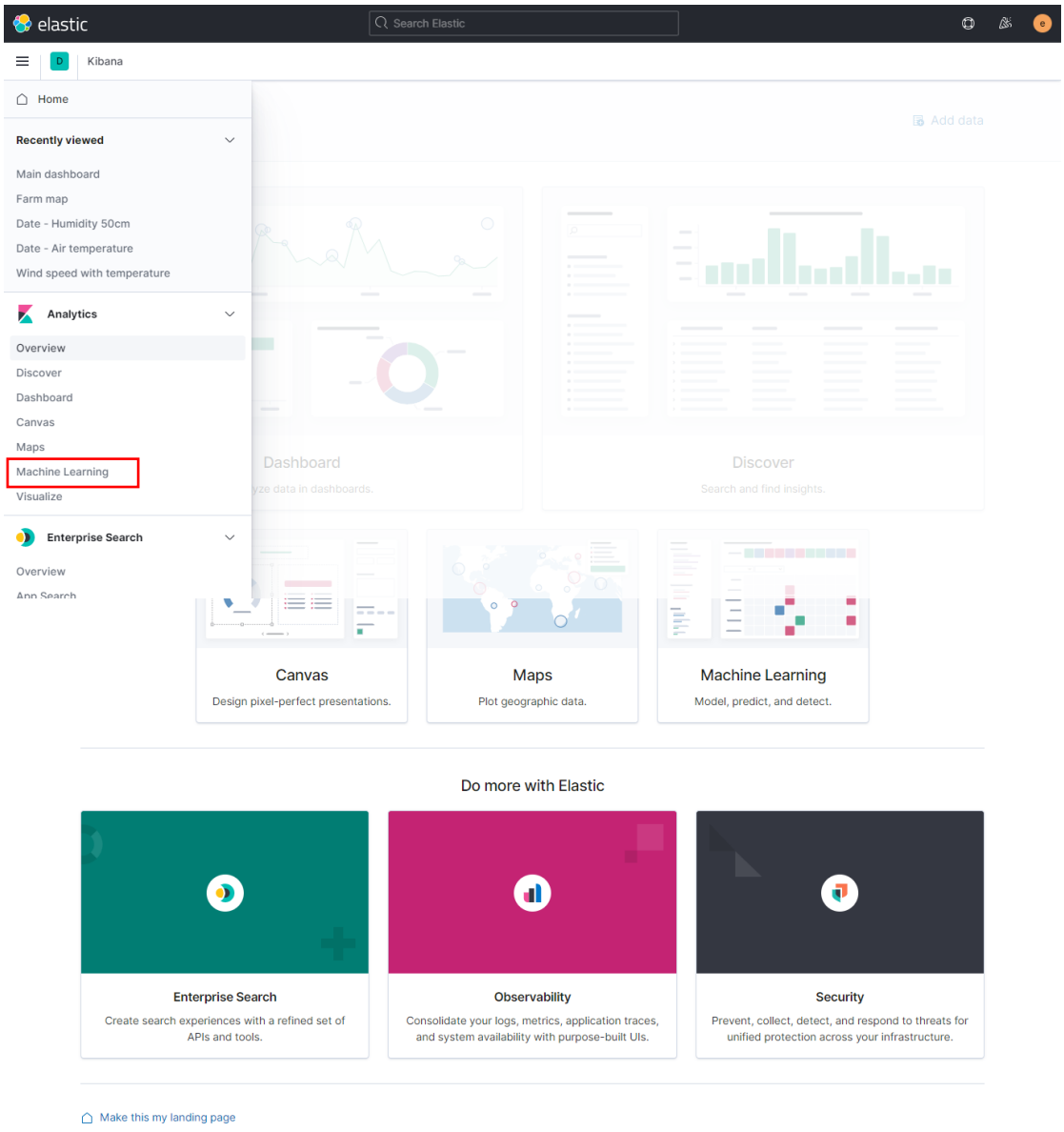


The user can navigate on the map and check on clusters or individual spots. If the user check on a single spot, all information attached to this spot is presented. An example of this information is depicted in the below figure.



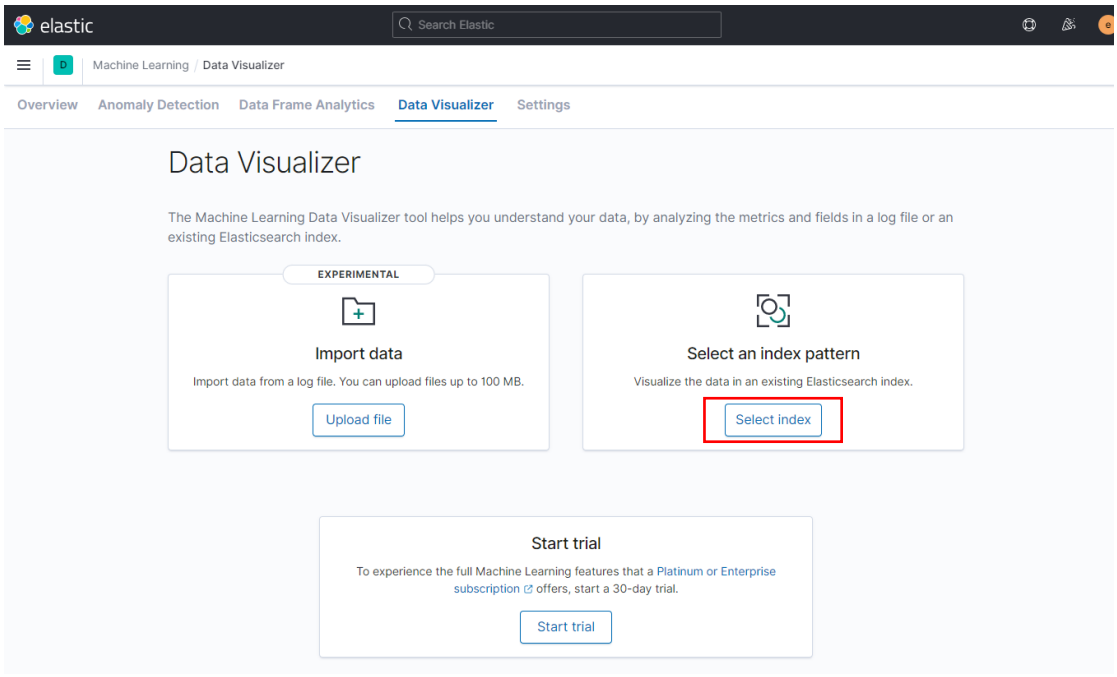
5.10 Machine learning

Another functionality supported by the Data Visualization tool is the “Machine learning” functionality. To access this functionality, the user needs to click on the second option of the “Machine learning” button under the “Analytics” tools from the main menu.

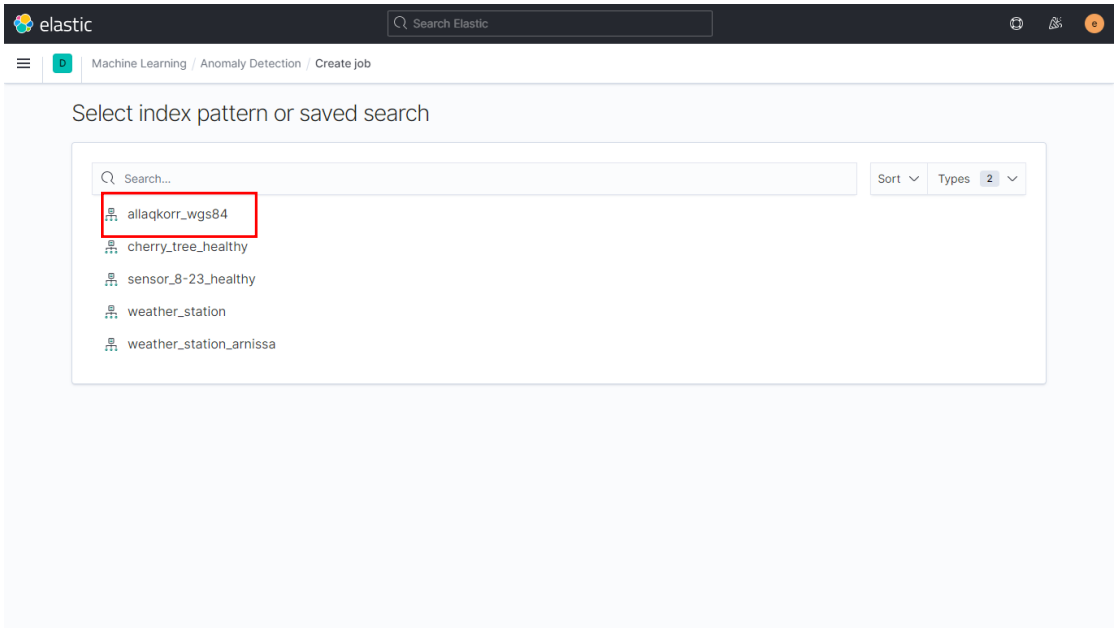


Here, the user can understand the data, by analyzing the metrics and fields in a log file or an existing Elasticsearch index. The options supported are to i) import data from a log file, or ii) select an index pattern. Another trial option accessing the full Machine Learning features is also offered.

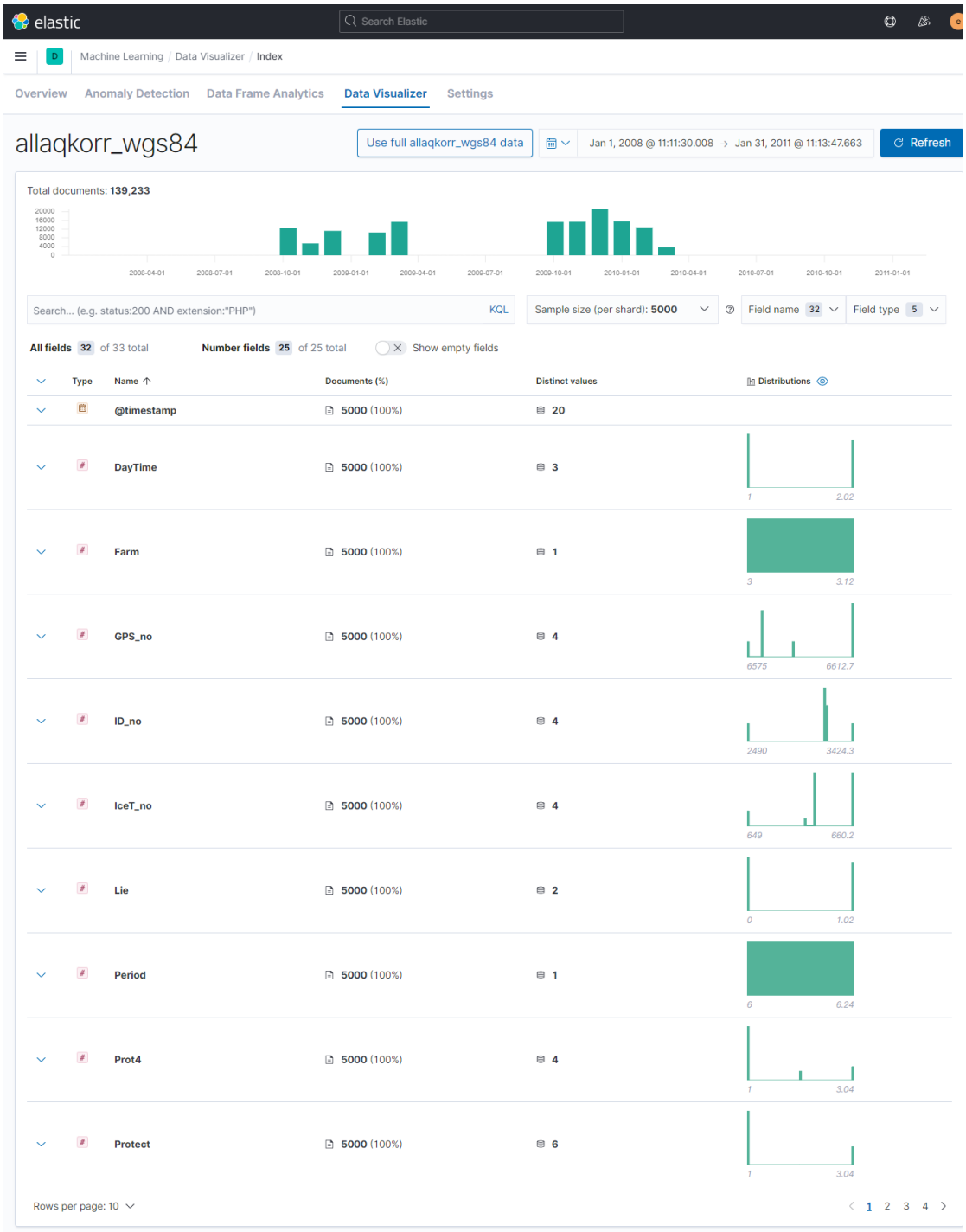
Let assume that the user clicks on the “Select an index pattern” button.



By clicking on the "Select an index pattern" button, the below page is presented asking the user to select the data collection with which he/she plans to work. Let assume that the user selects the "allaqkorr_wgs85" data collection that contains data about cattle.

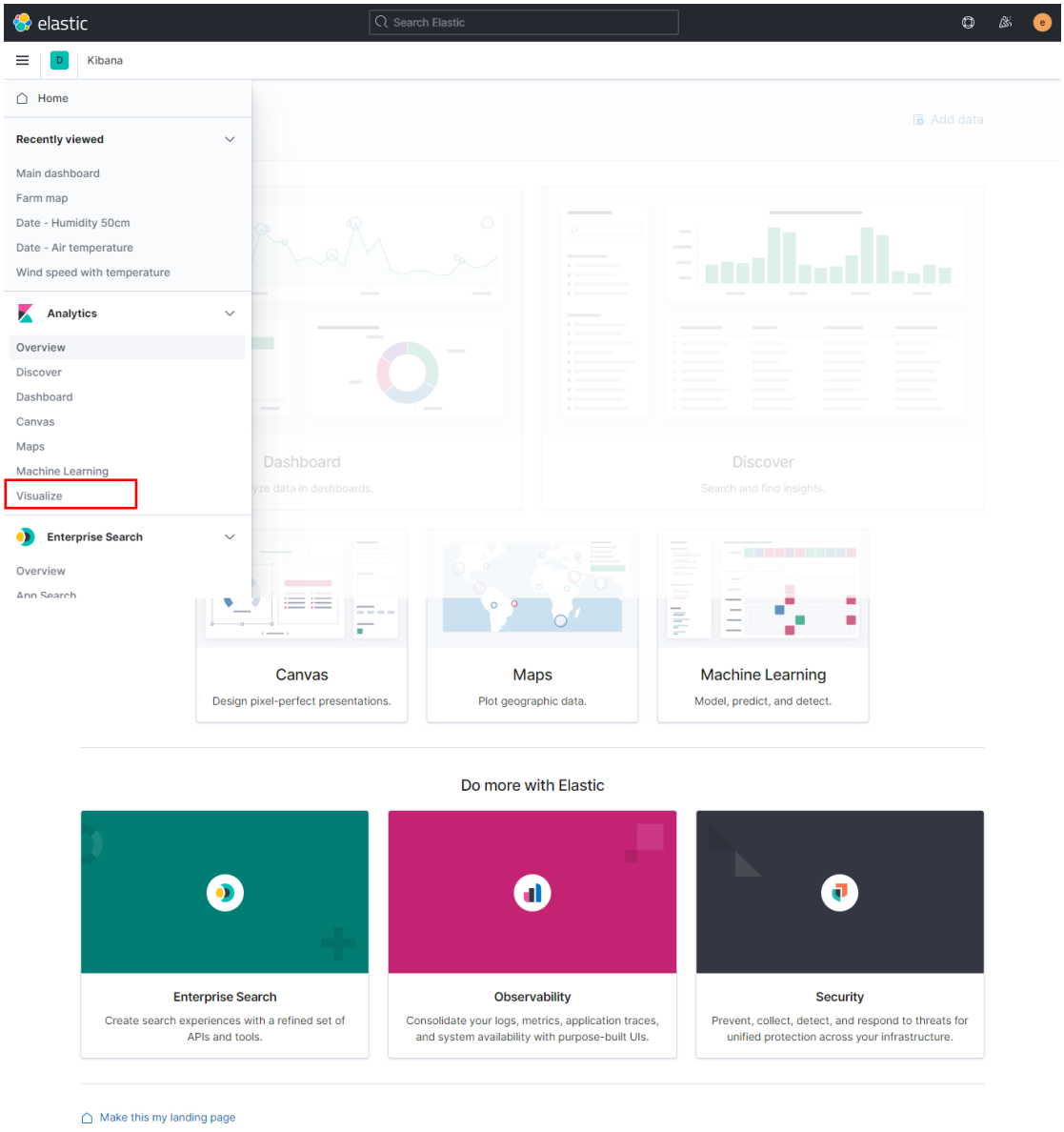


After clicking on this data collection, the below page is presented showing all information for all fields of the data collection.

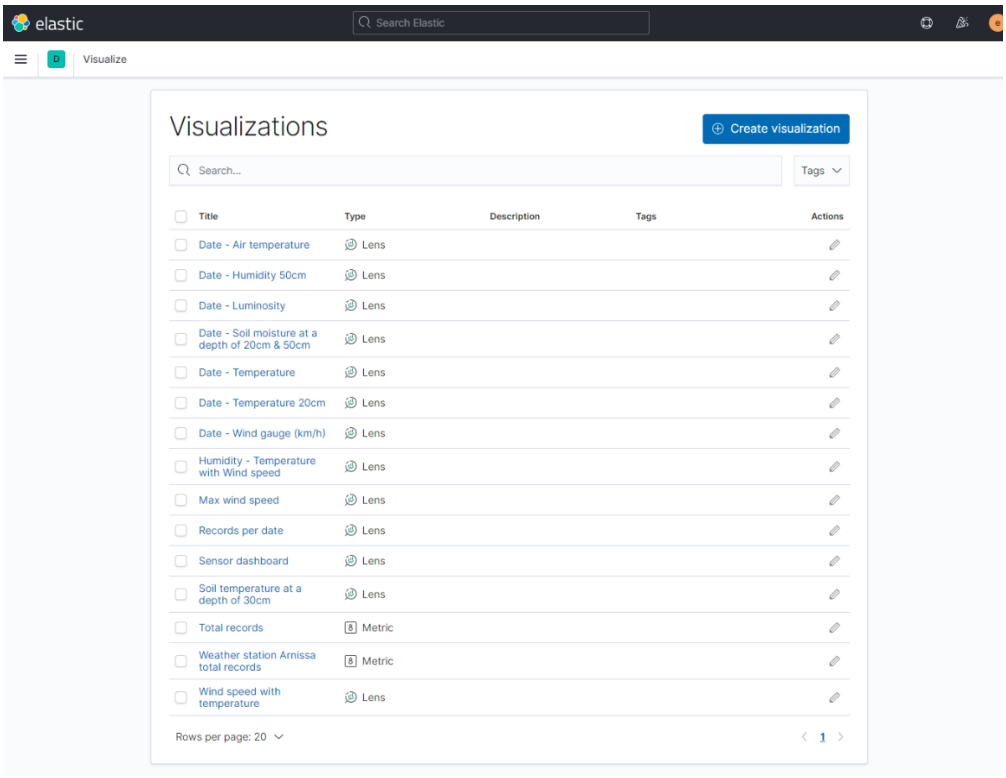

elastic
Search Elastic
Machine Learning / Data Visualizer / Index
Overview
Anomaly Detection
Data Frame Analytics
Data Visualizer
Settings
allaqkorr_wgs84
Use full allaqkorr_wgs84 data
Jan 1, 2008 @ 11:11:30.008 → Jan 31, 2011 @ 11:13:47.663
Refresh
Total documents: 139,233
Search... (e.g. status:200 AND extension:"PHP")
KQL
Sample size (per shard): 5000
Field name 32
Field type 5
All fields 32 of 33 total
Number fields 25 of 25 total
Show empty fields
Type
Name
Documents (%)
Distinct values
Distributions
@timestamp 5000 (100%) 20
DayTime 5000 (100%) 3 1 2.02
Farm 5000 (100%) 1 3 3.12
GPS_no 5000 (100%) 4 6575 6612.7
ID_no 5000 (100%) 4 2490 3424.3
IceT_no 5000 (100%) 4 649 660.2
Lie 5000 (100%) 2 0 1.02
Period 5000 (100%) 1 6 6.24
Prot4 5000 (100%) 4 1 3.04
Protect 5000 (100%) 6 1 3.04
Rows per page: 10
1 2 3 4

5.11 Visualize

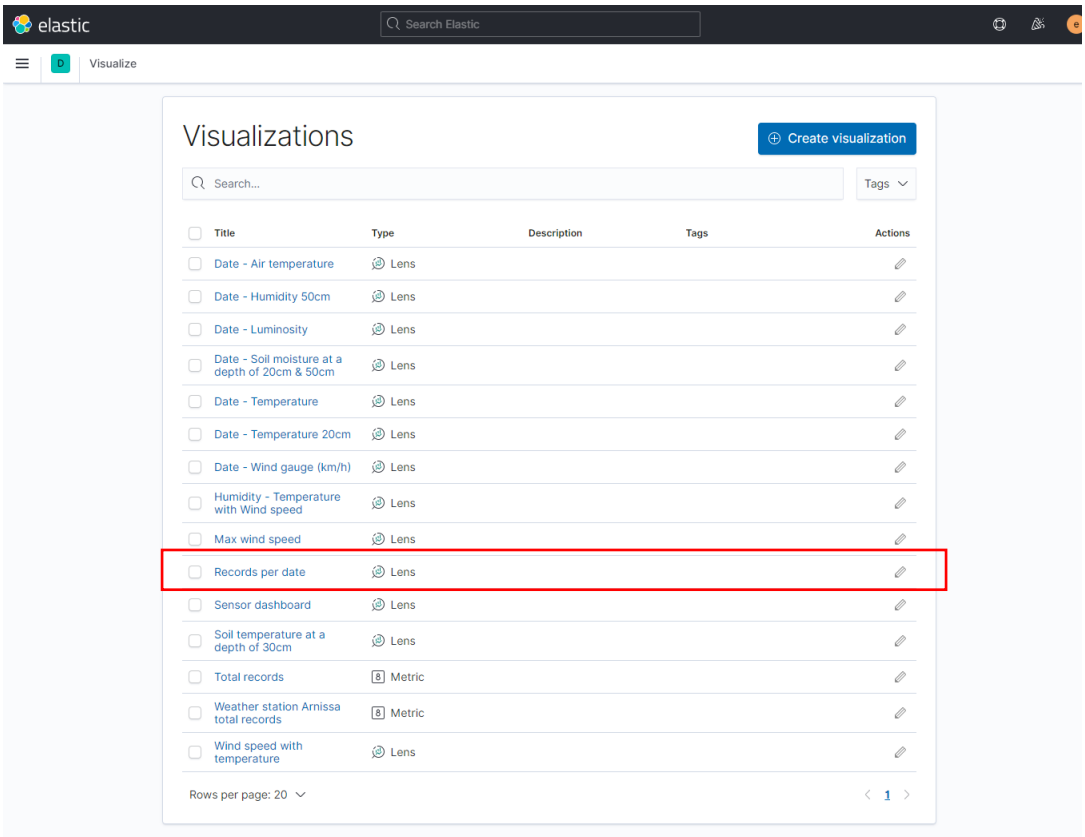
Another important functionality supported by the Data Visualization tool is the “Visualize” functionality. To access this functionality, the user needs to click on the second option of the “Visualize” button under the “Analytics” tools from the main menu.



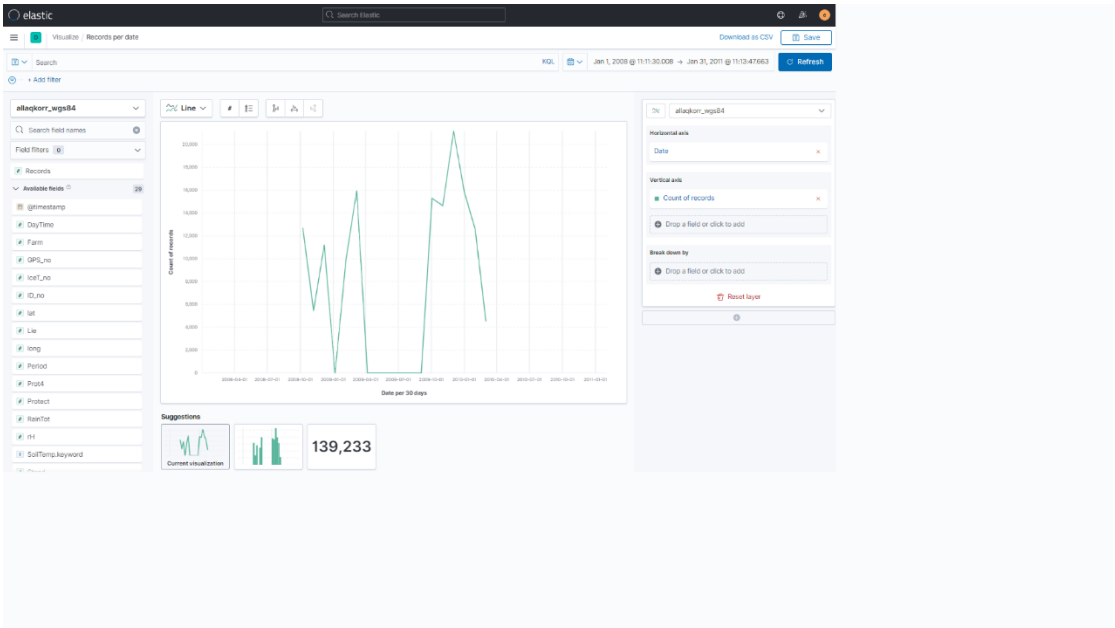
Here, the user can concentrate on the standalone visualizations. The user can preview one of the existing visualizations which are available in the Library or select to create a new visualization by clicking on the “Create visualization” option.



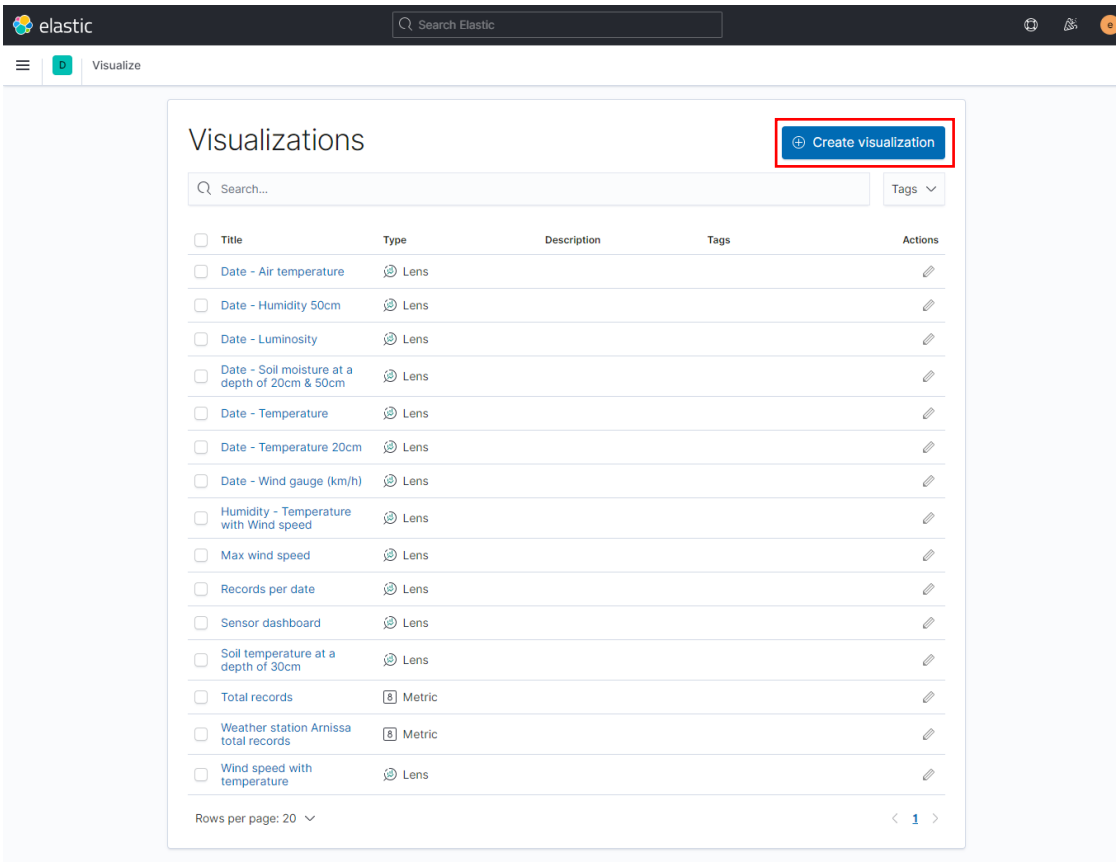
Let assume that the user clicks on the “Records per date” visualization which is one of the existing visualizations of the library.



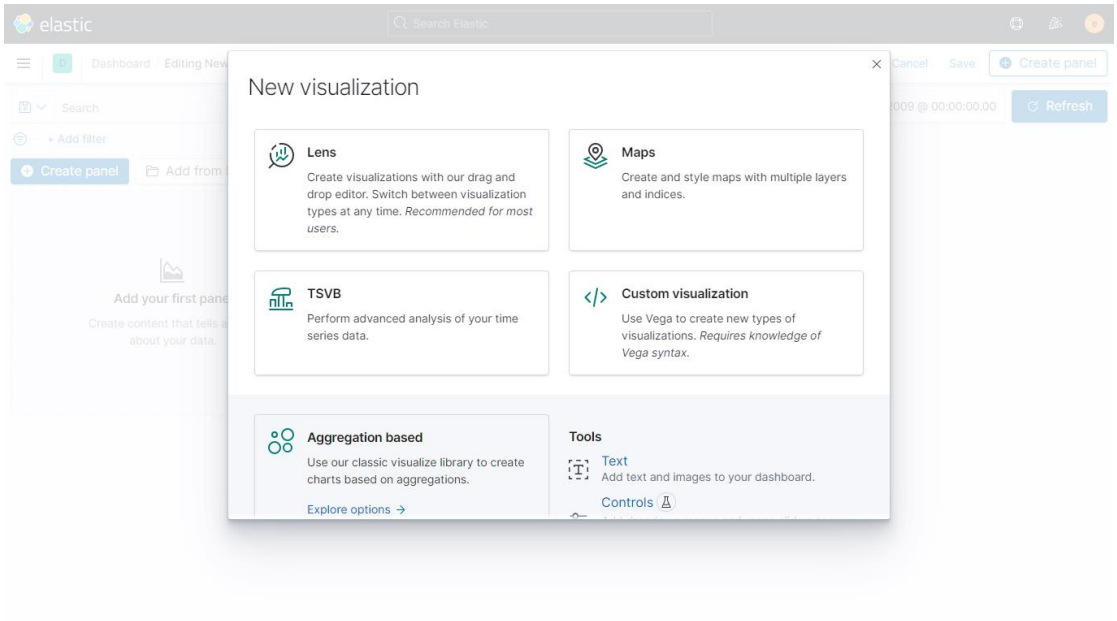
Then, the below page is presented displaying the selected visualization.



Let assume that the user clicks now on the “Create visualization” button.



Then, the below page is presented asking the user to select the method for creating the new visualization (this page has been already displayed under the “Dashboard” button).

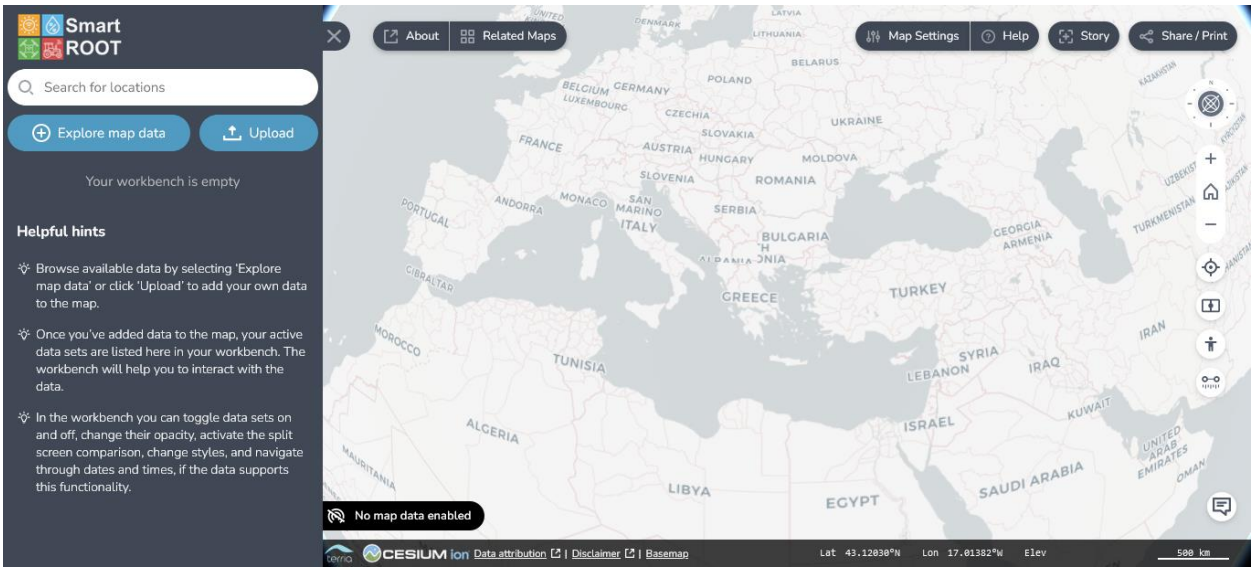


6 A tool for web-based geospatial catalogue explorers – TerriaJS

6.1 Overview

TerriaJS is a feature-rich, open-source solution for building spatial data federation web platforms.

The tool has been built in the context of the SmartROOT project for educational purposes.



6.2 Background Knowledge

To effectively use TerriaJS, it is helpful to have a basic understanding of Geospatial data and especially familiarity with geospatial data formats and concepts is important. Understanding concepts such as coordinate systems (e.g., latitude and longitude), projections, and common geospatial data formats like GeoJSON or Shapefiles will help you work with spatial data in TerriaJS.

Knowledge of RESTful APIs is also valuable as TerriaJS can consume data from web services using this approach. Understanding how to make HTTP requests, handle responses, and work with data formats commonly used in web APIs (e.g., JSON) will be beneficial for integrating external data sources into your TerriaJS applications.

Finally, as TerriaJS relies on CesiumJS for its 3D geospatial visualization capabilities, familiarity with CesiumJS concepts, such as entities, imagery layers, terrain rendering, and camera manipulation, will help you take full advantage of the mapping and visualization capabilities provided by TerriaJS.

6.2.1 Technology behind the tool

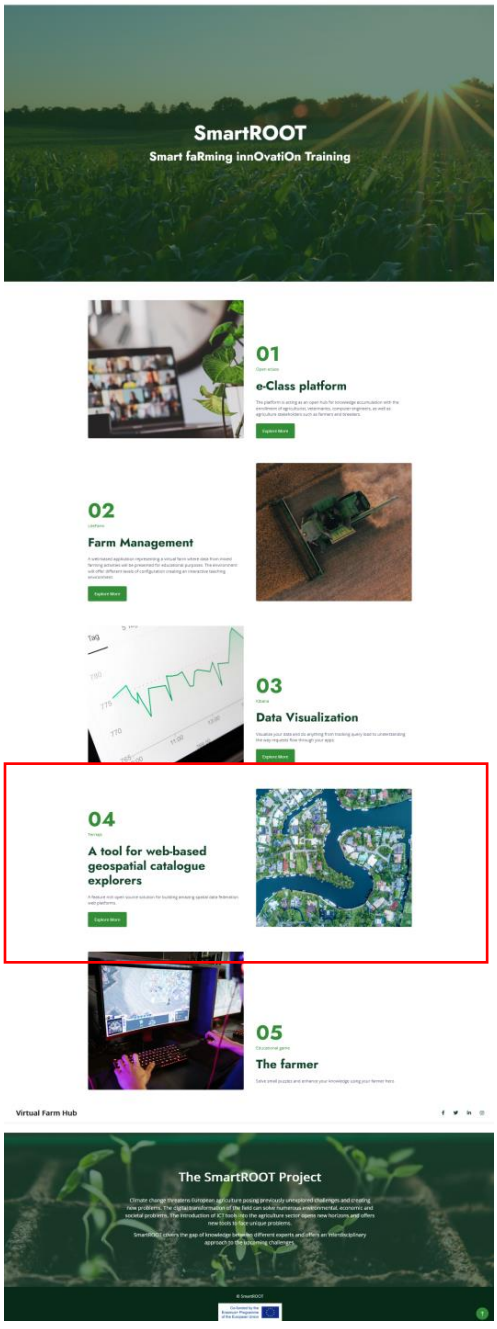
TerriaJS is an open-source, web-based geospatial data visualization platform developed by the Australian Government's National Map team. It provides a framework for building interactive geospatial applications and maps in a browser environment. The technology stack behind TerriaJS includes several key components:

1. JavaScript: TerriaJS is primarily built using JavaScript, a popular programming language for web development. It leverages modern JavaScript frameworks and libraries to create a rich and interactive user experience.
2. Web technologies: TerriaJS utilizes various web technologies such as HTML (Hypertext Markup Language) for structuring the content, CSS (Cascading Style Sheets) for styling, and JavaScript for interactivity.
3. CesiumJS: TerriaJS relies on CesiumJS, an open-source JavaScript library for creating 3D globes and maps in a browser. CesiumJS provides powerful geospatial visualization capabilities, including terrain rendering, imagery, and vector data.
4. React: TerriaJS employs the React library, a popular JavaScript framework for building user interfaces. React helps in creating reusable components and efficiently managing the application's state, making it easier to develop complex and interactive applications.
5. Redux: Redux is a predictable state container for JavaScript applications. TerriaJS uses Redux to manage application state, allowing for centralized control and easier tracking of changes across various components.
6. Node.js: TerriaJS can be run on the server-side using Node.js, a JavaScript runtime environment. Node.js allows TerriaJS to perform server-side operations and interact with external services, such as data sources or authentication systems.
7. RESTful APIs: TerriaJS can consume data from various sources using RESTful APIs (Representational State Transfer). It can fetch geospatial data, such as maps, imagery, and other spatial information, from web services and display them on the map interface.
8. GeoJSON and OGC standards: TerriaJS supports various geospatial data formats, including GeoJSON (a common format for representing geospatial data in JSON) and Open Geospatial Consortium (OGC) standards. This allows integration with a wide range of geospatial data sources and services that comply with these standards.
9. Plugin architecture: TerriaJS features a plugin architecture that allows developers to extend and customize its functionality. This architecture enables the integration of additional features, such as new data providers, geospatial analysis tools, or user interface enhancements.

Overall, TerriaJS leverages a combination of JavaScript, web technologies, geospatial libraries like CesiumJS, and modern web development practices to provide a powerful and flexible platform for building interactive geospatial applications and maps.

6.3 Walkthrough the tool for web-based geospatial catalogue explorers

From the navigation page of the Virtual Farm Hub (IO3) https://virtualfarm.infalia.com/, anyone can access the tool for web-based geospatial catalogue explorers https://terria.infalia.com/, which is the 4th available tool of the Virtual Farm Hub platform.

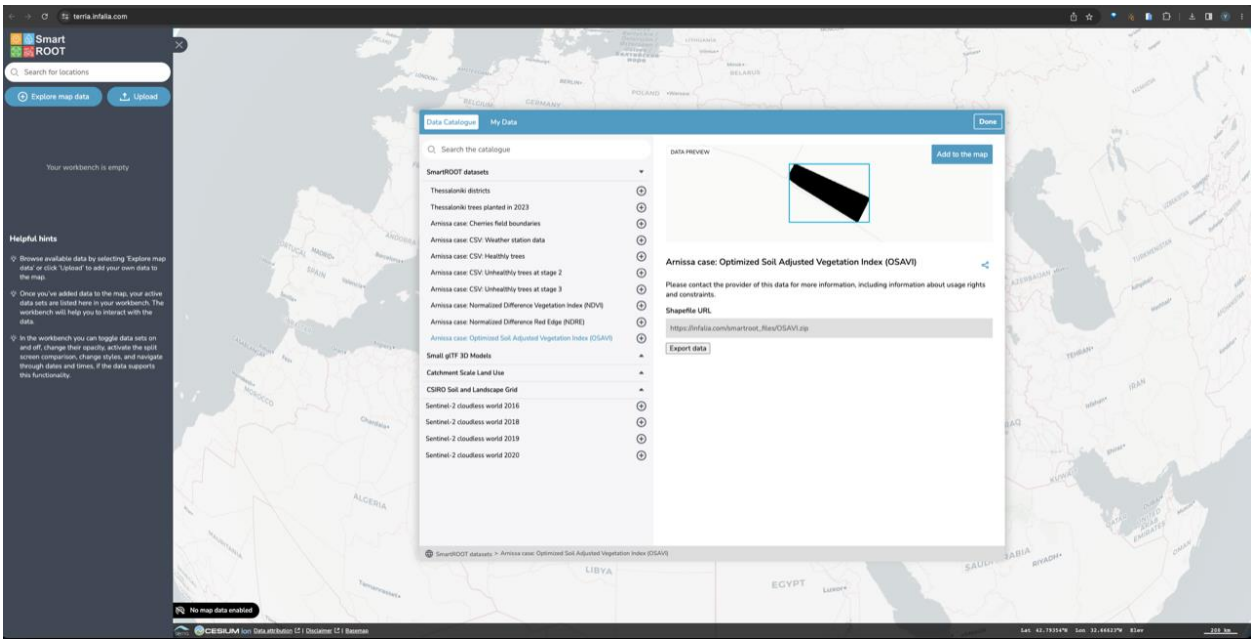


6.4 Overview

In SmartROOT Virtual Farm Hub, we customized the TerriaJS software to enable users to visualize their field data and plot parameters related to their fields.

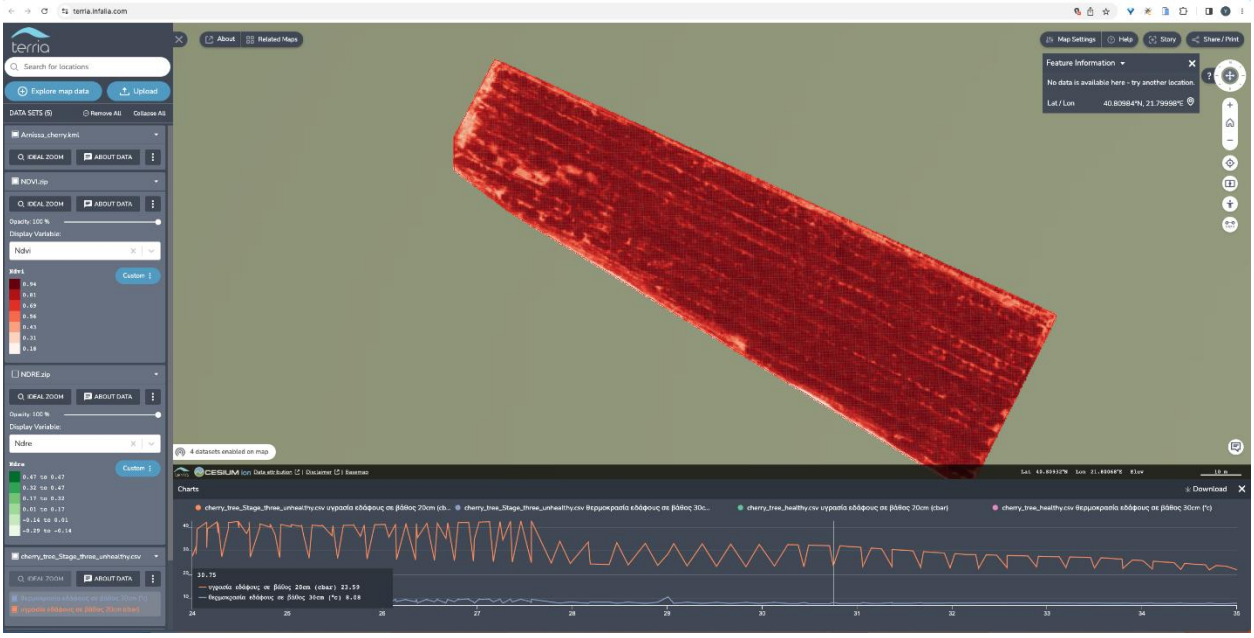
6.5 Customizations for the SmartROOT project

When the user enters the tool, a map is loaded and shows the European area. Moreover, the user is provided with a SmartROOT folder where s/he can find all available datasets from fields coming from the MARS project. By clicking on a dataset, the user can visualize the specific field and parameters related to that field.

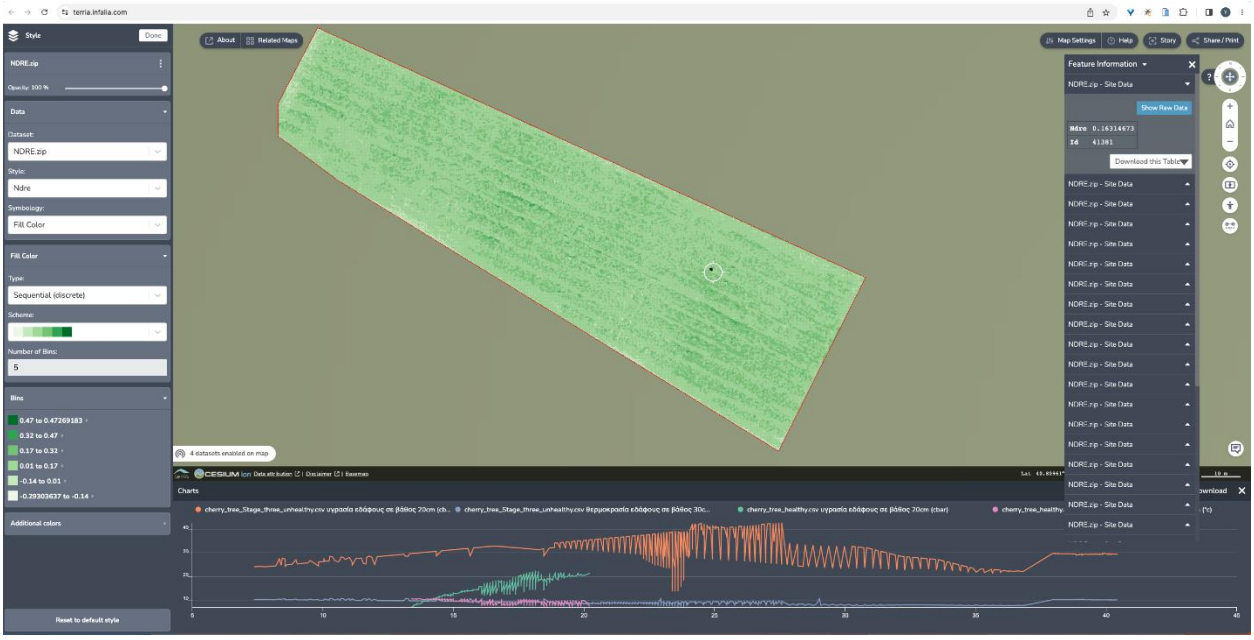


6.6 Examples with visualizations

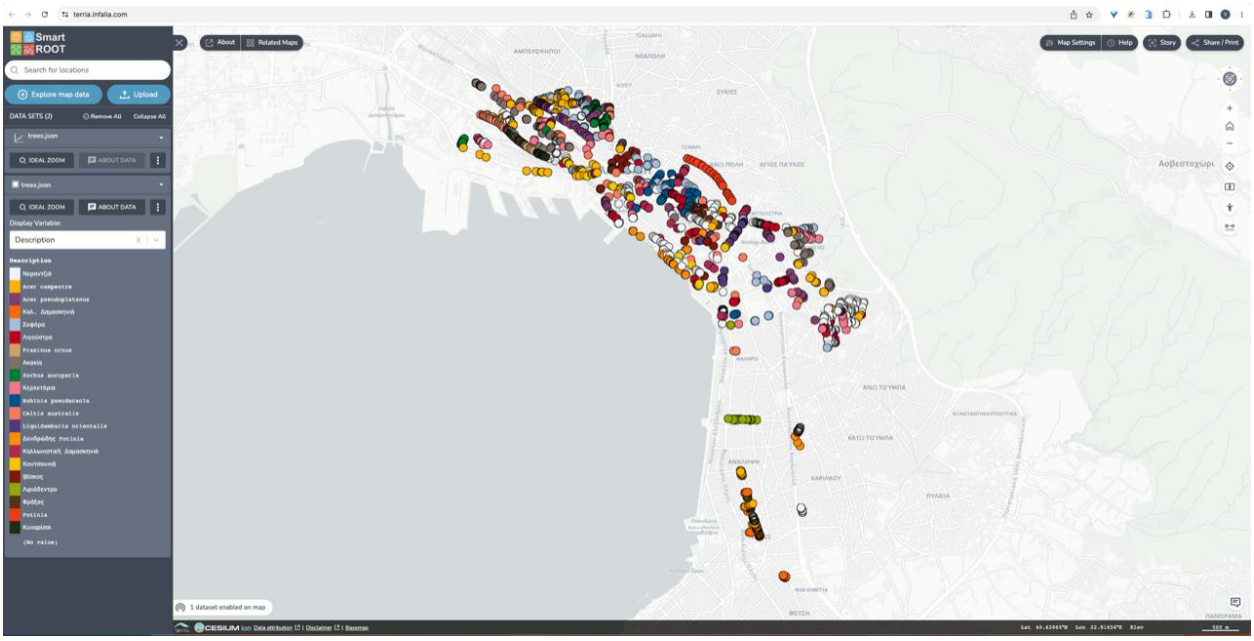
Below, we can see two visualization examples produced using the TerriaJS software from a field csv dataset coming from the MARS project. In the first visualization example, we can see the Ndvi of the field while below the visualization there are two plots with the soil temperature at a depth of 30cm and the soil humidity at a depth of 20cm.



Similarly, in the second visualization example (shown in the below figure), we can see the Ndre of the field. below the visualization, there are plots regarding the soil temperature and the soil humidity.



Another visualization example is coming from a dataset depicting the trees in Thessaloniki. With different colors are depicted the different tree categories.



7 Material/Data Needs

Data from mixed farming activities is required to initially populate the platform and be used for the training courses and for the educational activities. This data is expected to be provided by rest SmartROOT partners.

7.1 UOWM

UOWM provided a list of topics that have been used for the creation of the course structure in the educational platform.

The provided topics have been developed based on the chapters of the E-Book (IO1):

1. Introduction to Mixed Farming Systems
2. ICT in Agriculture
3. Food and safety
4. Animal production
5. Smart farming in Europe

The courses that have been developed in the educational platform and are correlated with the topics extracted from IO1 are presented below.

Main Course 1. Introduction to Mixed Farming Systems

Course subjects:

- Introduction
- Soil analysis
- Crop monitoring architecture
- Animal monitoring
- Food quality evaluation

Main Course 2. ICT in Agriculture

Course subjects:

- Introduction
- UAVs
- Big data in Agriculture
- Image processing
- Network communication technologies

Main Course 3. Food and safety

Course subjects:

- Preservation of agricultural goods
- Preservation of meat

- Best practices

Main Course 4. Animal production

Course subjects:

- Animal husbandry
- Precision livestock farming

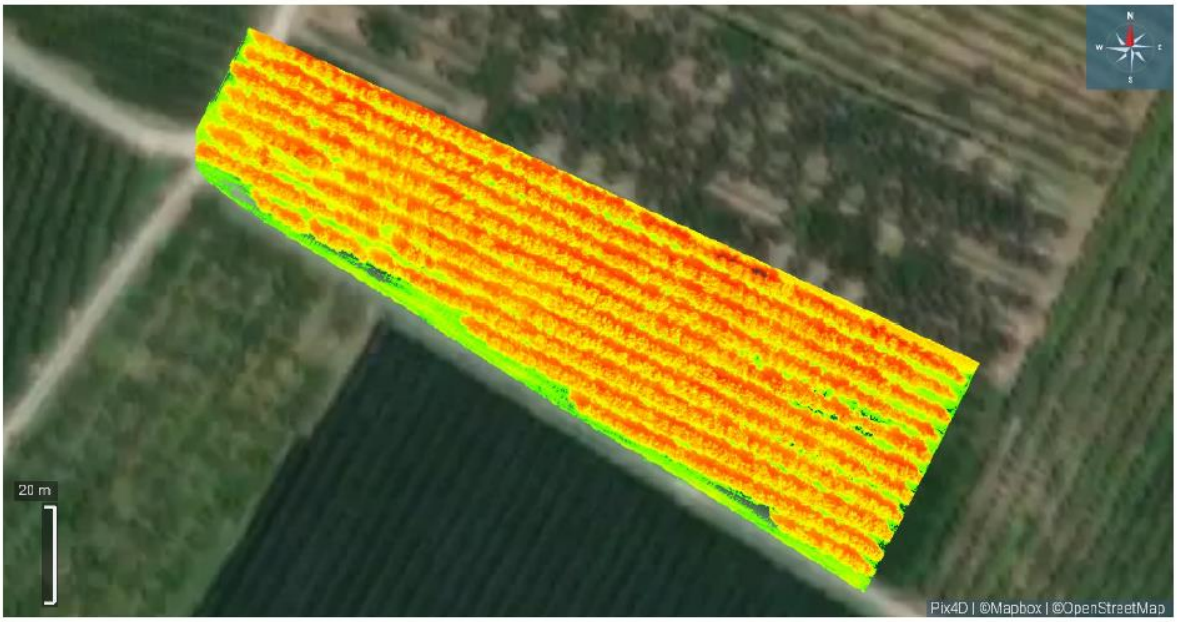
Main Course 5. Smart farming in Europe

Course subjects:

- Best farm practices for profitable farming
- The art of managing grain quality with silos
- Reshaping modern farming through agrotechnological fusion

Moreover, UOWM provided several multimedia files (images and a video) that have been derived from the MARS project[6] and can be used for the creation of educational activities. Some examples of these multimedia files are shown below:

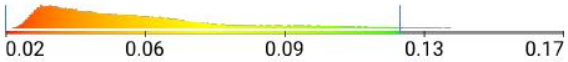
[6] https://project-mars.eu/



Map details

GSD	6.78 cm/px
Index	green

Histogram and Legend

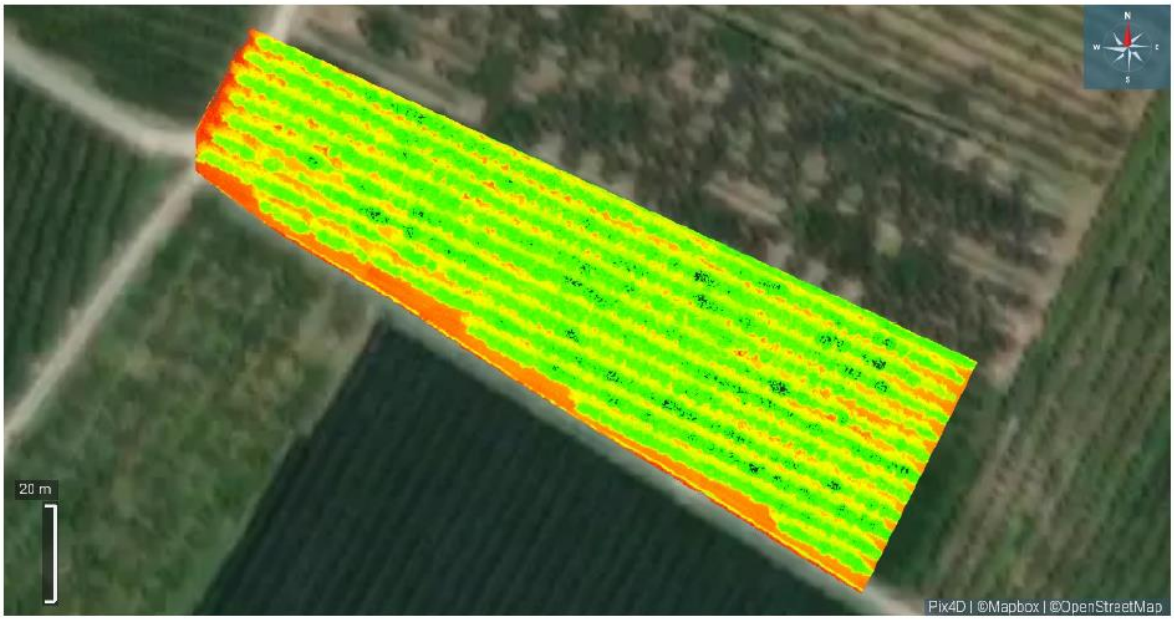


Visualization settings

Histogram equalization:	Off
Selected minimum value:	0.02
Selected maximum value:	0.12
Values out of range:	Transparent

Statistics

Layer area (ha):	0.59
Mean index value:	0.05
Index value SD:	0.03
Mean index value (visible):	0.05
Index value SD (visible):	0.02



Map details

GSD	6.78 cm/px
Index	NDVI

Histogram and Legend

Visualization settings

Histogram equalization: Off
Selected minimum value: 0.20
Selected maximum value: 0.92
Values out of range: Transparent

Statistics

Layer area (ha): 0.59
Mean index value: 0.70
Index value SD: 0.20
Mean index value (visible): 0.70
Index value SD (visible): 0.19

7.2 SLU

Moreover, SLU has provided some experimental data from an experiment with cattle, while additional experimental data are also available from an experiment with lambs and another with grazing cattle. Some examples of these experimental data are shown below:

Group data

Group data on purebred dairy and dairy x beef steers in forage and pasture-based production systems, where spring-borne cattle were kept on a high feed intensity and slaughtered at 21 months of age, while autumn-borne cattle were kept on a low feed intensity and slaughtered at 28 months of age. (IP = indoor period)

Pen. no	13	14	15	16	17	18	19	20
Breed[a]	1	2	1	2	1	2	1	2
Feed intensity[b]	1	1	1	1	1	1	1	1
Pen pair, no.	1	1	2	2	3	3	4	4
Parasites[c]	1	1	2	2	1	1	2	2
Dietary intake, kg of dry matter IP1	6.323	5.812	6.245	6.134	5.745	5.837	5.489	5.380
Dietary intake, % of liveweight IP1	2.357	2.629	2.481	2.542	2.429	2.534	2.485	3.003
Intake of neutral detergent fiber, kg IP1	3.427	3.037	3.358	3.248	3.040	3.046	2.843	2.673
Feed efficiency, ME MJ g gain^{-1} IP1	62.88	62.98	65.19	60.88	59.67	56.91	56.79	58.30
Dietary intake, kg of dry matter IP2	11.021	11.308	12.124	12.111	12.372	12.133	11.638	11.472
Dietary intake, % of liveweight IP2	0.091	2.211	2.297	2.346	2.233	2.166	2.252	2.428
Intake of neutral detergent fiber, kg IP2	7.047	5.969	6.491	6.485	6.724	6.526	6.348	6.261
Feed efficiency, ME MJ g gain^{-1} IP2	114.66	113.50	117.57	110.69	103.94	101.99	103.33	103.08
Dietary intake, kg of dry matter IP3	.	.	.	.	.	.	.	.

Dietary intake, % of liveweight IP3	.	.	.	.	.	.	.	.
Intake of neutral detergent fiber, kg IP3	.	.	.	.	.	.	.	.
Feed efficiency, ME MJ g gain^{-1} IP3	.	.	.	.	.	.	.	.

Individual data

Individual data on purebred dairy and dairy x beef steers in forage and pasture-based production systems, where spring-borne cattle were kept on a high feed intensity and slaughtered at 21 months of age, while autumn-borne cattle were kept on a low feed intensity and slaughtered at 28 months of age (IP = indoor period, GP = grazing period)

Animal ID	8247	8255	8271	8286	8244	8254	8276	8294
Date of birth	150418	150425	150505	150509	150415	150425	150506	150511
Pen no.	13	13	13	13	14	14	14	14
Breed[a]	1	1	1	1	2	2	2	2
Feed intensity[b]	1	1	1	1	1	1	1	1
Pair of calves, no	1	2	3	4	1	2	3	4
Parasites[c]	1	1	1	1	1	1	1	1
Weight gain IP1, kg d^{-1}	1.210	1.072	1.115	0.991	0.987	0.982	1.045	1.066
Weight gain GP1, kg d^{-1}	0.243	0.560	0.577	0.835	0.412	0.500	0.539	0.518
Weight gain IP2, kg d^{-1}	1.175	1.349	1.198	1.127	1.063	1.012	0.944	1.123
Weight gain GP2, kg d^{-1}	.	.	.	.	.	.	.	.
Weight gain IP3, kg d^{-1}	.	.	.	.	.	.	.	.
Weight gain total, kg d^{-1}	0.951	1.003	0.995	0.982	0.855	0.864	0.890	0.937
Weight at slaughter, kg	676.5	680.5	675.0	654.0	580.0	578.5	564.0	601.0
Carcass weight, kg	329.8	333.7	333.7	320.5	262.6	271.1	253.2	267.5
Dressing, %	48.8	49.0	49.4	49.0	45.3	46.9	44.9	44.5

Conformation, score[d]	5	6	5	6	3	4	4	4
Fatness, score[e]	7	6	8	7	6	7	6	6
Marbling, score[f]	2	1	2	1	3	1	2	1
Weight of HQ[g], kg	84	84.5	84.5	81.5	68.5	69.5	65.5	69
Trim fat, % of HQ	4.87	4.39	7.88	4.61	7.99	6.81	6.09	5.78
Gr. 2 meat ass.[h], % of HQ	22.1	23.1	20.6	22.2	20.2	20.0	20.6	21.6
Gr. 3 meat ass.[i], % of HQ	11.8	10.2	12.4	12.0	9.8	9.6	11.2	11.4
Bone, % of HQ	20.8	20.2	19.1	19.9	21.4	22.0	21.7	21.6
Retail cuts[j], % of HQ	37.2	38.8	35.3	37.8	36.4	37.8	36.6	35.2
Slaughter age, d	648	641	631	627	651	641	630	625
Relative age[k], d	3	10	20	24	0	10	21	26
Initial weight IP1, kg	157	132.5	131.5	117.5	112.5	106.5	77.5	89
Initial weight GP1, kg	494	431	442	393.5	387.5	380	368.5	386
Initial weight IP2, kg	528.5	510.5	524	512	446	451	445	459.5
Initial weight GP2, kg	.	.	.	.	.	.	.	.
Initial weight IP3, kg	.	.	.	.	.	.	.	.

[a]1 is dairy x beef crossbreed, 2 is dairy breed.

[b]1 is high feed intensity with 21 months slaughter age, 2 is low feed intensity and 28 months slaughter age.

[c]1 is not infected, 2 is infected.

[d]EUROP system on a scale 1 = poor, 15 = excellent.

[e]EUROP system on a scale 1 = lean, 15 = fat.

[f]Visually determined in *Musculus longissimus dorsi* between 10th and 11th ribs on a scale 1 = lean and 5 = well marbled.

[g]Right hind quarter.

[h]Commercial cut meat assortment estimated to contain 10% fat.

[i]Commercial cut meat assortment estimated to contain 23% fat.

[j]High-value retail cuts; strip loin, fillet, topside, outside round, eye of round, top rump, and rump steak

[k]Relative to the oldest animal in that feed intensity group.

8 References

J. Shepherd, P. Bunting και J. Dymond, “Operational large-scale segmentation of imagery based on iterative elimination”, Remote Sensing, 2019. https://doi.org/10.3390/rs11060658

Appendix A: The “Farmer” educational game

Farmer (https://farmer.infalia.com/) is the name of the interactive game that has been developed as an extra feature on top of the context of the SmartROOT Virtual Farm Hub platform for educational purposes under the frame of IO3. With the “Farmer” game, students can play and, in the meantime, test their knowledge in the MSF field. The tool has been developed with the Unreal Engine 4.22, which is one of the most powerful real-time 3D creation tools.