D6.3 - Interactive multi-dimension visualization & dissemination tools

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Contributors	Elena Rubinacci (Neatec)
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1. Executive summary

The purpose of this document is to describe the design and development work of the mobile application that exposes the data and services of the Sebastien project. The mobile application was conceived as an alternative to the desktop portal, allowing users to access data and services anytime and anywhere, even without a PC, directly from their mobile phones. This premise clearly indicates that the mobile app has been designed and developed to offer users the same functionalities available in desktop mode, albeit adapted for different usability.

Like the portal, the mobile app queries and retrieves forecasting indicators that are produced periodically, and to achieve this, it is closely integrated with the Sebastien data lake. This document will describe the technologies chosen for the application's development (3. Technology Stack), outlining the considerations that led to this choice and illustrating the advantages of their implementation.

Following this, the services available within the mobile app will be presented, accompanied by screenshots that clearly demonstrate the functionalities available to users. This chapter will also describe other pages or features deemed necessary to implement within the app to provide the expected support to users.

Finally, the last chapter presents the conclusions of this work. This effort is the result of an analysis of the requirements for the application services, stemming from continuous interaction with partners and stakeholders to identify end-user needs and how the data should be accessible and displayed. The web portal will be built "on top" of the forecasting models and will query and/or retrieve the forecasting indicators produced periodically. To provide unified access to data sets and services, the web portal requires close integration with the SEBASTIEN data lake.

2. App design and development

The design phase of the mobile app was a crucial step in the development process, aimed at ensuring an optimal user experience and meeting the specific needs of the target audience. Initially, a thorough analysis of the requirements was conducted, involving stakeholders to gather feedback and understand their expectations. This phase also included market research to analyze any apps centered on similar themes, identifying best practices and areas for improvement.

Subsequently, an information architecture map was developed, clearly defining the app's structure and user flows. Through the creation of wireframes, we began visualizing the layout of the screen elements, facilitating an initial exchange of feedback. These wireframes were refined over time through a long interactive process involving all project partners and stakeholders during meetings. Once the wireframes and all expected functionalities were defined, the design of the user interface (UI) and user experience (UX) commenced, creating high-fidelity mockups and interactive prototypes. This phase concluded with the drafting of detailed design specifications, which served as a guide during the development phase, ensuring a consistent execution aligned with the project objectives.

Once the implementations were completed, usability testing was conducted to verify the application's response from both a functional and performance perspective. During the usability tests, valuable insights were gathered to optimize user flows and interactions, ensuring that the app was not only aesthetically pleasing but also intuitive and functional.

The following paragraphs illustrate the screens that make up the app and the functionalities contained within them.

2.1 Login

Once the app is downloaded and installed, after an initial screen displaying the Progetto logo, the user registration form appears. Registrations for the app and the portal use the same service; therefore, the user can register for the first time on either channel and use the same account to log in.

In the case of a user who has never registered (not even on the portal), the user can click the "Register" link located at the bottom right of the form:
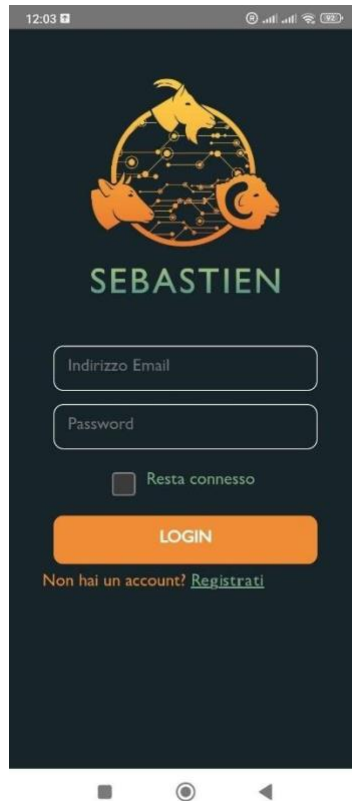
Clicking on this link will load a new form where the user can enter their personal information and confirm their registration:
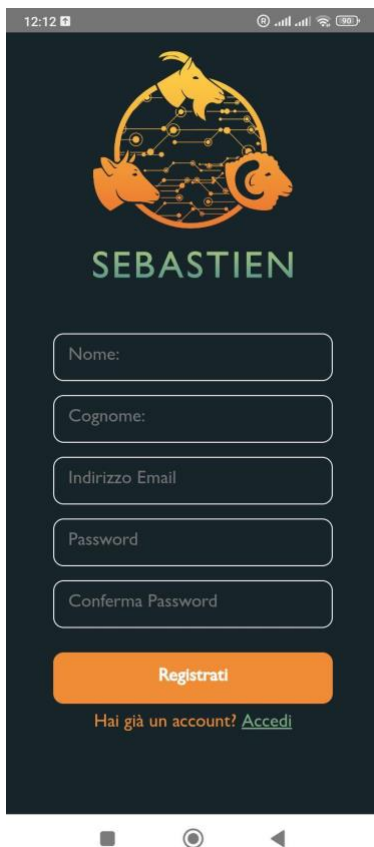
The entered data can still be modified over time through an edit form that will be made available on the user's Profile page (see 2.3 Home).

On the other hand, in the case of an already registered user, they can directly enter their credentials and click the "LOGIN" button to access the app:
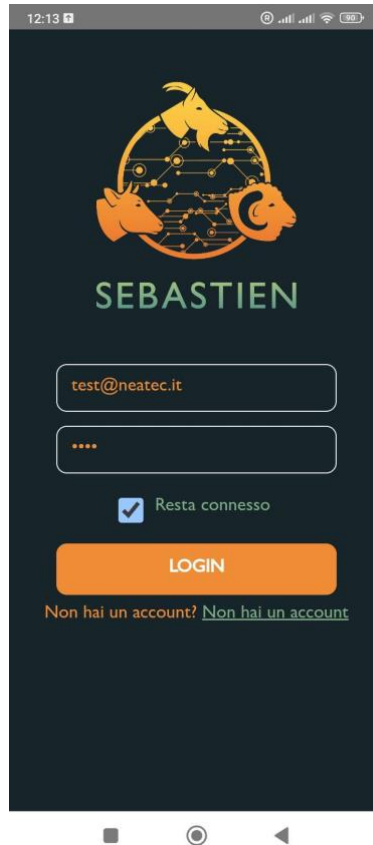

The user can also enable the "Stay connected" checkbox to keep the login active and avoid having to re-enter their credentials on subsequent visits.

2.2 Tutorial

Upon first access to the app, a tutorial appears that illustrates the main features of the application. Specifically, there are 4 screens explaining the 4 main services. For each of these, there is a corresponding logo and an introductory description.

The user can scroll through the tutorial using the arrow keys at the bottom or by swiping the screen. Alternatively, they can click the "Skip" button to close the tutorial. Once closed, the user will land on the Home page.
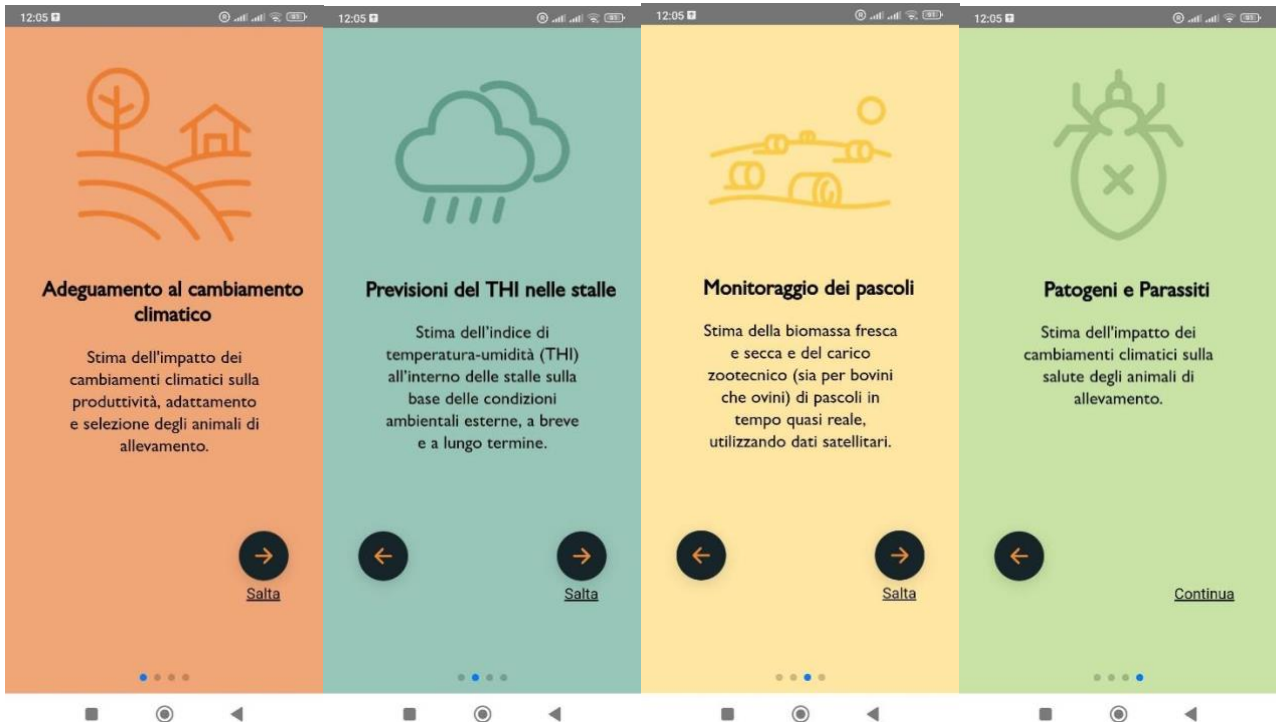
The tutorial will still be available under a dedicated section in the burger menu (see *2.3 Home*).

2.3 Home

The Home page features a very simple and intuitive structure, making it familiar to users from the first use. At the top of the page, there is a slider that hosts scrolling cards: each card presents a brief description and a background photograph.

The idea was to create a communication space between the Progetto Sebastien and its users: the slider can host static cards that illustrate the project's features or display news and events that will change dynamically over time.

To this end, the component was developed to be very flexible, able to respond to various needs that may arise over time. Currently, four cards with static information representative of the Sebastien project have been included.

The central (and largest) part of the screen is reserved for the four services of Sebastien. Each service is represented by a button with the corresponding logo and label. When clicked, the user is taken to the detail page of the service or to an intermediary page in the case of sub-services.

For more details, please refer to section 2.4 Services.

Finally, in the top right corner, there is a burger menu, which is a button that opens a panel containing the following pages:
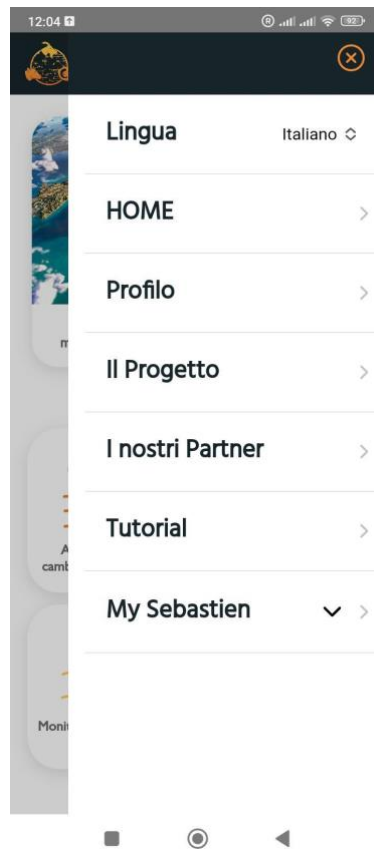
- **Language**: Clicking on this option opens a popup that allows the user to choose their preferred translation (Italian or English). For now, only these two languages have been implemented, but the library used (see *3.4 Ngx-translate*) allows for additional translations to be added dynamically.
- **Home**: Clicking on this option will redirect the user to the Home page. This link can be very useful when the user is in a deeply nested screen, where the "back" button would require too many clicks to return to the initial page.
- **Profile**: Clicking on this option takes the user to a screen that allows them to view and modify the data they entered during registration. In particular, the user can click the "Change Password" button to modify it; by clicking the "Edit Personal Info" button, the user can change the first and last name they previously selected:
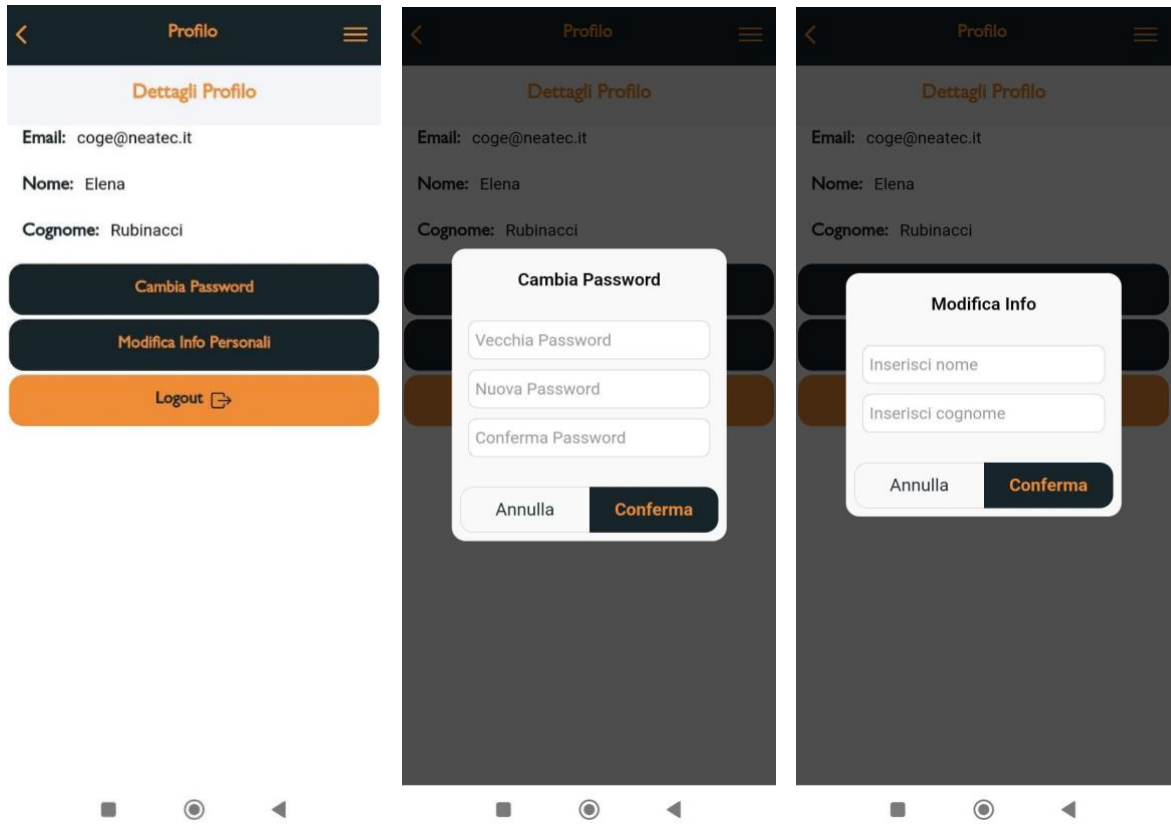
- **The Project**: This page serves as a descriptive space dedicated to the project, providing users who encounter Sebastien for the first time through the mobile app with immediate access to information to understand its objectives and purposes:
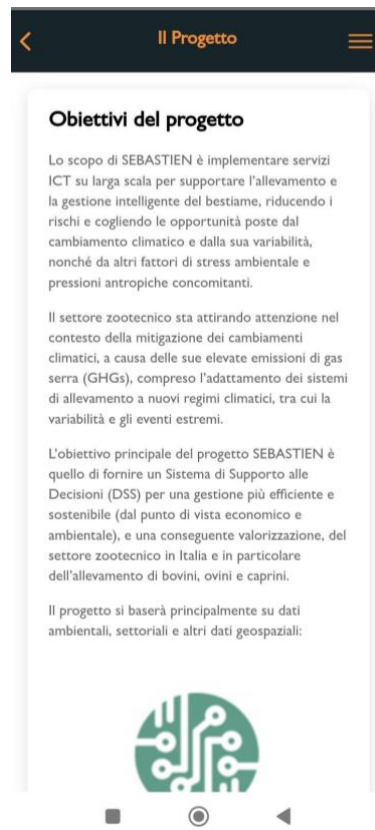
- **Our Partners**: This screen displays a list of all the partners who participated in the Sebastien project. Each partner has a dedicated card, which includes their logo and a description:

- **Tutorial**: Clicking on this option takes the user to the tutorial slider, allowing them to explore it further.
- **My Sebastien**: Clicking on this option opens a submenu consisting of three items: Stables, Pastures, and Sensors. In addition to services, Sebastien provides access to a catalog of data and indicators. For more details, please refer to section *2.5 My Sebastien*.
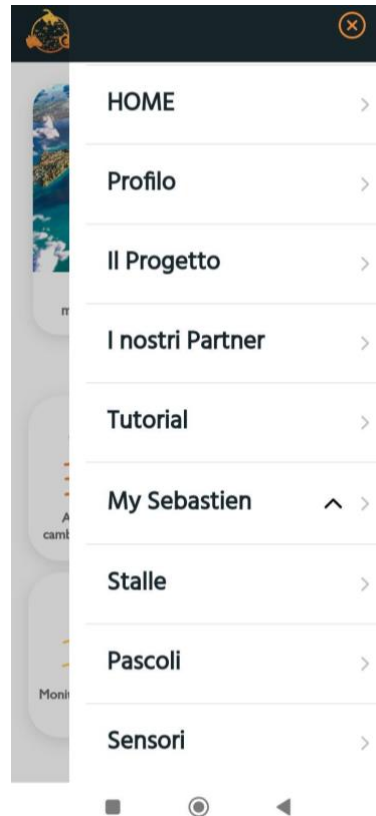
2.4 Services

This paragraph describes the main functionality of the mobile app, which is access to the services and their related data. The services are as follows:

1. **Service 1: Coping with environmental stressors for breeds**
2. **Service 2: Intensive farming risk management under climate extremes**
3. **Service 3: Extensive farming management and feed availability**
4. **Service 4: Livestock farming under risks from combined abiotic and biotic factors**

The following wireframes describe what the web interface that will allow end users to interact with services on the Sebastien portal should look like. They are the result of UX/UI design which had as its requirements the output of the analysis conducted with partners and stakeholders to identify the needs of end users. Milestone 4 "Report on data synthesis methodologies" extensively reports, instead, the relationship between the input data stored in the data lake and how the ML models interact with them in order to carry out the needed computations to reach the final output. The results are then represented in the web interface upon user requests.

2.4.1 Service 1: Coping with environmental stressors for breeds

The aim of this service is to support livestock farming towards breed adaptation to environmental conditions and production needs.

This service has been divided into the following two sub-services:

- Service 1A: Estimation of production loss as a function of climatic variables
- Service 1B: Adaptability of species/breeds to stress due to climate change

The user can access this service by clicking the button on the left in the first row (Adaptation to Climate Change). Once the button is clicked, the user will land on an intermediary page with two buttons representing the two sub-services:

In case of an error, the user can click the arrow in the top left to return to the previous screen.

Service 1A: Estimation of production loss as a function of climatic variables

The aim of this sub-service is the estimation of the impact of climate, both external and internal to the stable, in the short and long term, on the quantitative and qualitative characteristics (percentage of fat and protein) of the milk.

In particular, by utilizing climate data, the service will provide information on the risk of production loss in terms of quantity of milk, proteins, and fats, due to heat stress in dairy cattle.

When the user accesses this sub-service, the screen displays a geographical map, which may contain pins representing the stables that have been saved previously. As with every service, a button ⓘ is placed in the bottom left that explains the purpose of this sub-service:
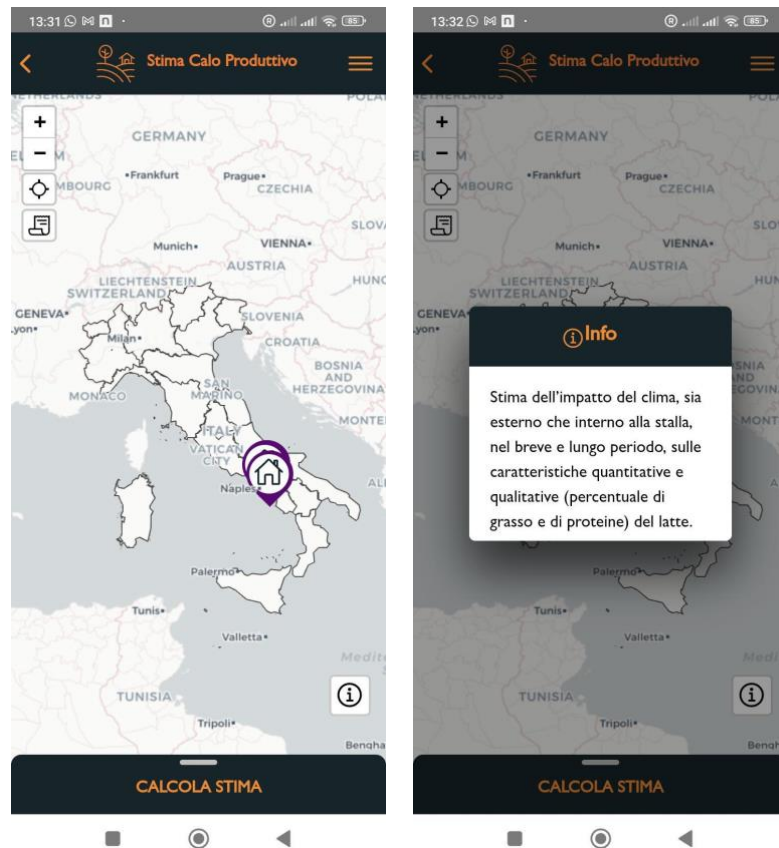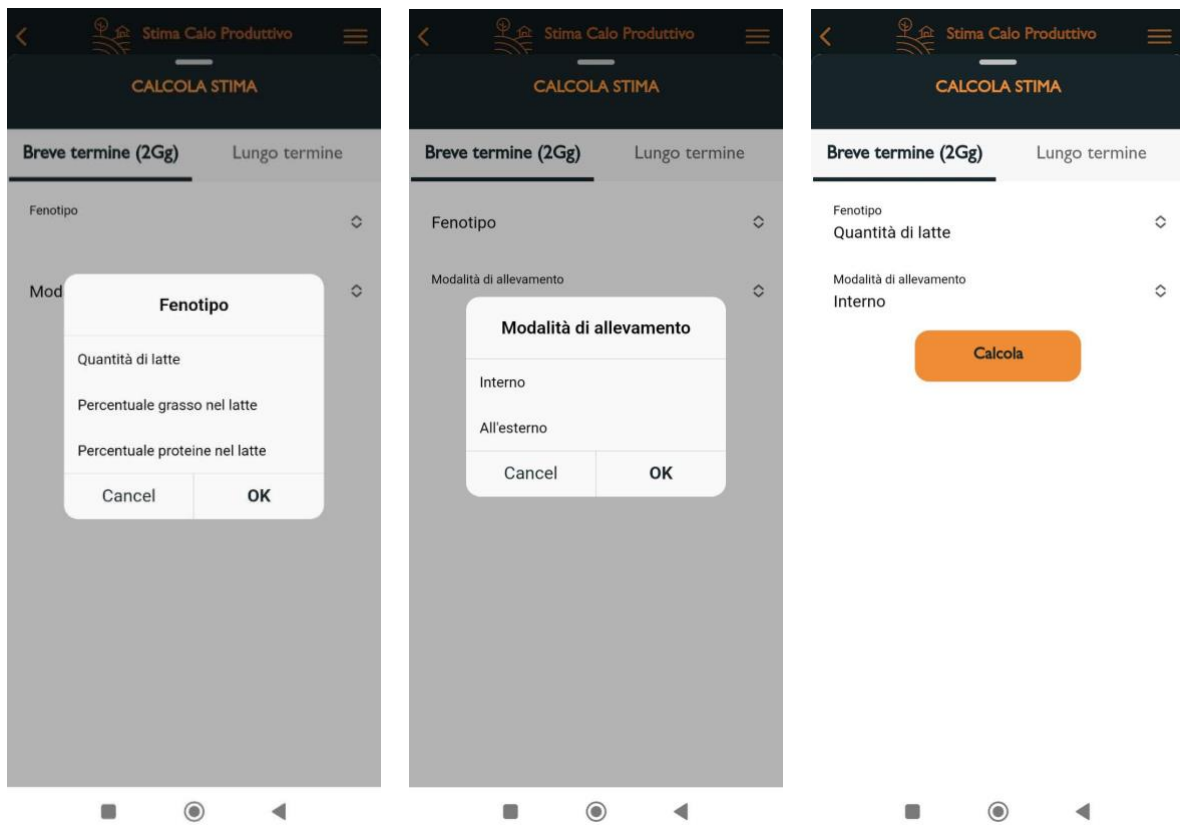

To start the calculation, the user must scroll down the "CALCULATE ESTIMATE" panel and enter the desired input data.

- **Period:** Short term (2 days) or Long term
- **Phenotype:** amount of milk, amount of fat, amount of protein
- **Breeding method:** in the stable, outdoors

The first input parameter is selected by choosing the tab: the left one for the short term and the right one for the long term:
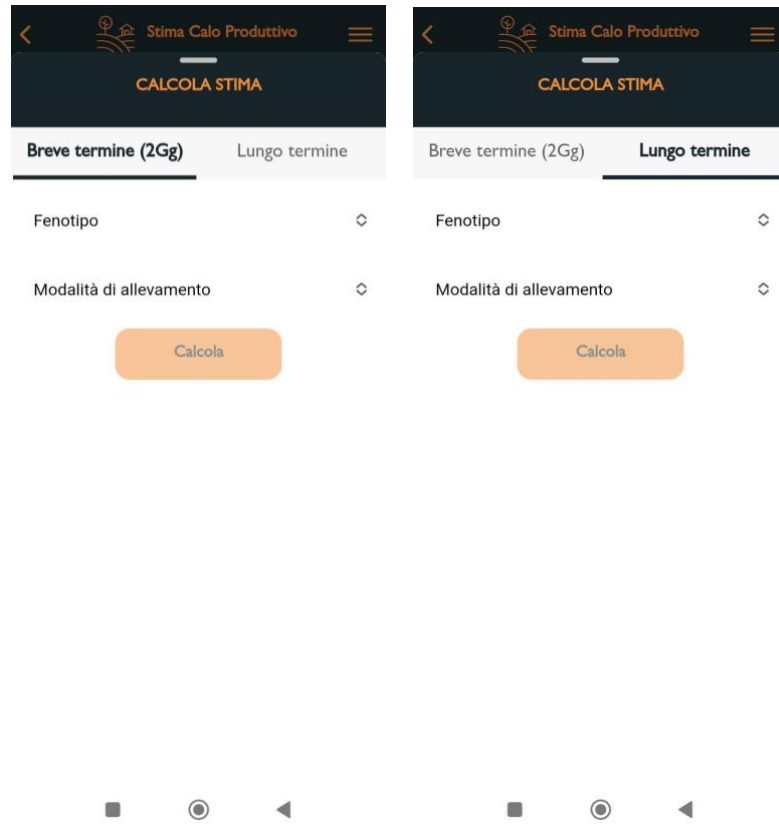
Once the tab is selected, it contains two buttons related to the other input parameters. Clicking on each button opens a popup that presents the available values to guide the user in making their selection:

Only after selecting the parameters will the "Calculate" button be enabled, allowing the user to start the request. The output data obtained is the coloring of the map in relation to the estimated production loss. Clicking the button ⊞ (in the top left) will open a popup with the legend that explains the color values displayed on the map:
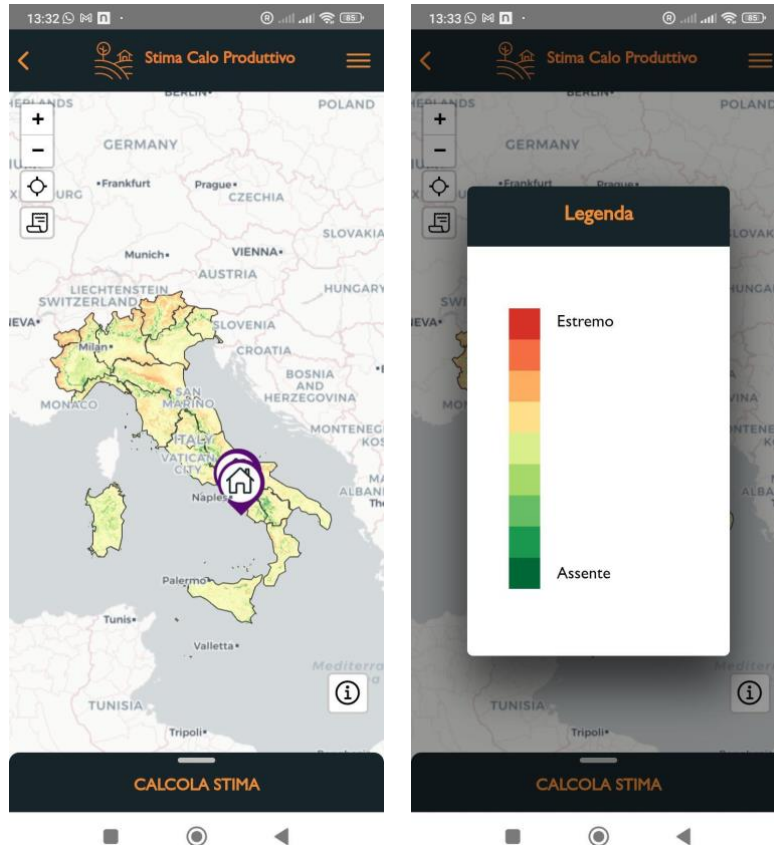

Service 1B: Adaptability of species/breeds to stress due to climate change

The service will provide information on the adaptability of species and breeds to stress due to climate change.

When the user accesses this sub-service, the screen displays a geographical map, which may contain pins representing the stables that have been saved previously. As with every service, a button ⓘ is placed in the bottom left that explains the purpose of this sub-service:
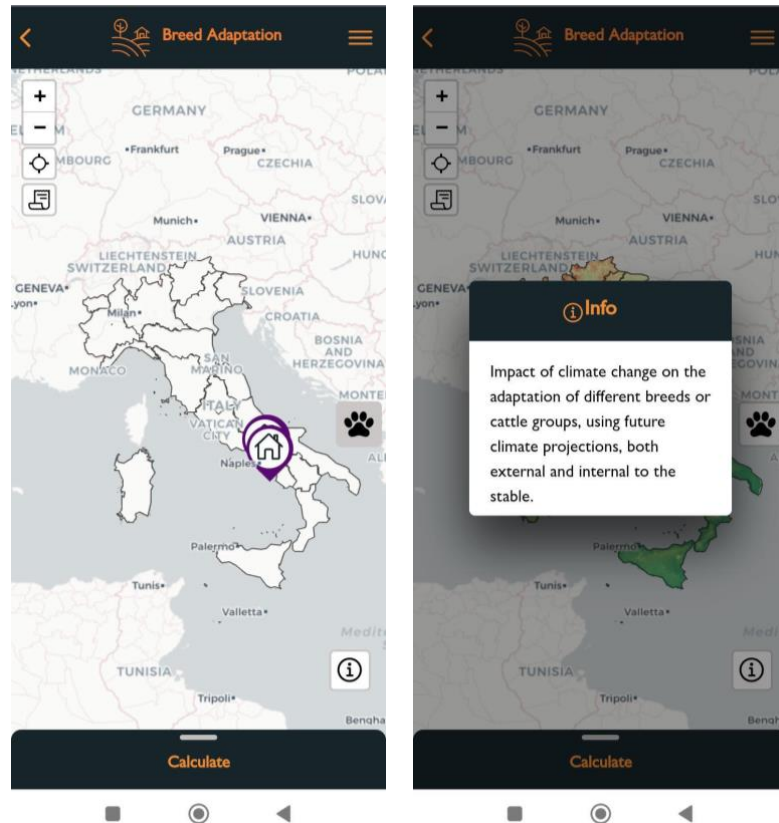
To start the calculation, the user must scroll down the "CALCULATE" panel and enter the desired input data in the appropriate popup:

- **Temperature Humidity Index:** in the stable, outdoors
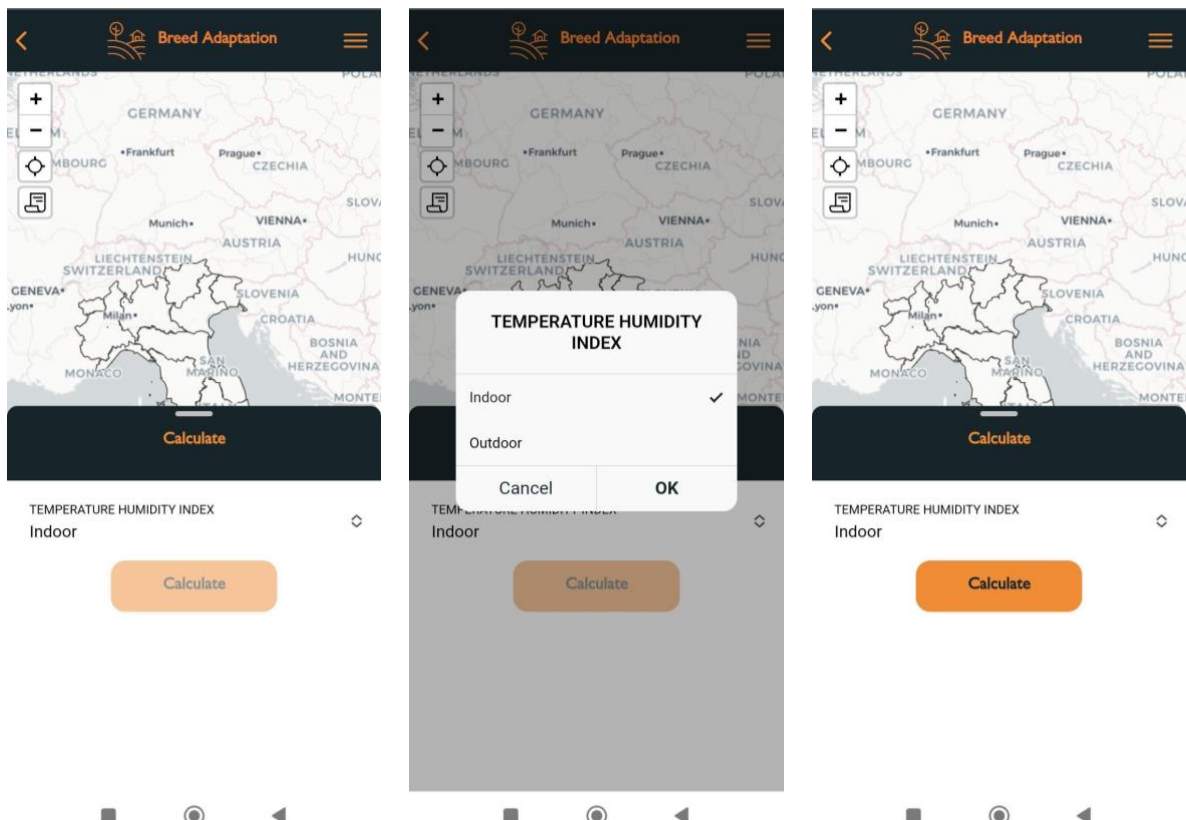
Only after selecting the parameter will the "Calculate" button be enabled, allowing the user to start the request. The output data obtained is the coloring of the map of Italy to show the estimated THI values. Clicking the button ⬓ (in the top left) will open a popup with the legend that explains the color values displayed on the map:
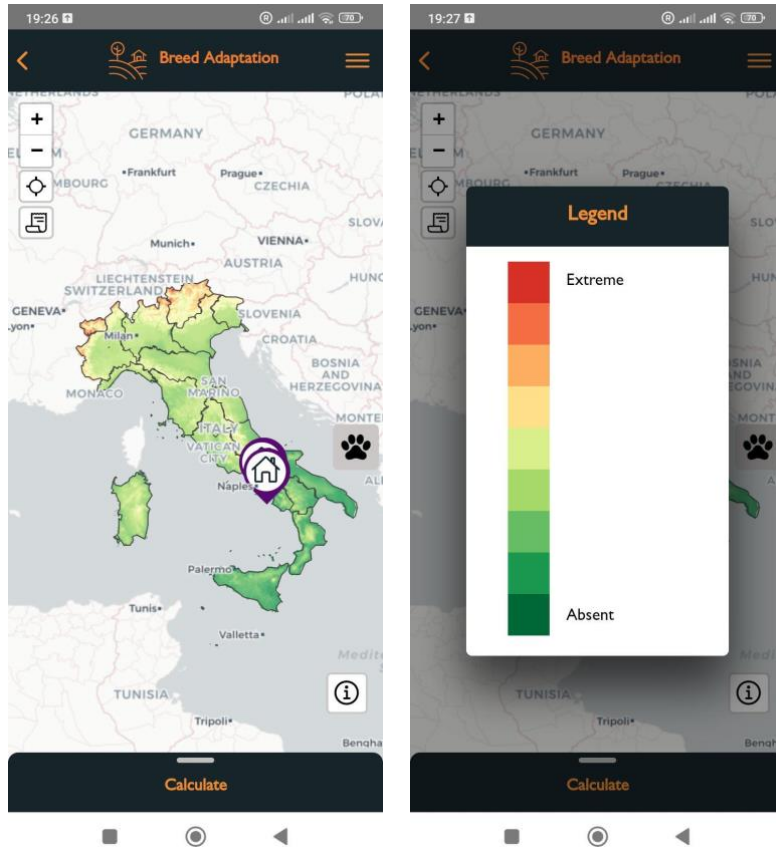
At this point, by clicking on a point of interest on the map, the button 🐾 will be enabled, allowing the identification of the breeds compatible with the projected THI for the future. Clicking this button will open a popup that shows which breeds are compatible with the THI value at that location and which are not:
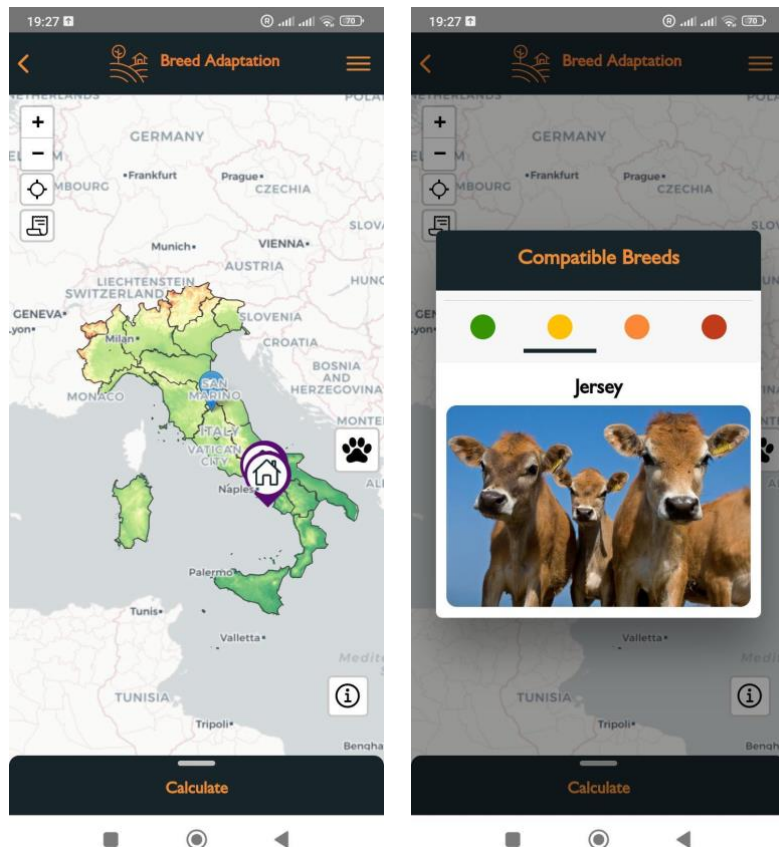
2.4.2 Service 2: Intensive farming risk management under climate extremes

The aim of this service is to alert about approaching or projected dangerous environmental circumstances for cattle.

This service has been divided into the following two sub-services:

- Service 2A: Estimation of the environmental conditions of the stables
- Service 2B: Projection of the environmental conditions of the stables in the long term

The user can access this service by clicking the button on the right in the first row (THI Forecasts in Stables). Once the button is clicked, the user will land on an intermediary page with two buttons representing the two sub-services:
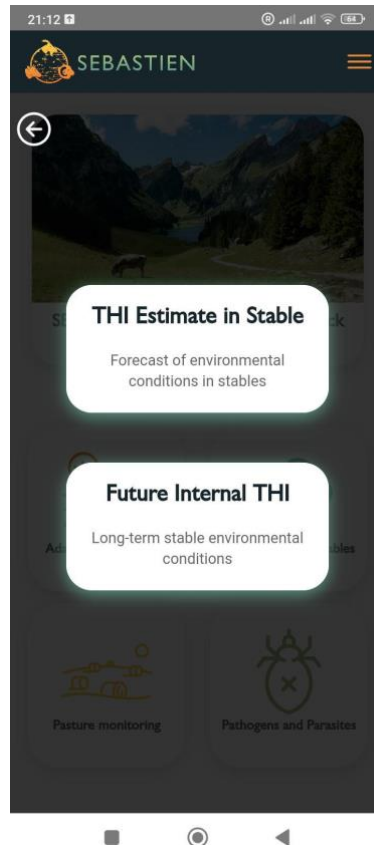
In case of an error, the user can click the arrow in the top left to return to the previous screen.

Service 2A: Estimation of the environmental conditions of the stables

The aim of this sub-service is the estimation of the temperature-humidity index (THI) inside stables based on external environmental conditions, in the short term.
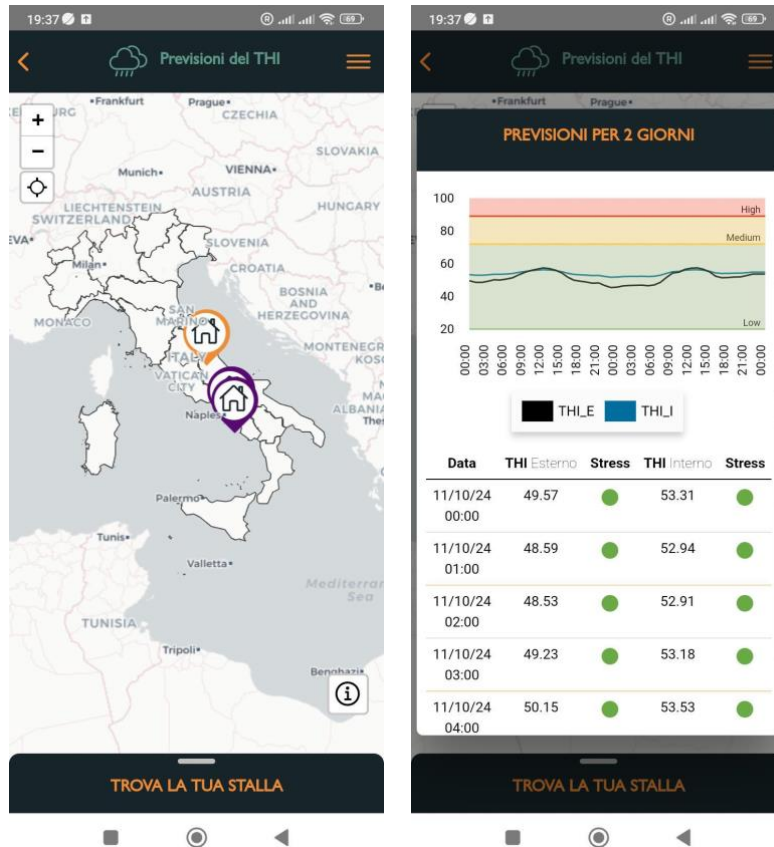
When the user accesses this sub-service, the screen displays a geographical map, which may contain pins representing the stables that have been saved previously. As with every service, a button is placed in the bottom left that explains the purpose of this sub-service:
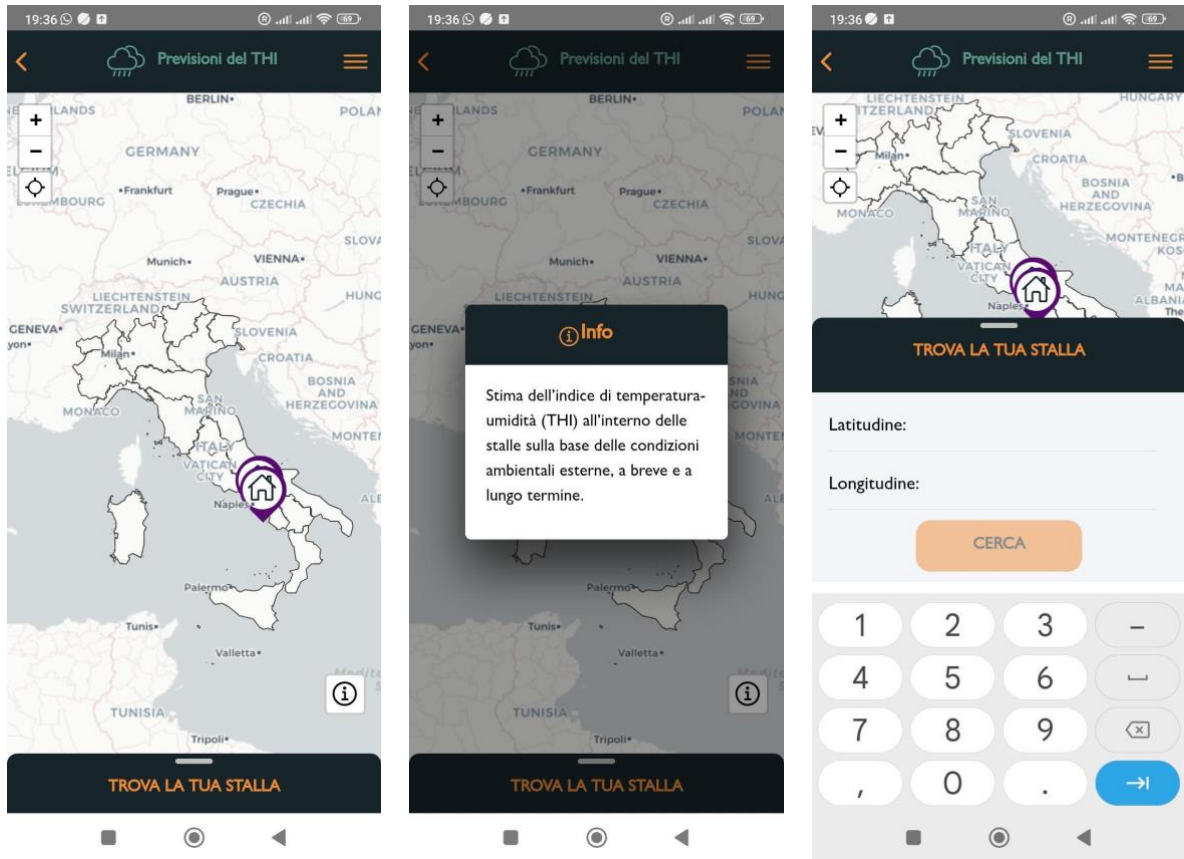
To start the calculation, the user can click on a desired point on the map or enter the coordinates in the "Calculate" panel. In both cases, a popup will appear asking the user if they want to save the coordinates as a new stable; if they confirm, a wizard will begin, which is a guided procedure consisting of successive popups to assist the user in registering the data for the new stable being added to the system.

çBy clicking the "Go to Forecasts" button, the user will return to the map where a new pin will be created. To distinguish it from the stables already created, the new pin is colored orange. When clicked, a popup will open showing the THI forecast for the next two days:


Service 2B: Projection of the environmental conditions of the stables in the long term

The aim of this sub-service is the estimation of the temperature-humidity index (THI) inside stables based on future external environmental conditions.

When the user accesses this sub-service, the screen displays a geographical map, which may contain pins representing the stables that have been saved previously. As with every service, a button ⓘ is placed in the bottom left that explains the purpose of this sub-service:
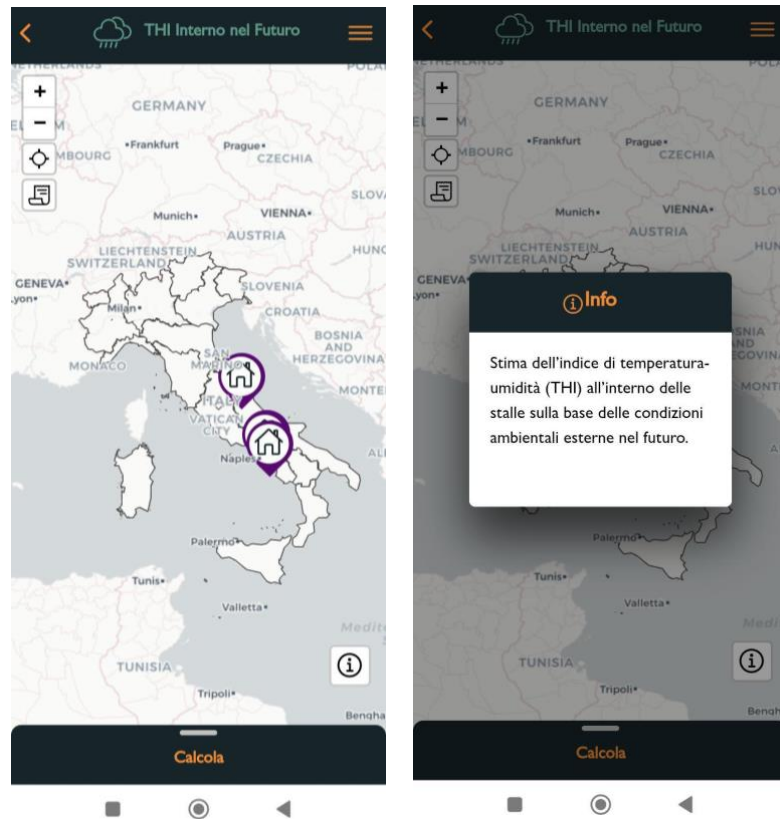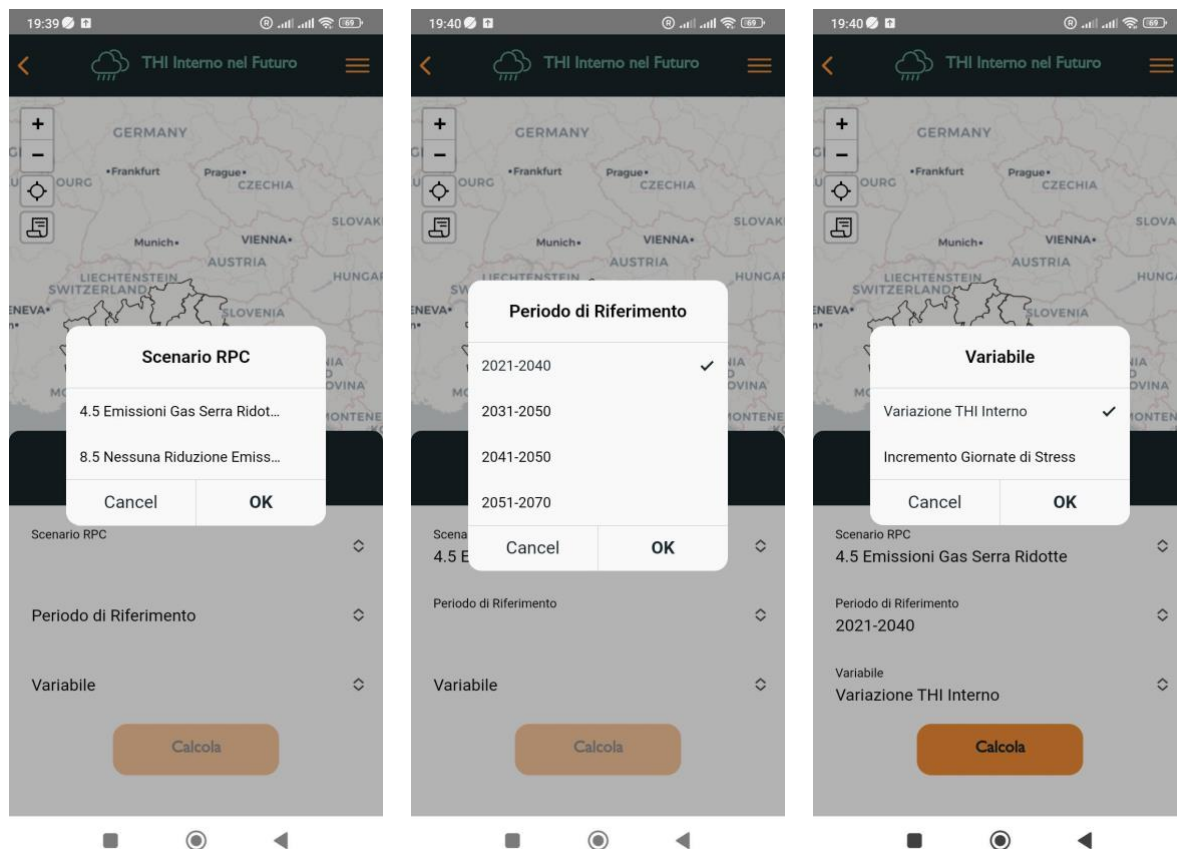
To start the calculation, the user must scroll down the "CALCULATE" panel and enter the desired input data:

- **RCP Scenario:** 4.5 Reduced Greenhouse Gas Emissions, 8.5 No Emission Reduction
- **Reference Period:** 2021-2040, 2031-2050, 2041-2060, 2051-2070
- **Variable:** Internal THI Variation, Increase in Stress Days

For each of these input parameters, there will be corresponding buttons; clicking on each button will open a popup that presents the available values to guide the user in making their selection:

Only after selecting the parameters will the "Calculate" button be enabled, allowing the user to start the request. The output data obtained is the coloring of the map in relation to the projection of long-term environmental conditions in the stables. Clicking the button 🖳 (in the top left) will open a popup with the legend that explains the color values displayed on the map:
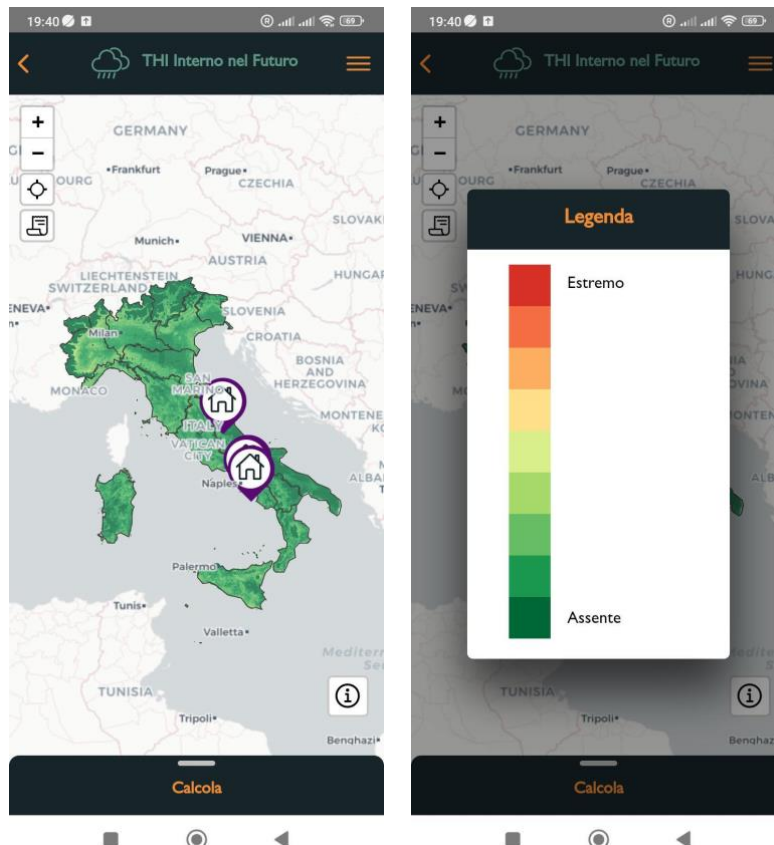
### 2.4.3 Service 3: Extensive farming management and feed availability

This service is based on indicators/indices about the phenological stage and greening of the naturally vegetated or managed areas used to feed livestock heads when conducted outdoors.

The user can access this service by clicking the button on the left in the second row (Pasture Monitoring). In this case, there is no more than one sub-service; however, to provide a consistent and smooth navigation experience, it was decided to include an intermediary page containing the only sub-service available:
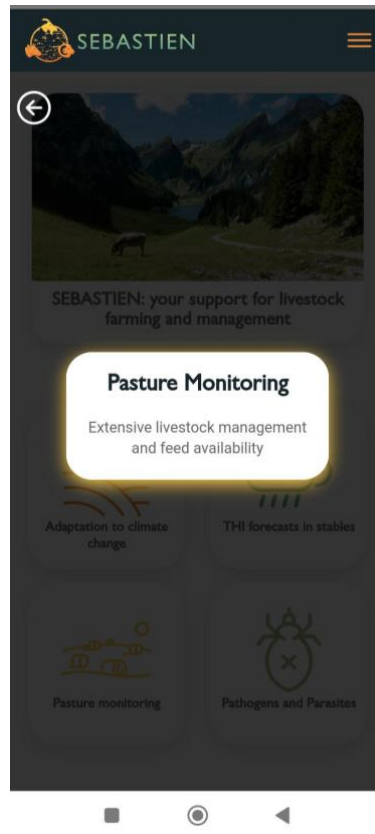
When the user accesses this sub-service, the screen displays a satellite map where, as with every service, a button ⓘ is placed in the bottom left that explains the purpose of this sub-service:
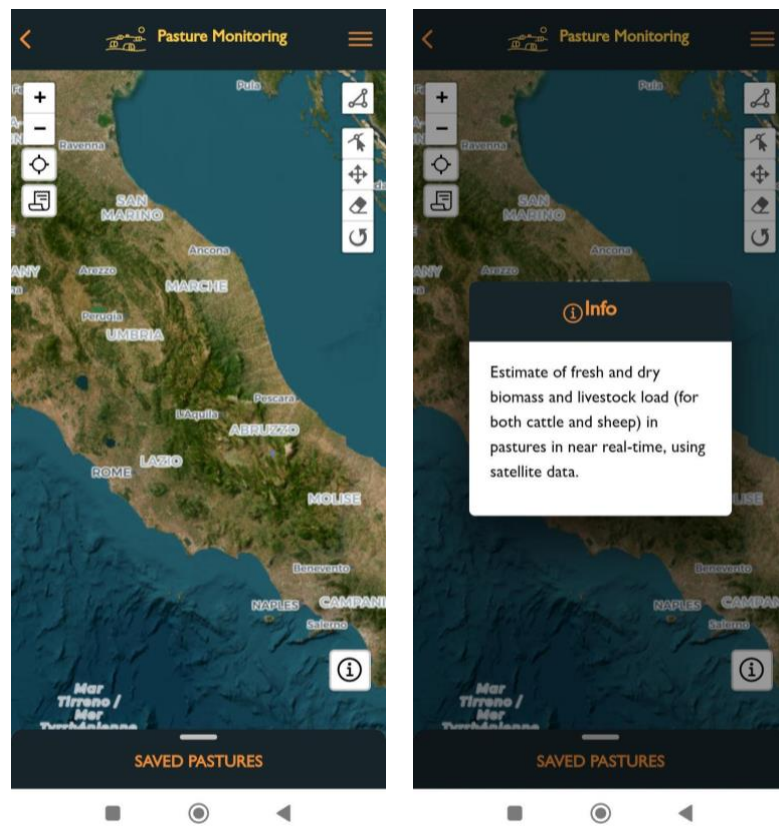
Using the available tools (see the buttons in the top right), the user can outline the area of interest for pasture by drawing directly on the map:
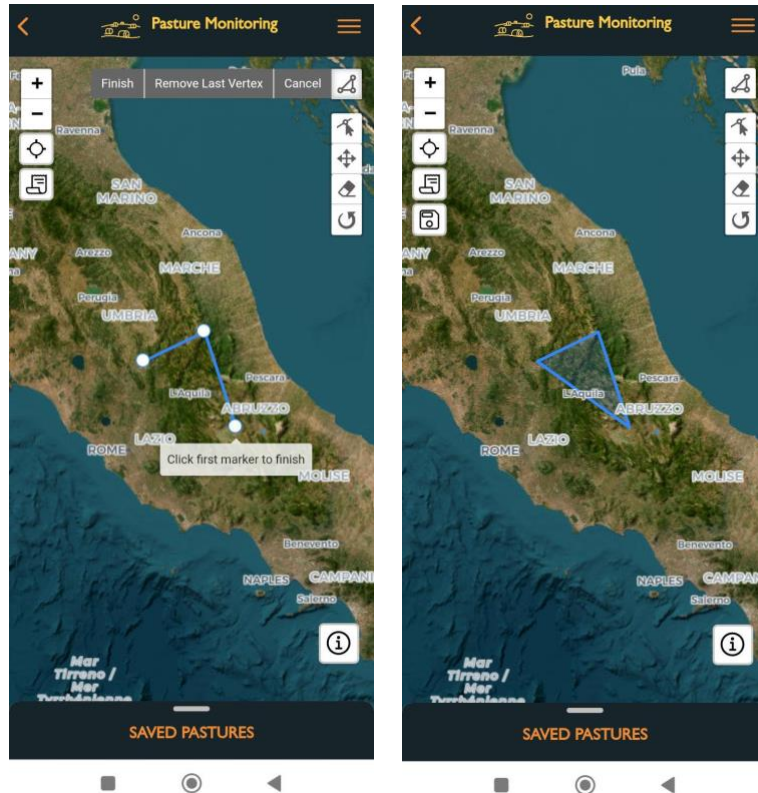
Once the pasture area is drawn, the user can save it by clicking the appropriate button and entering a name for the saved area:
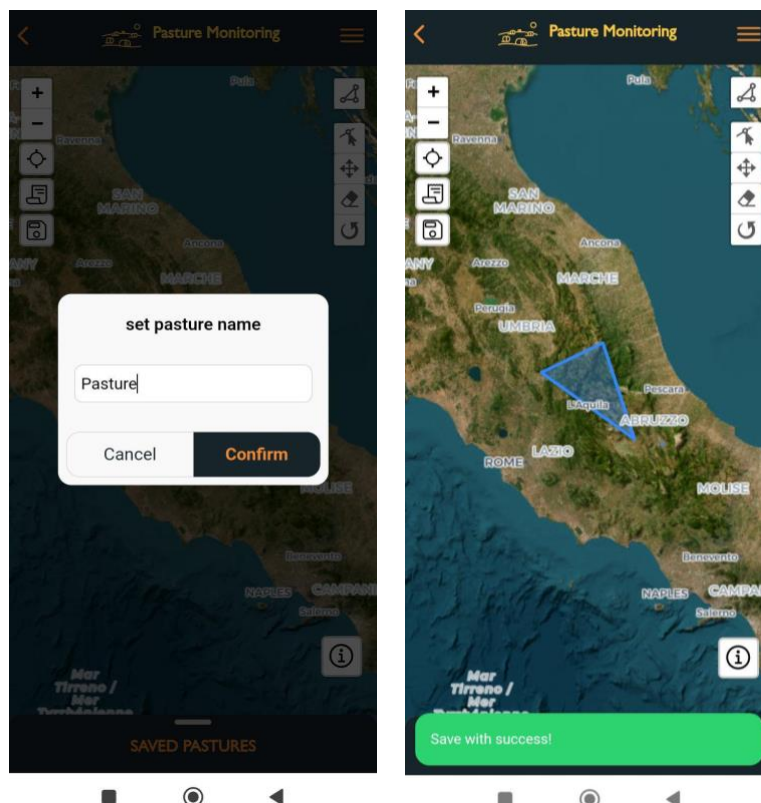
By scrolling down the "SAVED PASTURES" panel, the user can view a list containing all the pastures saved previously. Clicking the button will open a popup that allows the user to modify the name of the pasture:
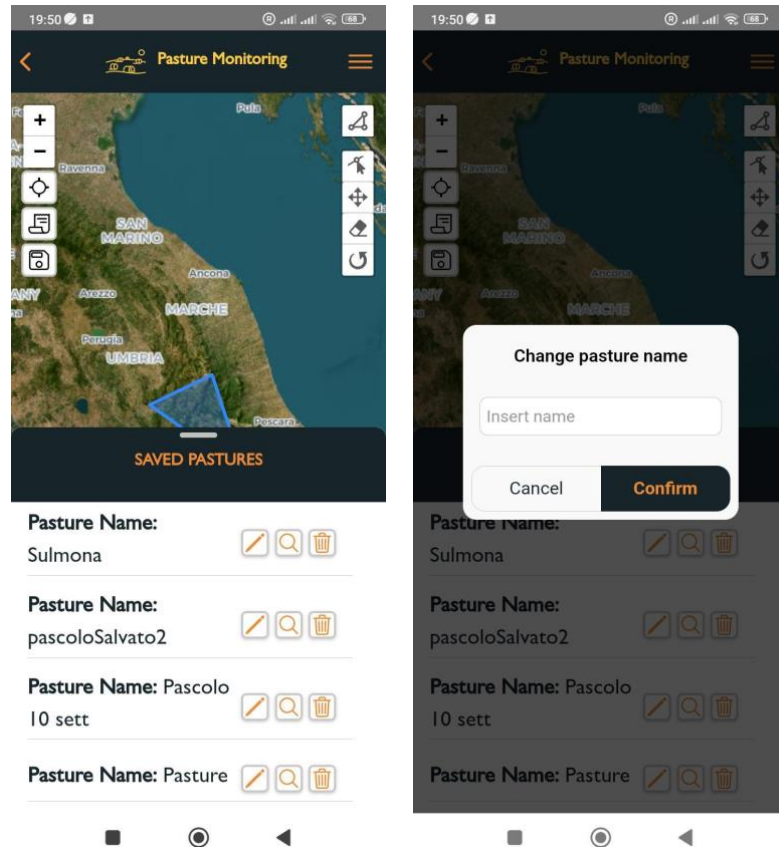
By clicking the "magnifying glass" button, the user will be taken to the location where the pasture was registered. A popup will appear on the map with some summary information, and by clicking the "+" button, a panel will open to access the detailed information and modify it:
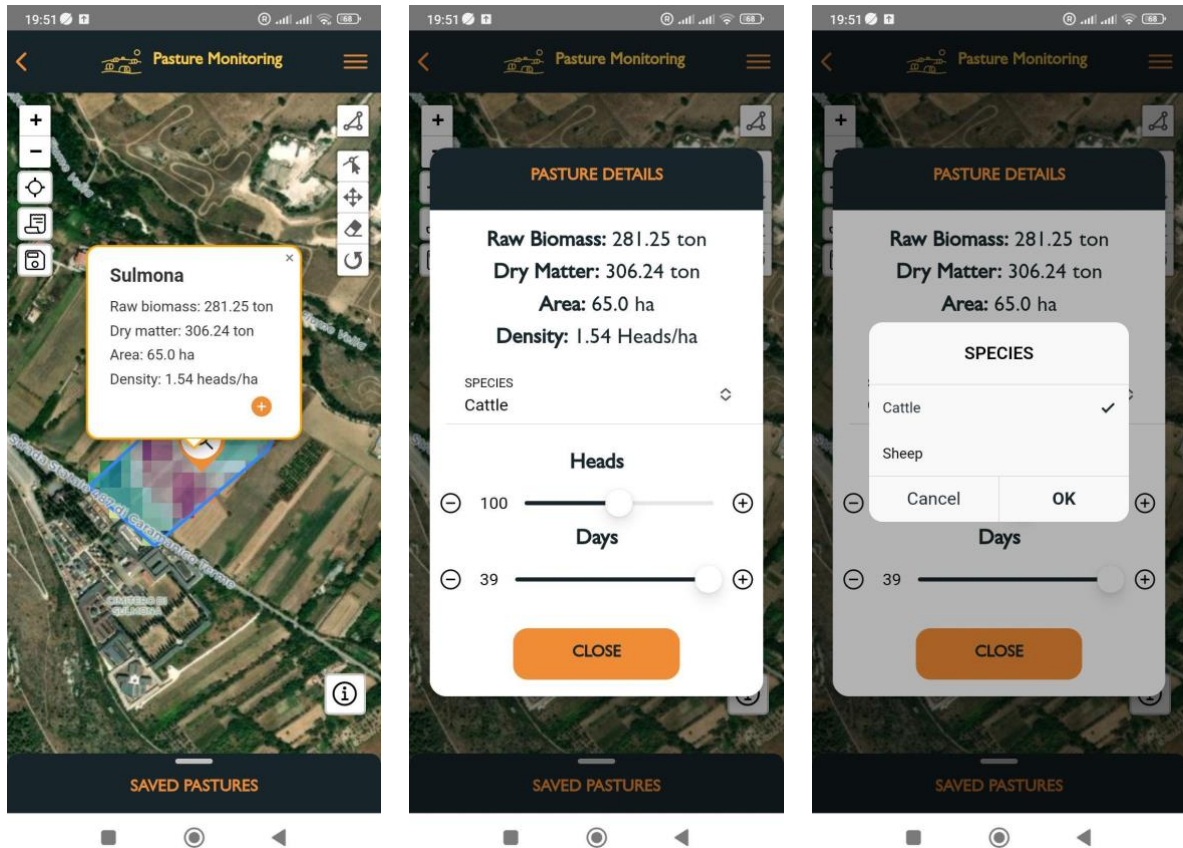
2.4.4 Service 4: Livestock farming under risks from combined abiotic and biotic factors

The aim of this service is to provide updated risk maps of parasites and diseases spread.

In particular, maps will be produced showing the long-term risk of disease spread (up to 2050) based on epidemiological, ecological, and climatic data for certain regions of Italy and, for some diseases, across the entire national territory.

This service has been divided into the following two sub-services:

- Service 4A: Mastitis
- Service 4B: Blue Tongue

The user can access this service by clicking the button on the right in the second row (Pathogens and Parasites). Once the button is clicked, the user will land on an intermediary page with two buttons representing the two sub-services:
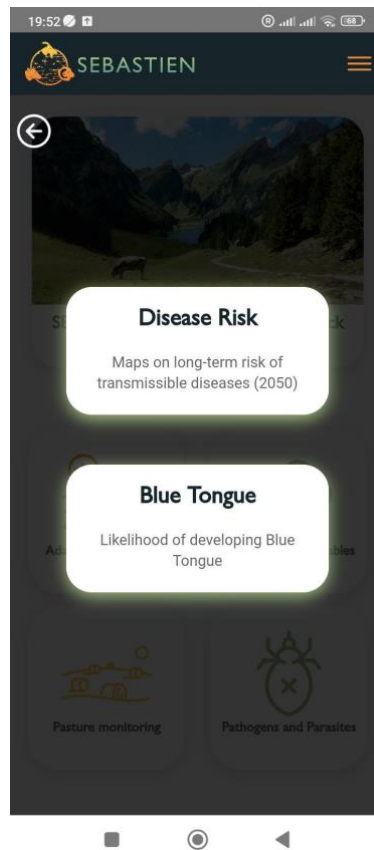
Service 4A: Mastitis

When the user accesses this sub-service, the screen displays a geographical map, which may contain pins representing the stables that have been saved previously. As with every service, a button [i] is placed in the bottom left that explains the purpose of this sub-service:
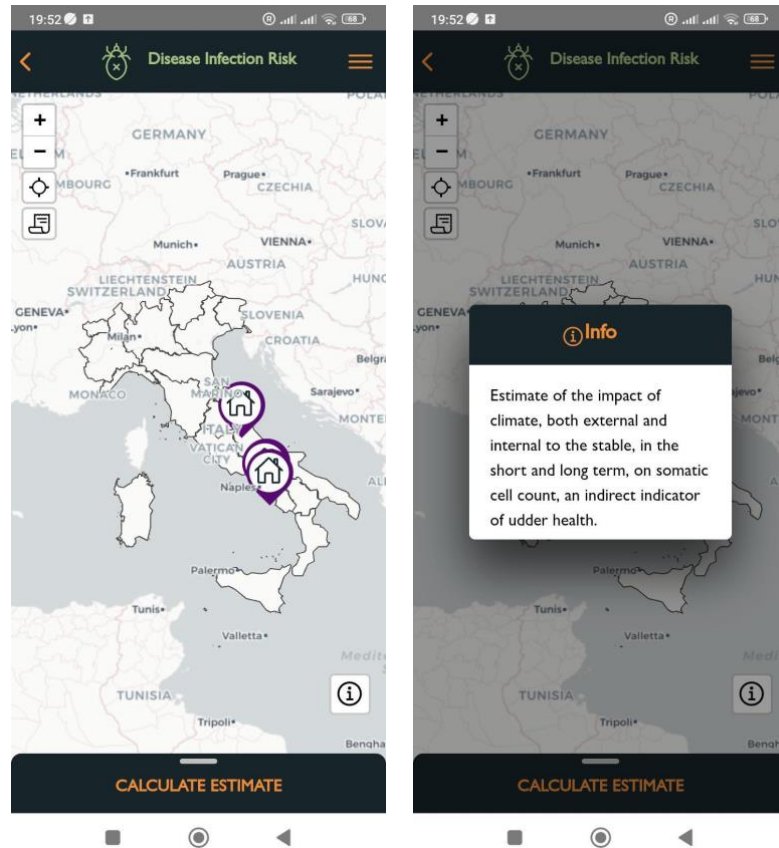
To start the calculation, the user must scroll down the "CALCULATE ESTIMATE" panel and enter the desired input data:

- **Period:** Short term (2 days) or Long term
- **Farming method:** Indoor, Outdoor

The first input parameter is selected by choosing the tab: the left one for the short term and the right one for the long term:
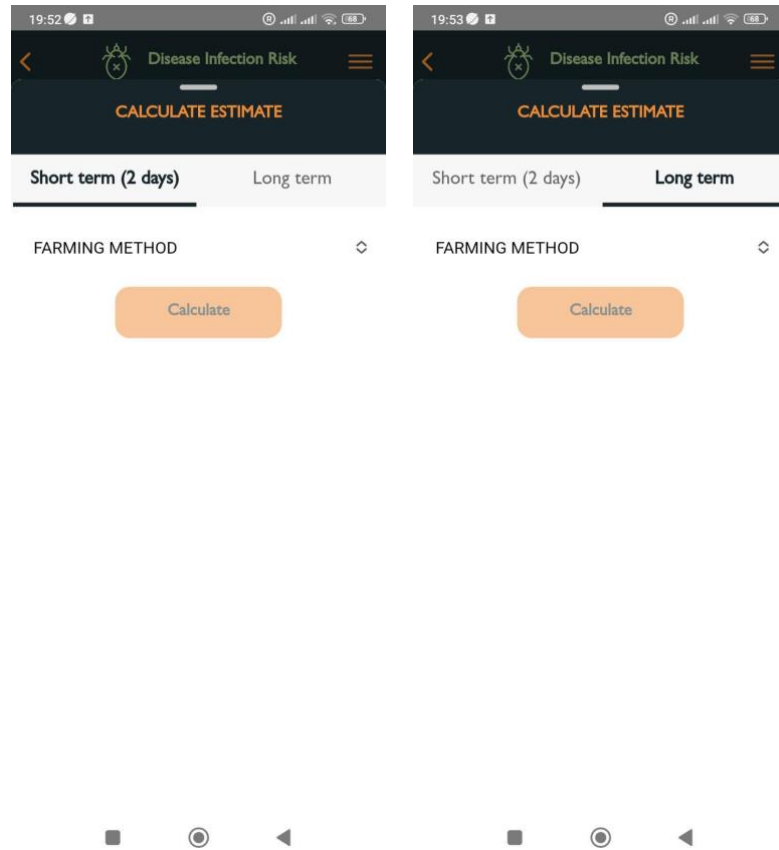
Once the tab is selected, there are two buttons inside related to the second input parameter. Clicking on each button opens a popup that presents the available values to guide the user in making their selection:
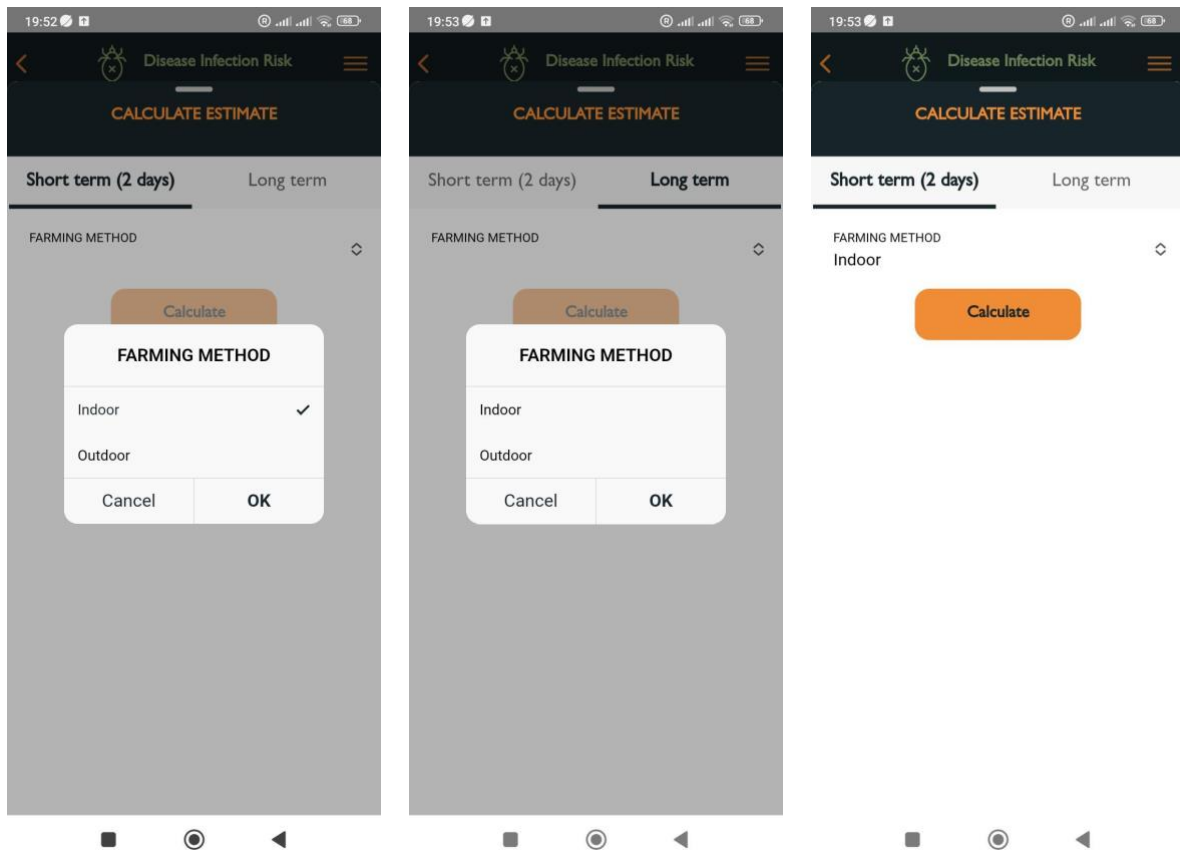
Only after selecting the parameters will the "Calculate" button be enabled, allowing the user to start the request. The output data obtained is the coloring of the map in relation to the risk of mastitis in cattle in Italy. Clicking the button ⊡ (in the top left) will open a popup with the legend that explains the color values displayed on the map:
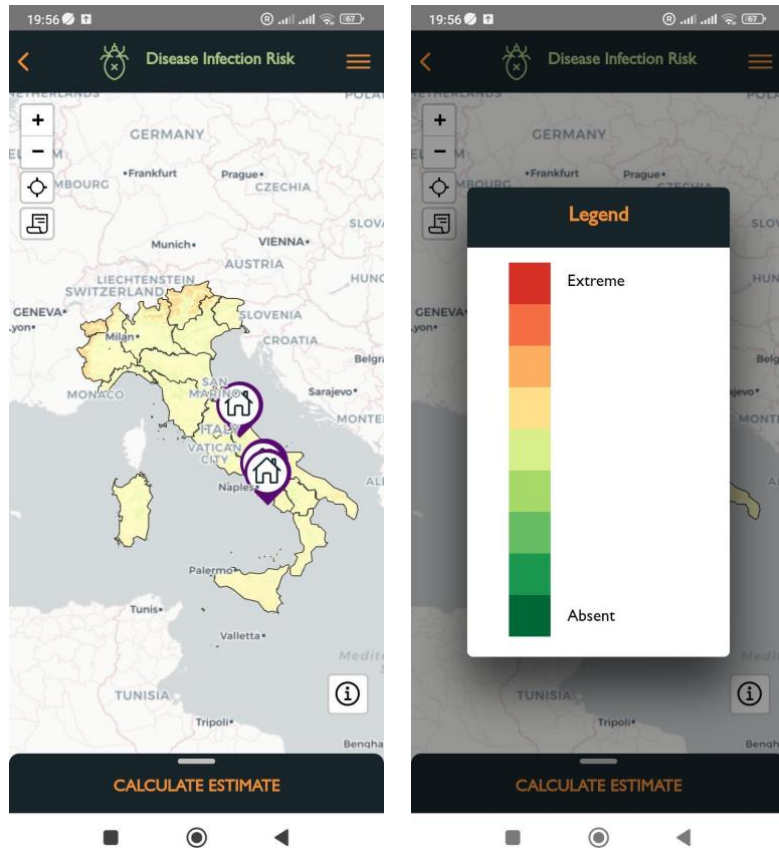
Service 4A: Blue Tongue

This sub-service assesses the risk of Blue Tongue in cattle in the region of Sardinia. When the user accesses this sub-service, the screen displays a map focused on the region of Sardinia.

As with every service, a button ⓘ is placed in the bottom left that explains the purpose of this sub-service. Clicking the button 🖫 (in the top left) will open a popup with the legend that explains the color values displayed on the map:
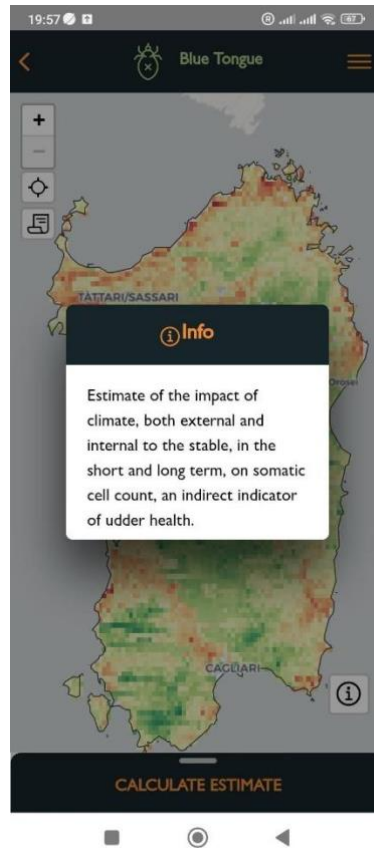
To start the calculation, the user can enter the input value for **Period** in the "Calculate Estimate" panel and then initiate the request. The output will return a colored map representing the risk of disease for the selected period:
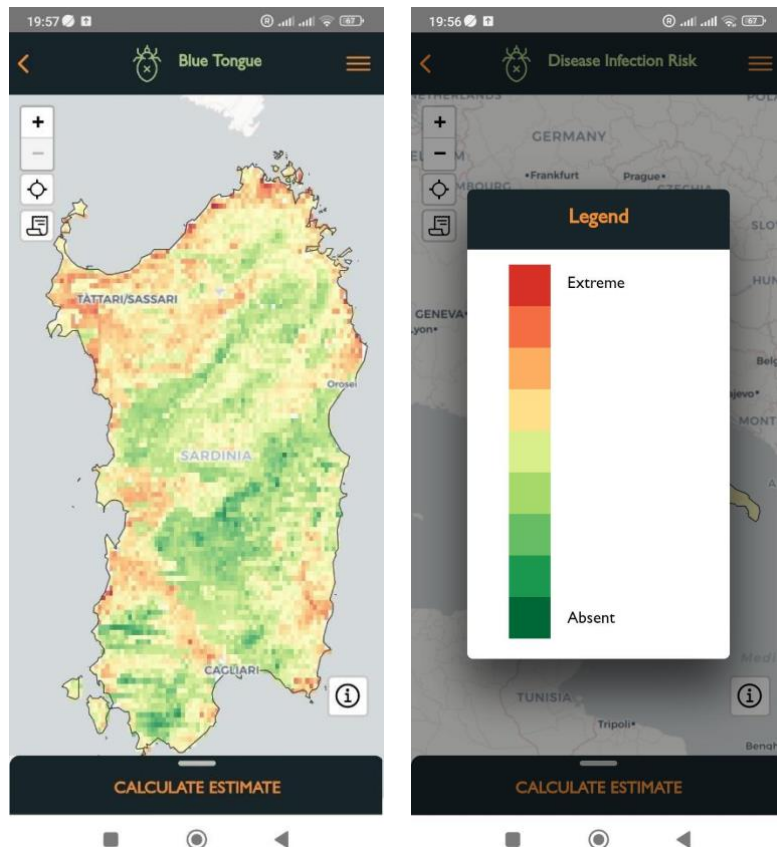
2.5 My Sebastien

In this section, available within the burger menu discussed in paragraph *2.3 Home*, both data recorded by the user via the mobile app or web portal (Stables and Pastures) and some data and indicators made available to users for consultation (Sensors) are gathered.

Stables

Within this section, there is a list of all the stables that the user has saved in the system, whether through the mobile app or the web portal. This means that, regardless of the device used, the data is saved in a single database, directly linked to the user's account and always available.

This list consists of "n" accordions: when clicked, the item expands to show all the details related to the selected Stable. The user can also modify the previously chosen name using the appropriate button:
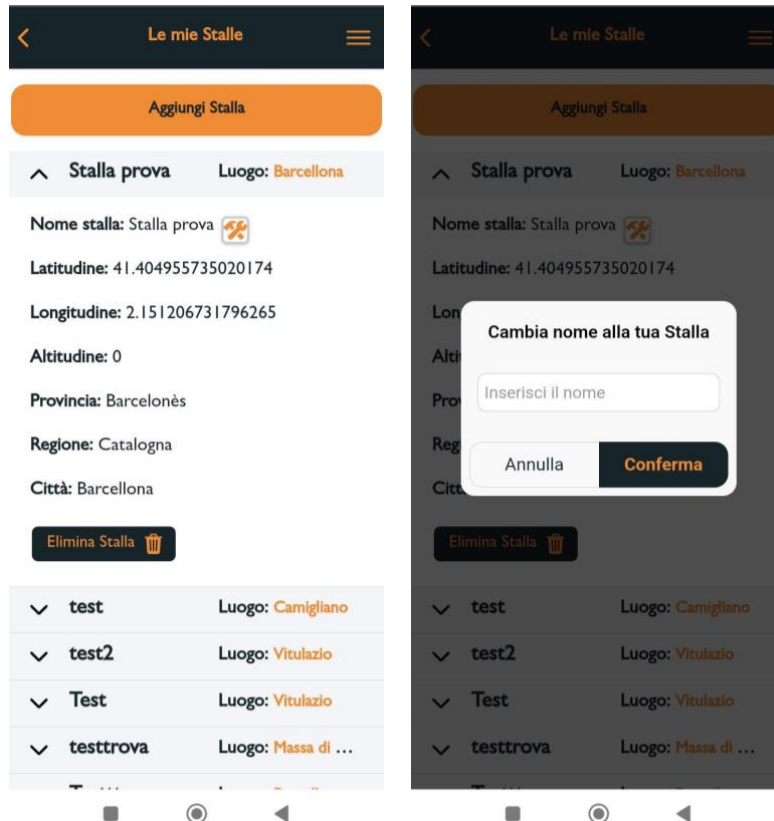
By clicking the "Add Stable" button, the user can also add a new stable by entering the relevant coordinates in the panel or by directly selecting the point on the map:
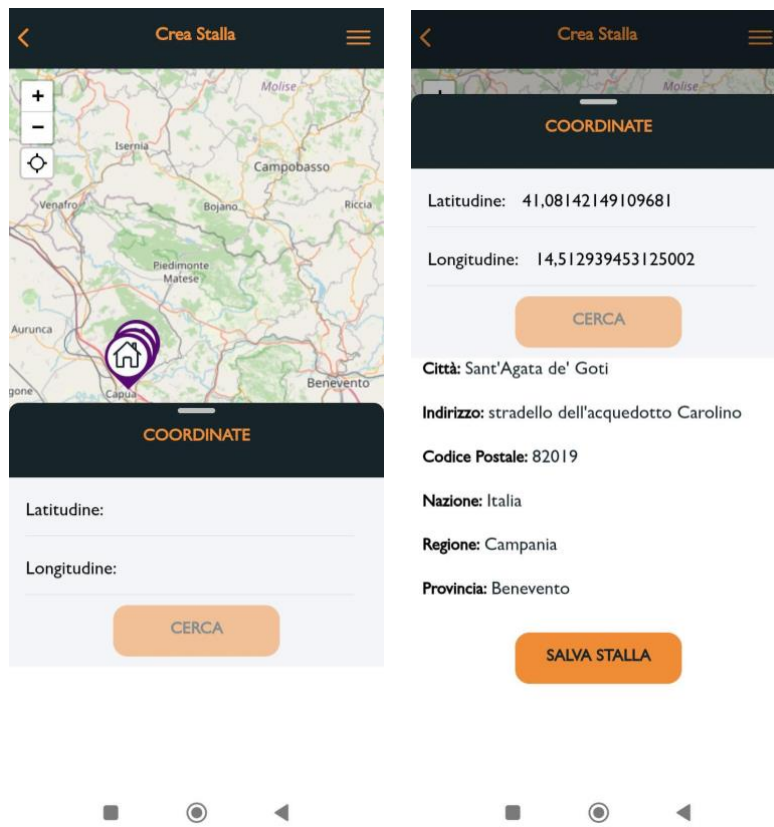
Pastures

As described for Stables, the Pastures section also contains a list of all the elements that the user has saved in the system, through the mobile app and/or the web portal.

For each item in the list, there is an edit button that allows the user to change the previously chosen name, as well as a delete button to remove the saved pasture:
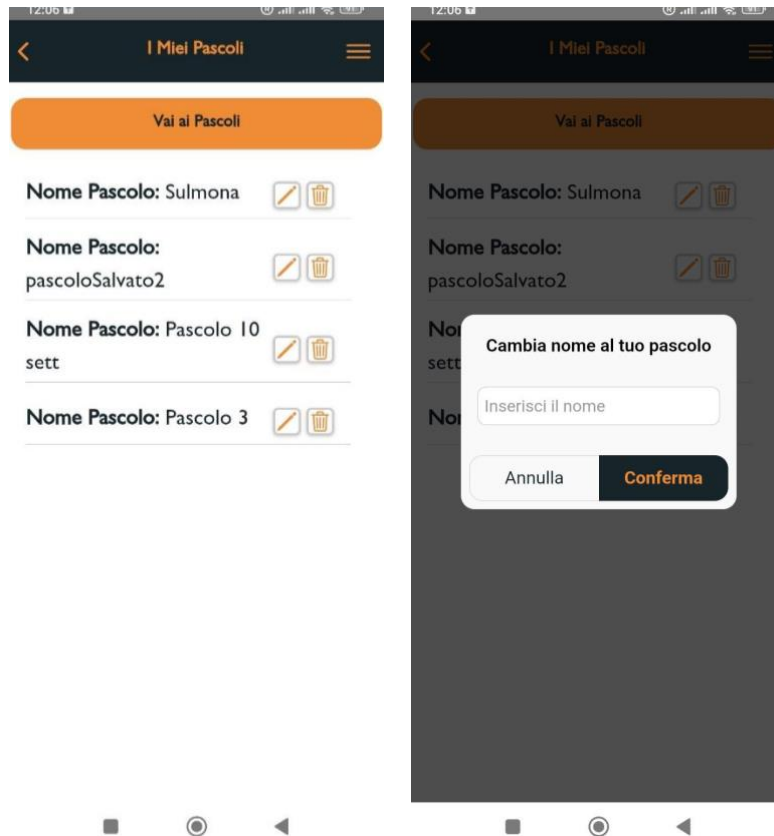
By clicking the "Go to Pastures" button, the user is taken to the map, where the pastures saved up to that point will be highlighted. The map screen will also have the panel with the edit buttons available:
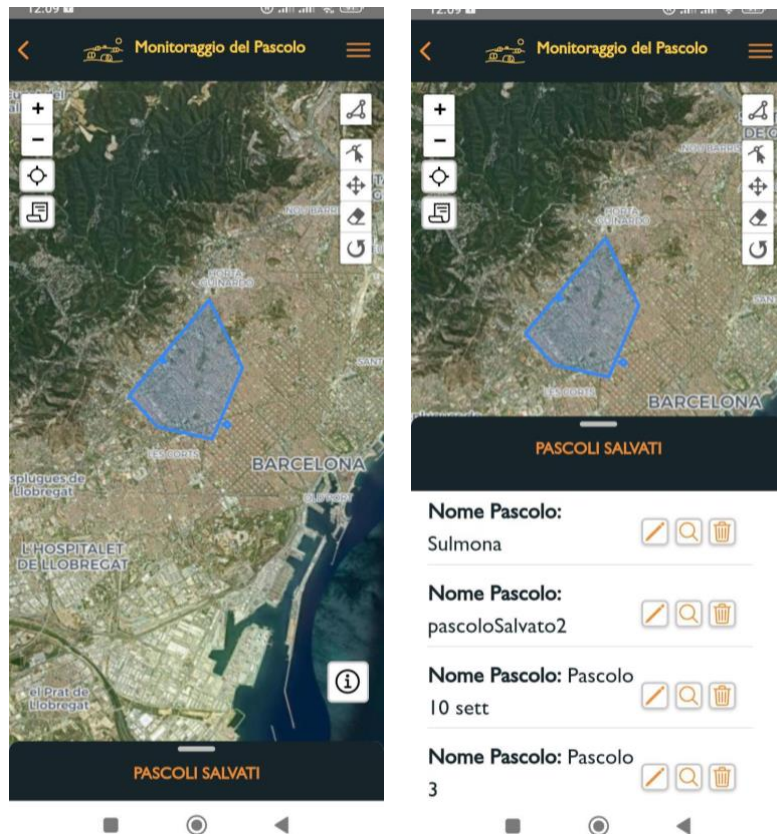
Sensors

This section serves as the access point to a dashboard for viewing data collected from sensors. In the context of the Sebastien project, Nature 4.0 has developed animal sensors that are used to gather physiological parameters in real time, providing the necessary information to assess the animals' well-being and physiological stress.

By accessing this section, the user can view the list of all sensors that have been placed in the stables or pastures and see the related information. Alternatively, the user can click the "Go to Sensors" button to view the map with pins indicating the location of each sensor. Thus, the user can specifically click on the pin of interest to view the corresponding data:

Screen 1:

Sensori

Vai ai Sensori

Numero di serie: 31246001
Numero di serie: 31246000
Numero di serie: 11245048
Numero di serie: 11245003
Numero di serie: 11245040
Numero di serie: 11245042
Numero di serie: 11245006
Numero di serie: 11245002
Numero di serie: 11245021
Numero di serie: 11245004
Numero di serie: 11245035
Numero di serie: 11245022
Numero di serie: 11245036
Numero di serie: 11245016

Screen 2:

Sensori

Vai ai Sensori

Numero di serie: 31246001

AirH:

AirT:

HeartRate:

THI:

accelerationX:

accelerationY:

accelerationZ:

battery:

cycle_duration:

device_id: 31246001

latitude: 42.4489227

longitude: 12.086417

sensor_time:

Screen 3:

Sensori

3. Technology stack

Within the Sebastien project, some frameworks and libraries were used to implement the mobile app; in particular:

• **Ionic:** framework used for the development of the application and its UI components.

• **Bootstrap:** front-end framework used for the creation of responsive and mobile-first user interfaces.

• **Angular:** framework used for front-end development based on TypeScript.

• **Ngx-translate:** library for Angular used for managing multilingual translation.

• **Leaflet:** JavaScript library used for the creation of interactive maps.

The following paragraphs illustrate in detail the characteristics of the technologies used.

3.1 Ionic

Ionic is an open-source framework for building cross-platform mobile, web, and desktop applications using web technologies such as HTML, CSS, and JavaScript/TypeScript. It provides a set of pre-designed UI components and tools for building high-quality, interactive applications.

Ionic provides tools and services for developing hybrid mobile, desktop, and progressive web apps based on modern web development technologies and practices, using Web technologies like CSS, HTML5, and Sass. In particular, mobile apps can be built with these Web technologies and then distributed through native app stores to be installed on devices by utilizing Cordova or Capacitor.

It is a cross-platform widely preferred by developers as it allows you to create applications for both Android and iOS. It is also highly customizable, allowing you to add features as needed. The framework is also fast, and apps typically take less time to build. Last but not least, Ionic is supported by a large community of developers who offer assistance whenever needed. All these advantages have led to the choice of this framework for the development of the mobile application of the Sebastien project.

3.2   Bootstrap

Bootstrap is a front-end framework that provides CSS and JavaScript tools for building responsive and mobile-first user interfaces. It includes a wide range of UI components such as grids, buttons, modals and more.

The main goal of Bootstrap is to create responsive and mobile-first websites, making sure that all the interface elements of a website work optimally on all screen sizes.

In the Sebastien project, it was decided to use this framework because of its ease of use and because it offers a predefined grid system, consisting of rows and columns, that allows you to create a grid inside the existing one instead of inserting media queries inside the CSS file. Bootstrap contains many media queries, which allow you to define custom breakpoints for each column according to the needs of your project. This system makes the data entry process easier and creates a very easy to work with data structure.

3.3   Angular

Angular is a TypeScript-based free and open-source single-page web application framework and is one of the most commonly used web frameworks. It is developed by Google and by a community of individuals and corporations. Angular is a complete rewrite from the same team that built AngularJS. The Angular ecosystem consists of a diverse group of over 1.7 million developers, library authors, and content creators and It offers robust frameworks for data management, routing, and reusable components.

Angular 2+, or just Angular, is an open-source framework for developing web applications, and is the evolution of AngularJS, developed mainly by Google. The language mainly used to develop with this framework is TypeScript. This technology allows you to design and implement structured

projects for the creation of user interfaces, with immediate advantages in terms of code robustness, testability and maintainability, creating applications that are also fast and high-performance. Angular provides an environment for the rapid creation of apps, modules, components and support for IDEs and numerous plugins make it easier to write code. These are the reasons that led to the choice of this technology for the development of the project.

3.4 Ngx-translate

As in the portal, the need arose in the mobile application to introduce a feature that allows users to change the language, independent of the system setting. To this end, Ngx-translate was introduced, which dynamically manages multilingual translation.

Ngx-translate is a library for Angular designed to handle the translation of web applications, making internationalization straightforward. It allows developers to load translation files and use keys to manage text in different languages within the application.

Among the main features that led to the choice of Ngx-translate are:

1. **Ease of Use**: It offers an intuitive API that simplifies the integration of translations into various Angular components.

2. **Support for Multiple Languages**: It allows defining separate translation files for each language, facilitating the management of different language versions of the app.

3. **Dynamic Loading**: It enables dynamic loading of translation files, allowing language changes without reloading the app.

4. **Pipes and Services**: It provides pipes to translate directly within templates and services to manage translations programmatically in the code.

5. **Support for Pluralization and Interpolation**: It is possible to handle complex translations that require plural forms or variables within the translated text.

3.5 Leaflet

Leaflet is an open-source JavaScript library designed to create interactive maps on the web. It is lightweight, easy to use, and highly customizable. In the Sebastien project, it was used to embed maps within the services, adding markers, polygons, and various overlays, as well as managing events like clicks and zooming.

Among the main features that led to the choice of Leaflet are:

1. **Simplicity**: Its API is intuitive, making integration easy even for those with little experience in JavaScript.

2. **Support for various map types**: It allows the use of raster and vector maps, as well as the integration of services like OpenStreetMap.

3. **Interactivity**: It enables the handling of events such as clicks on markers, map movement, and zoom changes.

4. **Extensibility**: There are numerous available plugins that add extra functionality, such as support for charts or loading data from external sources.

5. **Responsive**: The maps created adapt to different screen sizes, making them ideal for mobile devices.

4. Conclusions

This document describes the journey that led to the design and implementation of the mobile app, outlining the technologies chosen for its development. The development of the mobile app, alongside that of the web portal, has represented an important step in meeting user needs and achieving project objectives, as it provides an interface for accessing services and related data.

Through an iterative design process and a constant focus on usability, the goal was to create an app that is not only functional but also offers a smooth and engaging user experience. During the testing phase, an initial version of the app was uploaded to a test environment, and a select group of users was enabled to conduct functional and performance tests. The integration of modern technologies and agile development practices allowed for quick responses to user feedback, ensuring that the app remained aligned with project expectations.

Once a stable version was reached, the app was uploaded to the dedicated store, making it publicly available to everyone.