AI4SoilHealth

D4.9 Modules for in-field geolocated data collection

Version 1.0
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Lead Author: Vedran Mornar, FER and Marina Bagić Babac, FER

Contributors: David A. Robinson, CEH and Lur Epelde, Neiker

Reviewed by: Tomislav Hengl, OGH, Josip Križan, MultiOne and Luka Antonić, MultiOne

HISTORY OF CHANGES		
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		▪

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Executive Summary

The D4.9 Deliverable, titled "Modules for In-Field Geolocated Data Collection," describes a feature integrated into the AI4SoilHealth progressive web application aimed at supporting soil health management through efficient field data collection. These modules are designed for in-field operations, enabling seamless collection of geolocated data, including sensor readings, observations, and images.

The functionality allows users to capture data via the app's API services, directly from mobile phone cameras and connected sensors, ensuring reliable data collection in both online and offline environments. Users can configure dynamic forms for structured data input, with geolocation capabilities provided by the Geolocation API, enhancing the accuracy of collected data. Images captured in the field can also be filtered using an image moderation API, ensuring high-quality, relevant data is retained.

Integrating these modules into the AI4SoilHealth app improves soil health monitoring by streamlining field data collection and increasing the accuracy of real-time observations. It supports users in managing geospatial data with intuitive features, such as attaching images to observations and managing locations, while also facilitating efficient data validation and collaboration. This module aligns with the AI4SoilHealth project's goals of advancing sustainable soil management practices, providing a user-friendly solution for field-based data acquisition and analysis.

1. Introduction

The AI4SoilHealth app is an integral part of the AI4SoilHealth project's cyberinfrastructure, designed to seamlessly integrate various data systems, including ground-based, Earth Observation (EO), instrument-based, mobile, and desktop platforms (Fig. 1). By connecting these different data sources, the app provides a unified system for comprehensive soil health monitoring and analysis. This integration ensures flexibility and accessibility, allowing a broad range of users—from researchers and environmental professionals to farmers and policymakers—to effectively manage and interact with soil health data. With its intuitive and user-friendly interface, the app simplifies the process of visualizing, tracking, and analyzing soil health information, supporting data-driven decision-making and enhancing accessibility for users with varying levels of technical expertise [2-6].

The application is available at: https://app.ai4soilhealth.eu

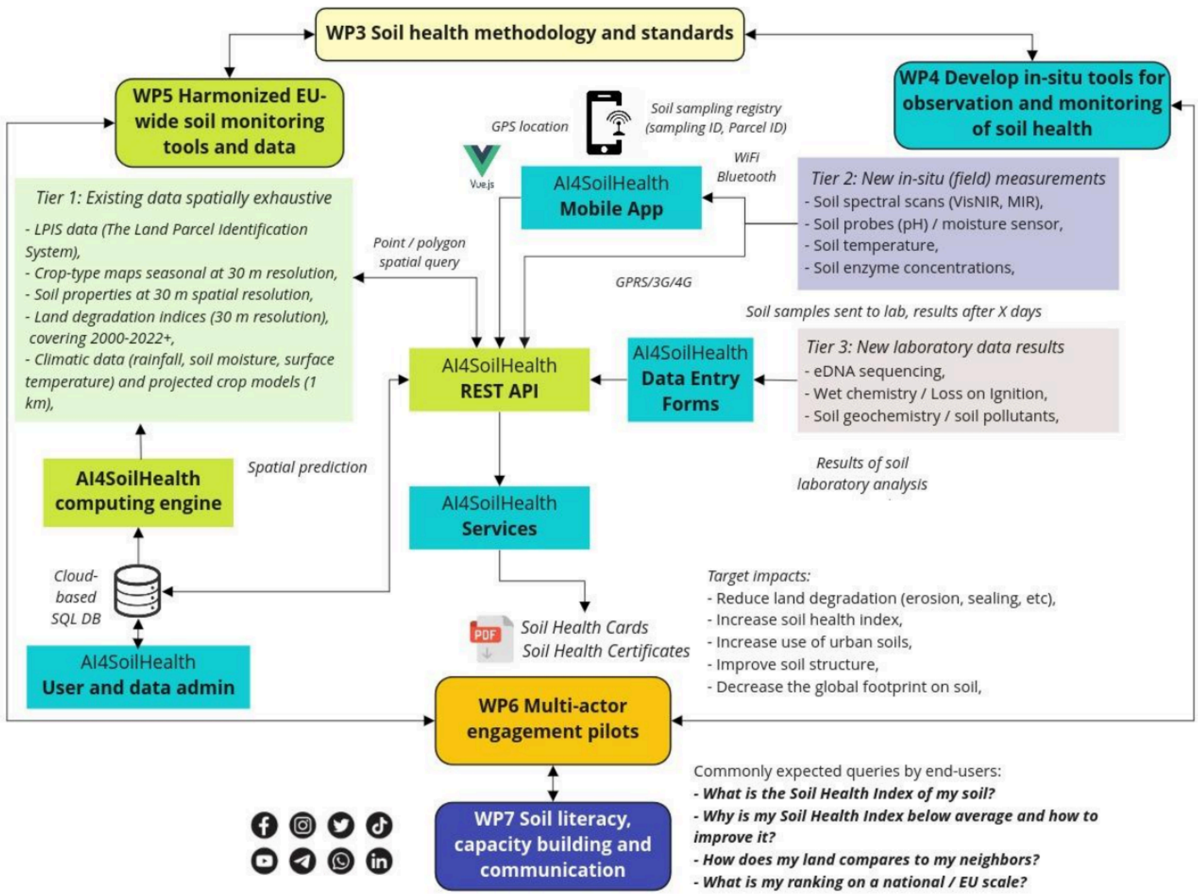


Fig. 1. General design and functionality of the AI4SoilHealth App: working with Tier 1 (exhaustive data from the data cube), Tier 2 (direct in-situ measurements) and Tier 3 (data sent to laboratory) observation and predictions [1]

The app's interface is designed with a focus on simplicity and ease of use, ensuring an intuitive and user-friendly experience. Leveraging modern design principles, the interface is primarily menu-driven, allowing users to navigate seamlessly through various features. Clickable buttons, dropdown menus, and interactive elements are strategically placed to enhance the user experience, providing a clean and efficient way to access the app's functionalities. This approach not only minimizes complexity but also ensures that users can quickly and confidently interact with the app, making it an ideal tool for both beginners and experienced users alike. The emphasis on intuitive design ensures that all actions, from adding geolocated points to generating reports, are easily accessible, streamlining workflows and improving overall usability.

Within this framework, Deliverable 4.9 focuses on one of the app's functionalities: geolocated data collection. These modules ensure reliable, accurate, and efficient acquisition of imagery and sensor data, essential for advancing the project's goals in soil health monitoring and sustainable management practices.

2. In-Field Geolocated Data Collection

The geolocated data collection modules are key features of the AI4SoilHealth app, designed to enable precise and efficient in-field data acquisition. They allow users to capture geolocated imagery and sensor readings directly from their mobile devices, ensuring accurate data collection even in offline settings.

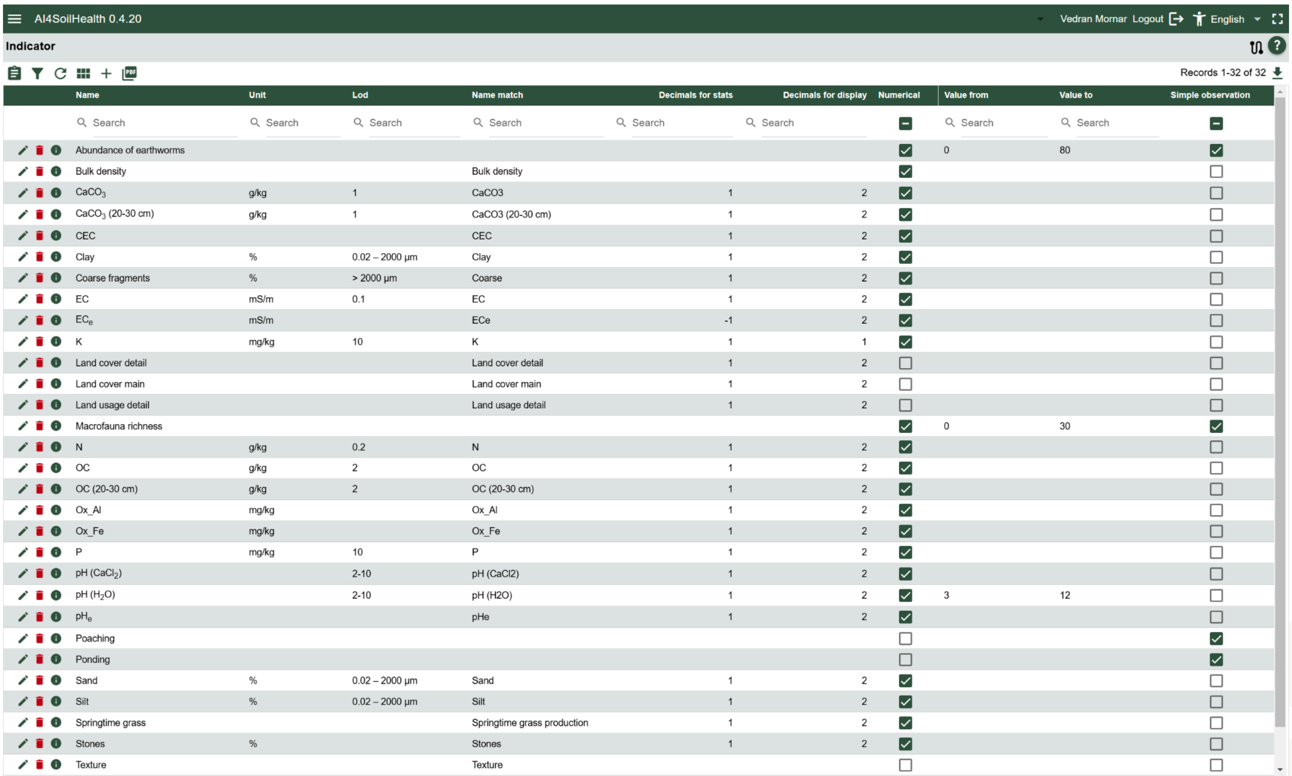
By integrating advanced functionalities such as configurable forms for structured data input, geolocation via the Geolocation API, and image moderation through automated or manual filtering, the module streamlines the process of gathering high-quality data. This ensures that the information collected is both relevant and actionable, supporting the broader objectives of the AI4SoilHealth project in soil health monitoring and sustainable management practices.

2.1 Definitions of the indicators that are to be collected in-situ

Not all of the indicators can be analyzed in-situ due to the complexity or specialized requirements of certain measurements, which necessitate laboratory equipment and conditions. However, a subset of indicators that can be directly observed, measured, or recorded in the field is clearly delineated in the Indicators table (Fig. 2). These indicators are marked by enabling the Simple observation flag, signifying that they can be collected using basic tools or visual assessment without requiring lab processing.

For these field-observable indicators, the module provides additional metadata to ensure data quality and consistency. Specifically, it defines an expected range of values through the “Value from” and “Value to” fields, which serve as a validation mechanism during data entry. This validation ensures that in-situ data falls within plausible thresholds, minimizing errors and enhancing reliability. The ability to identify and pre-define such indicators streamlines the data collection process, allowing for efficient and accurate in-field operations while reserving complex analyses for the lab.

In addition to these validations, the module supports dynamic customization of indicator definitions to adapt to various fieldwork scenarios. Users can update or refine the Simple observation flag and validation ranges as new requirements arise, ensuring flexibility and scalability for diverse research needs. This streamlined approach enables efficient and accurate collection of in-situ data, laying the groundwork for subsequent lab analyses and integration into broader datasets for various environmental or agricultural assessments.



Name	Unit	Lod	Name match	Decimals for stats	Decimals for display	Numerical	Value from	Value to	Simple observation
Abundance of earthworms						☑	0	80	☑
Bulk density			Bulk density			☑			☐
$CaCO_3$	g/kg	1	CaCO3	1	2	☑			☐
$CaCO_3$ (20-30 cm)	g/kg	1	CaCO3 (20-30 cm)	1	2	☑			☐
CEC			CEC	1	2	☑			☐
Clay	%	0.02 – 2000 µm	Clay	1	2	☑			☐
Coarse fragments	%	> 2000 µm	Coarse	1	2	☑			☐
EC	mS/m	0.1	EC	1	2	☑			☐
EC_e	mS/m		ECe	-1	2	☑			☐
K	mg/kg	10	K	1	1	☑			☐
Land cover detail			Land cover detail	1	2	☐			☐
Land cover main			Land cover main	1	2	☐			☐
Land usage detail			Land usage detail	1	2	☐			☐
Macrofauna richness						☑	0	30	☑
N	g/kg	0.2	N	1	2	☑			☐
OC	g/kg	2	OC	1	2	☑			☐
OC (20-30 cm)	g/kg	2	OC (20-30 cm)	1	2	☑			☐
Ox_Al	mg/kg		Ox_Al	1	2	☑			☐
Ox_Fe	mg/kg		Ox_Fe	1	2	☑			☐
P	mg/kg	10	P	1	2	☑			☐
pH ($CaCl_2$)		2-10	pH (CaCl2)	1	2	☑			☐
pH (H_2O)		2-10	pH (H2O)	1	2	☑	3	12	☐
pH_e			pHe	1	2	☑			☐
Poaching						☐			☑
Ponding						☐			☑
Sand	%	0.02 – 2000 µm	Sand	1	2	☑			☐
Silt	%	0.02 – 2000 µm	Silt	1	2	☑			☐
Springtime grass			Springtime grass production	1	2	☑			☐
Stones	%		Stones	1	2	☑			☐
Texture			Texture			☐			☐

Fig. 2. Indicators table – the app's interface for defining indicators

2.2 Data collection process

The process begins by defining the specific location where the data are to be collected. Each location serves as a central point for organizing and managing observations, providing geospatial context for the collected data. This location-based structure ensures that all observations are accurately tied to their respective geographic coordinates, enabling robust analysis and seamless integration with geospatial datasets or mapping tools.

Within a single location, it is possible to record multiple observations, each representing a distinct data point or set of measurements. Observations are designed to be flexible and can encompass various types of indicators, depending on the study's goals. By allowing multiple observations at a single location, the system supports comprehensive and detailed data collection workflows, making it well-suited for diverse field research needs.

Additionally, each observation can have several images attached, providing rich visual context and supporting a deeper understanding of the data. These images can document the conditions under which the data were collected, such as visible signs of erosion, plant health, or other relevant environmental factors. The ability to associate multiple images with an observation ensures that visual evidence is not lost, offering researchers and analysts a more holistic understanding of the conditions in the field.

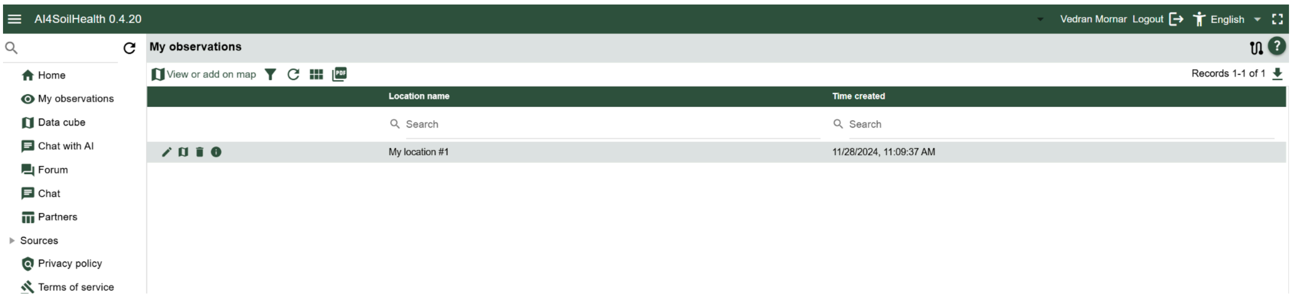


Fig. 3. My observations – the app's interface for defining observations on locations

From the main menu, the "My Observations" option allows for the management and interaction with observations (Fig. 3). This menu provides the ability to add new observations ("View or add on map") and includes additional features such as:

- Filter Form: Filter observations by location name or creation time.
- Reload Data: Refresh the observation list.
- Toggle Grid View: Switch between different display modes for the observations.
- Report Generation: Generate reports based on the filtered observations.

A new location can be created by selecting “View or add on map” from the “My Observation” menu. This action opens an interactive map interface (Fig. 4), where users have multiple options for adding geolocated points and polygons. Primarily, by clicking the "Add point at current GPS position" button, the user can add a point at the device's current GPS location, utilizing its GPS capabilities for quick and accurate geotagging. Alternatively, by selecting the "Add Point at Crosshair Position" option, the user can place a point at the crosshair location, a functionality engineered to ensure greater accuracy and precision. This approach compensates for the inherent difficulty of pinpointing an exact location on a touchscreen device. By dragging the map until the desired position aligns with the crosshair, users can ensure greater accuracy without relying on imprecise finger input.

By clicking on "Add...", the user can access a variety of options to customize the data input process. These options include "Point at mouse cursor position (click to select)", which allows the user to place a point at the current mouse cursor location, "Polygon (click to define vertices)", enabling the user to draw a polygon by clicking to set each vertex, and "Polygon (vertices at crosshair position)", which allows for the creation of a polygon with vertices placed at precise crosshair positions for increased accuracy. These intuitive options provide flexibility in how geolocated data is collected, catering to different user preferences and ensuring efficient interaction with the app.

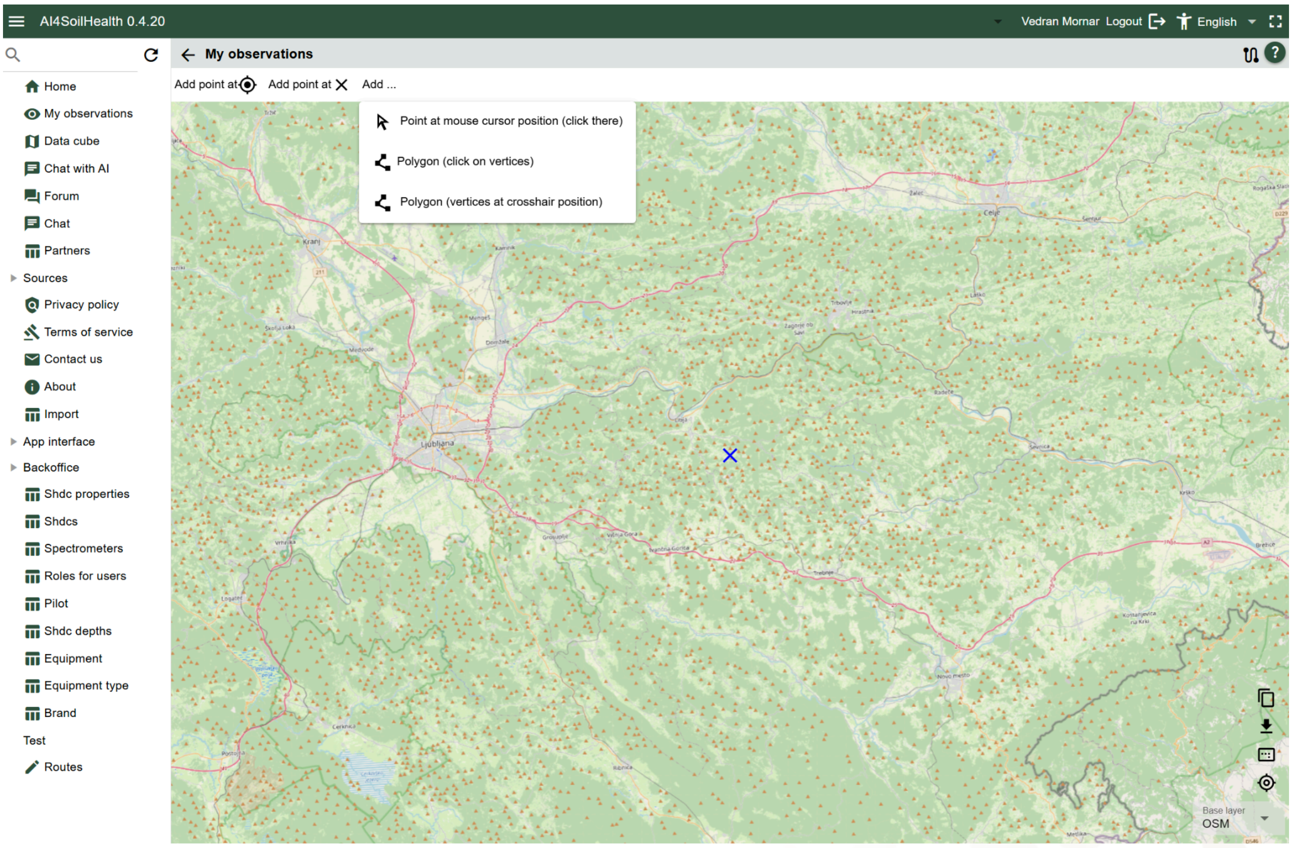


Fig. 4. Add point – the app's interface for adding location points and/or polygons

For desktop users, points can also be added by clicking the mouse cursor on the desired position.. Beyond individual points, the application supports the creation of polygons to define larger areas. Polygons can be created in two ways: by clicking the mouse to place vertices directly on the map or by positioning vertices under the crosshair and using a dedicated button within the application to finalize the shape. This dual functionality accommodates both touchscreen and mouse-based input methods, ensuring flexibility for different devices and user preferences.

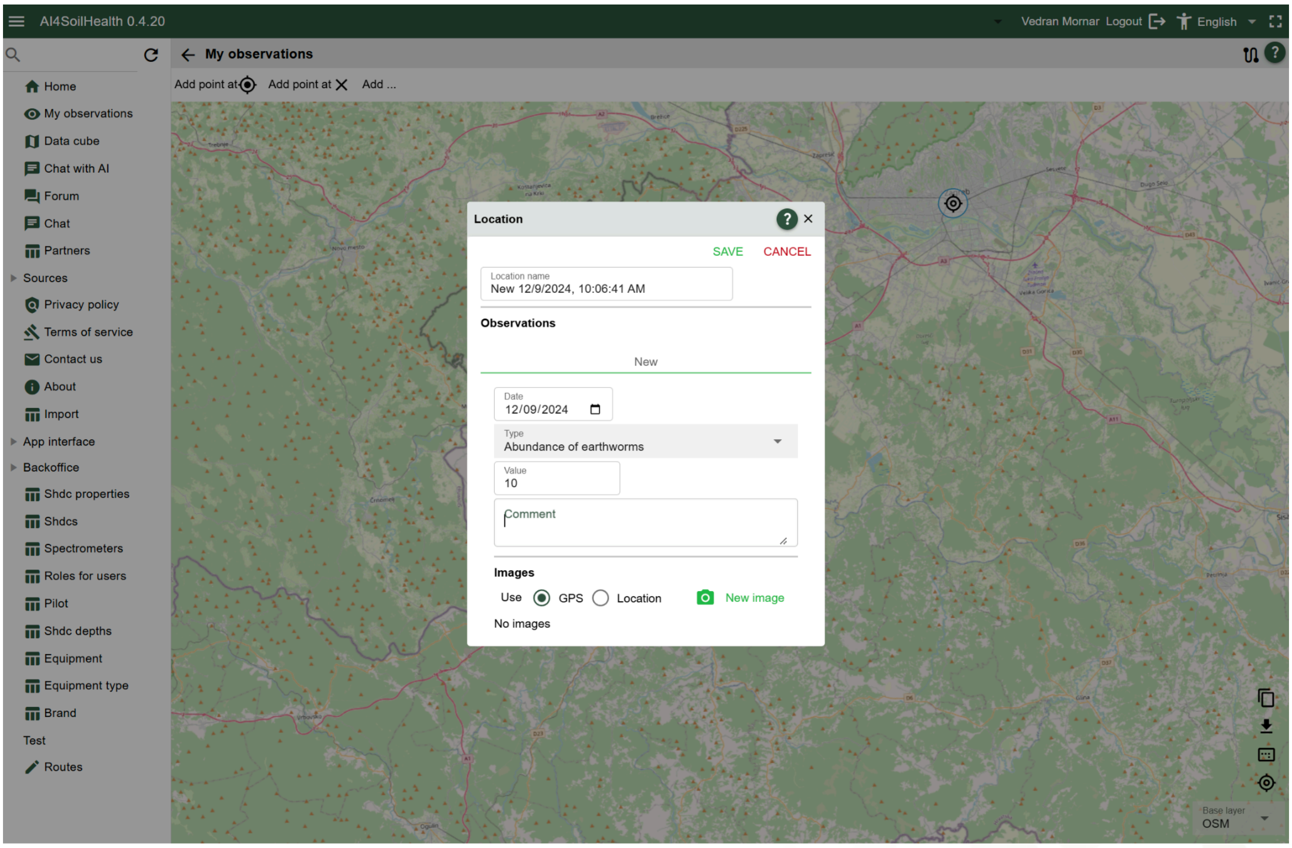


Fig. 5. Editing location data – the app's interface for defining observations and images for the specified location

When a location is created, a popup window opens (Fig. 5), allowing the user to input and manage location details. The popup includes a default name for the location, which can be edited immediately or at a later time to ensure meaningful and recognizable naming. Additionally, the date of the observation is displayed, providing a timestamp that is critical for tracking and analyzing temporal trends.

The user is then prompted to select the type of observation, choosing from a list of indicators marked as Simple observation. Once the observation type is selected, the user can enter the corresponding value. The application automatically retrieves validation parameters (e.g., acceptable ranges) and units of measure from the database to ensure accurate and consistent data entry. Any value entered outside the predefined range triggers a notification, allowing the user to recheck the input immediately.

To enhance data collection, the user can attach images to the observation by clicking the New image button (Fig. 5). On a PC, the user can upload an image by selecting it from the file system, providing flexibility for those working in office settings or using pre-existing datasets. On a mobile device, the user has the option to either select a previously taken image from the device's gallery or capture a new image using the device's camera (Fig. 6). This functionality is particularly useful for fieldwork, where real-time visual documentation of observations is often required.

The interface is designed to streamline the workflow for defining and editing observations, offering an intuitive and user-friendly experience. By combining efficient data entry mechanisms with flexible image-handling options, the application supports accurate, context-rich data collection across a variety of devices and environments.

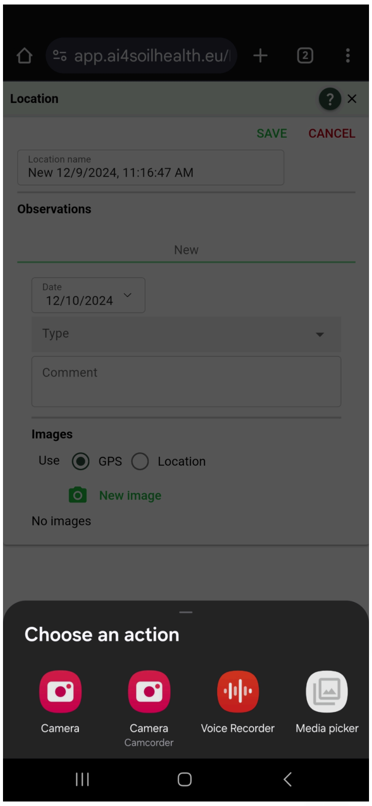


Fig. 6. Mobile interface for capturing new images in real time during fieldwork

An image can be saved either at the current GPS position or attached directly to the specific location where the observation is recorded. This flexibility allows users to precisely associate images with their intended geospatial context, whether capturing a moment in real-time or linking it to a predefined location.

Each observation can have multiple images associated with it, enabling visual documentation of the conditions or phenomena being studied. For example, users might attach one image showcasing the overall environment, another focusing on specific features such as soil texture or vegetation, and a third providing close-up details of the observed indicator. This multi-image functionality enriches the dataset, offering a more detailed and layered understanding of the observation.

To ensure efficient image management, metadata such as timestamps and geotags are automatically recorded for each image. These details are invaluable for subsequent analysis and help maintain data integrity across multiple observations and locations. Whether images are added via mobile devices or desktop systems, the application provides a seamless interface for organizing and retrieving visual assets linked to specific observations.

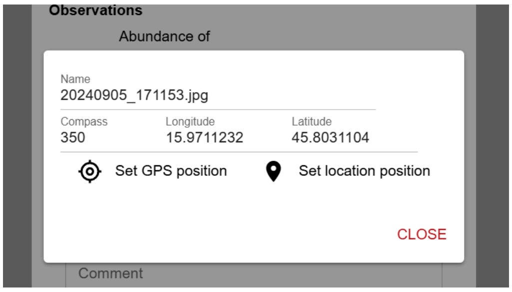


Fig. 7. Image capture on a mobile device: automatically recording the direction and geographic coordinates along with the image

If an image is captured using a mobile device, the application automatically records the direction in which the image was taken, along with the geographic coordinates (Fig. 7). This additional metadata provides valuable spatial context, enabling users to understand the orientation of the image relative to its location.

The recorded image attributes can be further refined by clicking the 'Edit Properties' icon. This feature allows users to update metadata, such as the image title, description, or associated observation details, ensuring that all information remains accurate and well-organized. The editing functionality is designed to support post-fieldwork adjustments or corrections, thereby improving data quality and usability for downstream analysis.

By combining automated metadata capture with flexible editing options, the application ensures that each image contributes to a well-documented and contextually rich dataset, supporting robust research and decision-making.

An image can be previewed at any time by clicking the 'Show Image' icon (Fig. 8). This functionality allows users to quickly inspect the captured image without needing to navigate away from the current interface. The preview provides an opportunity to verify the quality and relevance of the image, ensuring it accurately represents the observation or location before finalizing the data entry.

For fieldwork scenarios, this feature is especially useful as it enables users to confirm that critical visual details have been captured while still on-site, reducing the likelihood of missing important information.

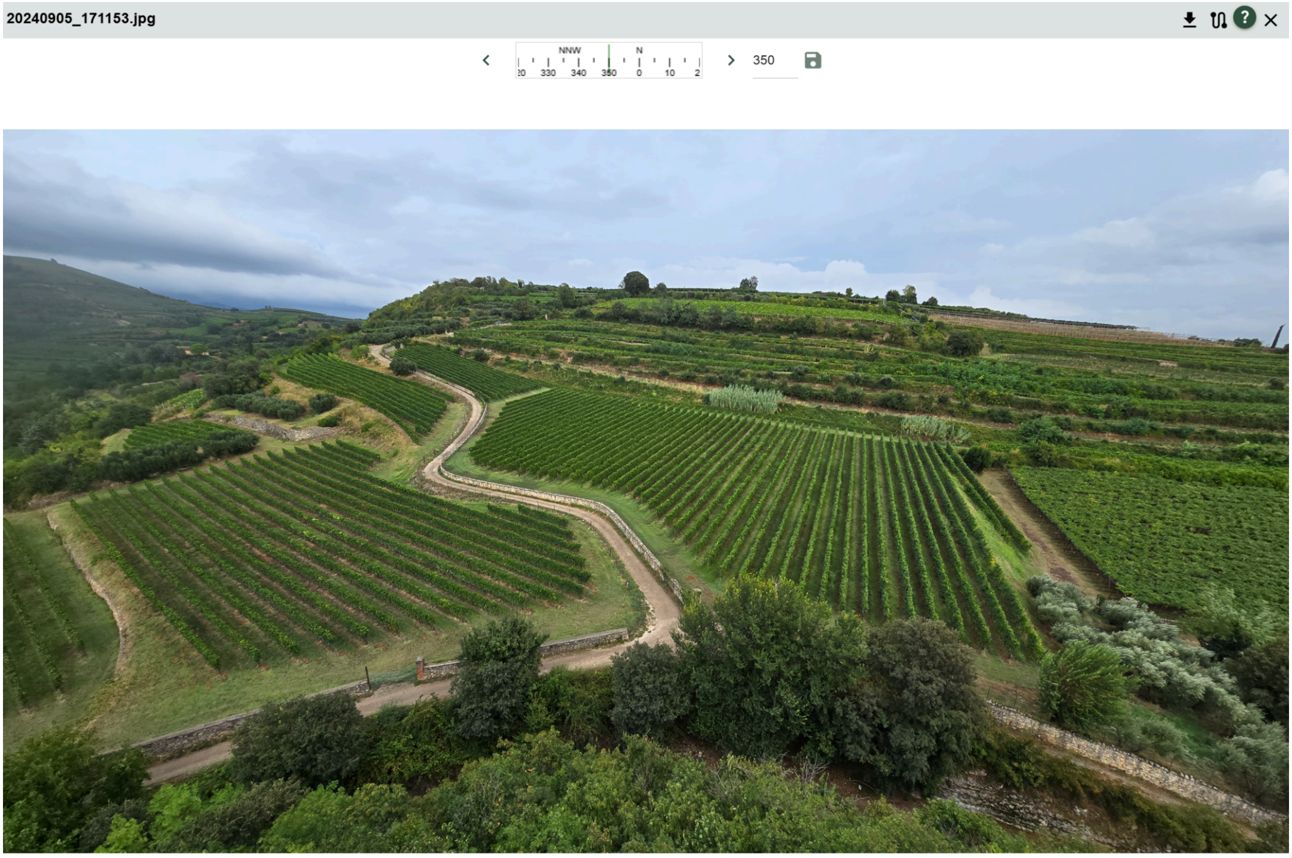


Fig. 8. Image Preview: Clicking the "Show Image" icon to view the captured image

If the direction is stored with the image, an editable compass control appears at the top of the image preview, allowing the user to adjust the direction as needed (Fig. 9). This feature provides flexibility, enabling users to correct or update the image's orientation if it was not accurately captured initially.

When the location is viewed on the map, images are symbolized with a viewpoint icon, which is oriented based on the recorded direction. This ensures that the images are displayed in their proper spatial context, giving users a clear understanding of the viewpoint from which the image was taken. The orientation of the viewpoint icon corresponds to the actual direction, allowing for precise visual representation of the field data in relation to the surrounding environment.

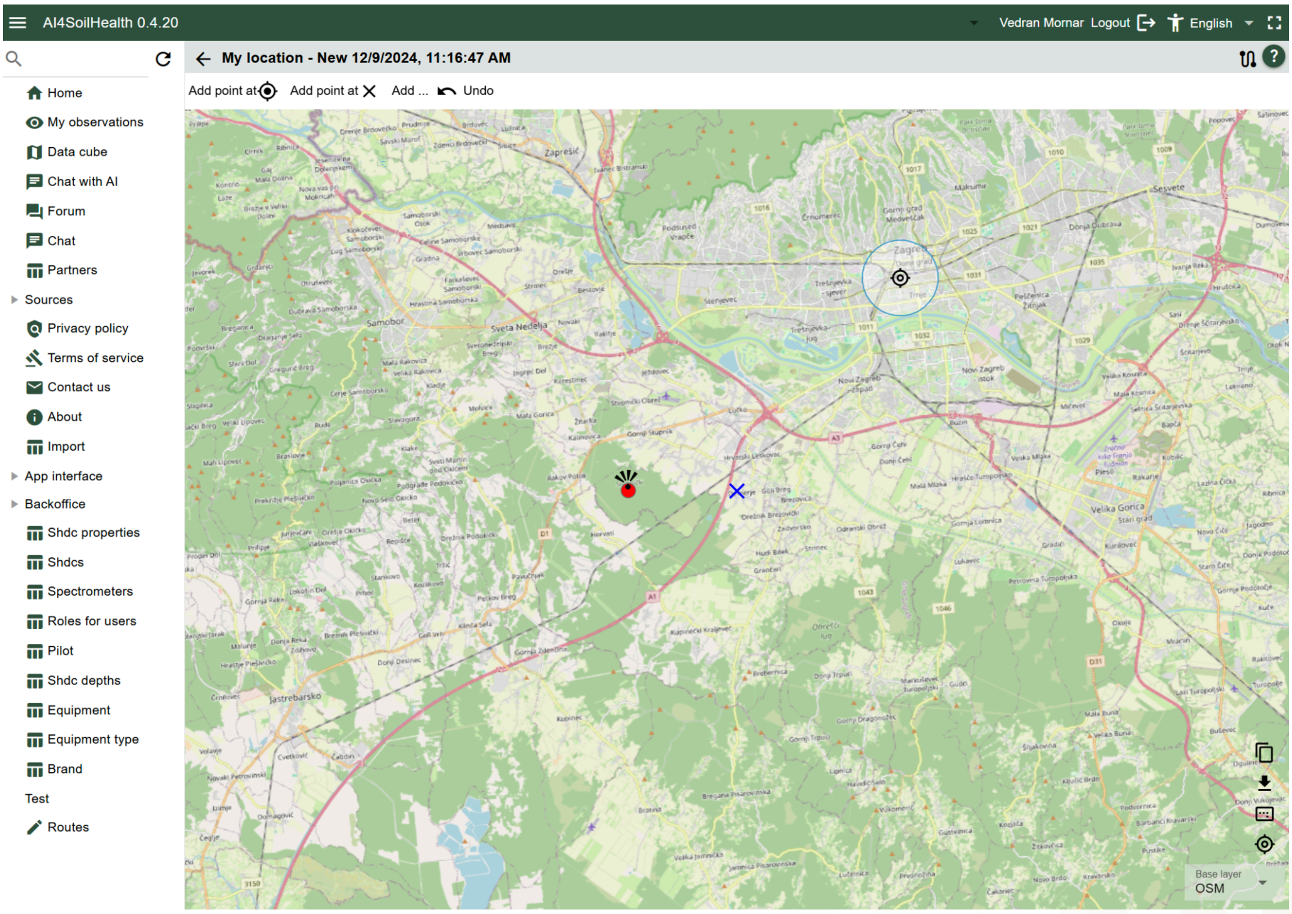


Fig. 9. Image direction control and map visualization: adjusting image direction with the compass and displaying oriented viewpoint icons on the map

When the user clicks on the viewpoint icon, the corresponding image opens in a preview mode, allowing for quick inspection of the visual data. Clicking on a location point or polygon brings up the data editing form, where users can manage the associated information. This includes the ability to add, edit, or delete observations and any attached images, ensuring that all data remains up-to-date and accurate.

Additionally, the map interface supports interactive manipulation. Points, polygons, and images can be easily repositioned by dragging them to a new location, offering users the flexibility to adjust the spatial arrangement of data as needed. This functionality enhances the user experience by enabling dynamic data management and providing a more intuitive way to update geospatial information directly on the map.

2.2 Data privacy

All locations, observations, and images are accessible and editable only by the users who created them or their designated partners. This ensures that sensitive data is protected and can only be modified by authorized individuals.

A user can manage their designated partners by editing the Partners table (Fig. 10). To add a new partner, the user must know the AI4SoilHealth username of the person they wish to designate. This ensures that only trusted collaborators can access and update shared data, facilitating controlled and secure data sharing within the system.

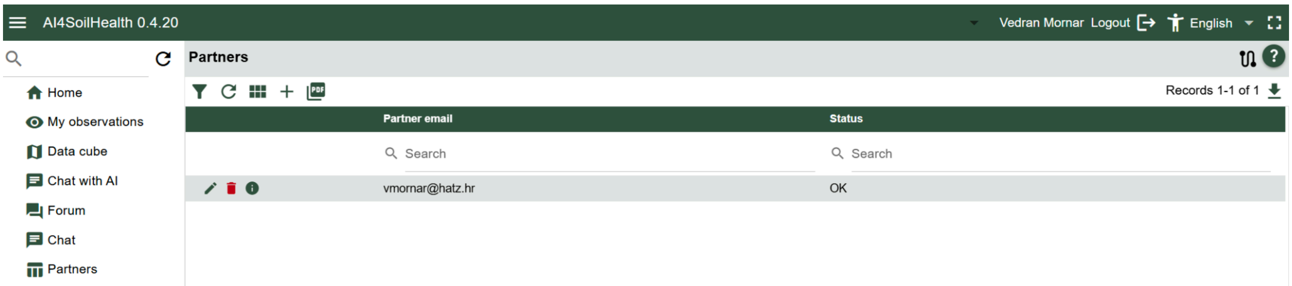


Fig. 10. Managing designated partners: editing the Partners table to add new partners using their AI4SoilHealth username for secure data sharing

We plan to introduce a public flag for each location, observation, and image, allowing users to designate these items as publicly accessible. When the flag is activated, the associated data will be accessible in read-only mode to other users of the system. This feature will enable users to share specific data with the broader community, enhancing collaboration while maintaining control over the ability to modify or delete the shared information.

3. Conclusion

The In-Field Geolocated Data Collection modules provide a robust and user-friendly system for real-time collection, management, and sharing of geospatial data. By integrating location-based observations with rich metadata, images, and flexible editing options, the module enhances data accuracy, documentation, and collaboration in the field. Users can easily add, edit, and organize data points, ensuring a comprehensive and precise representation of field conditions. The ability to associate images with specific locations and observations, along with the incorporation of directional data and geospatial visualization, facilitates a more complete understanding of the environment being studied.

Further work will focus on expanding the functionality of this module, including the introduction of the public flag feature, which will allow users to share their data with the broader community while maintaining control over its accessibility. Additionally, we aim to enhance the editing capabilities of the Partners table to simplify the management of collaborators and improve the user interface for better navigation and interaction with large datasets. The goal is to continually improve the module's usability, flexibility, and collaboration features, ensuring it remains a valuable tool for field-based data collection and analysis.

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