

Geolocation and sensor data supported ESM



application User Guide

Introduction

This document describes the features and capabilities of the GeoSenEsm application. GeoSenEsm enables the creation of periodic survey forms for respondents in studies using the experience sampling method. Additionally, respondents' answers are correlated with their location and sensor readings measuring temperature and humidity in their surroundings. The project includes: a mobile application for Android and Apple devices. In order to create a survey you would also need to host an administrator application for creating surveys and viewing (monitoring) results.

GeoSenEsm, an abbreviation for Geolocation and Sensor data supported Experience Sampling Method, integrates geolocation and sensory data with the Experience Sampling Method (ESM). ESM is a widely-used research technique that captures participants' real-time self-reports on experiences, behaviors, and emotions. GeoSenEsm enhances this approach by incorporating contextual and environmental data, such as participant geolocations and sensor readings for local temperature and humidity. This integration addresses the limitations of traditional ESM, which often relies solely on subjective reports, by providing objective environmental metrics. In urban studies, GeoSenEsm offers valuable insights into how individuals interact with their environments. By bridging the gap between subjective experiences and objective environmental data, the application enables researchers to uncover more nuanced relationships between urban environments and human behaviors.

Contents

Chapter 1. GeoSenEsm project	4
1.1. System architecture	5
Chapter 2. Supported sensors	7
Chapter 3. Mobile application	9
3.0.1. First login setup	10
3.1. Home screen	14
3.2. Filling in Survey Responses	15
3.3. Types of Survey Questions	18
3.4. Notification System for Surveys	26
3.4.1. Offline Functionality	26
3.5. Survey Interaction and Design Consistency	27
3.6. Additional modules and views	28
3.7. Conclusions	33
Chapter 4. GeoSenEsm - server admin application	34

CHAPTER 1

GeoSenEsm project

GeoSenEsm is an open-source project under MIT license, the code can be found here:

<https://github.com/geosenesm>

Project features:

- **Simple design inclusive for older respondents** - main screen of the application is only dedicated to surveys. Surveys display only one question at a time and support large fonts.
- **Data security** - all data is sent to and stored in one place only - researcher own server. The researcher is the only one who has access to all data.
- **Scheduling and notifications** - set up start and finish time for your surveys, repeat them multiple times a day, respondents will be notified on survey start and when it comes to an end.
- **Fully operational offline** - all surveys and responses are saved locally in the app and saved data are cached and will be uploaded as soon as there is an internet connection.
- **Admin portal** - setup surveys and review results during the study using the admin portal. All study data can be exported to csv format.
- **Location and sensor data** - enrich survey data with geolocation and information on temperature and humidity from Xiaomi or Kestrel sensors (possibility to extend to others in the future). Limit the study to specific geographical region.
- **Open source and anonymous** - setup your own server following our guideline, collect data with our mobile app, generate anonymous accounts for respondents. Researcher have full control over access to study.
- **Multiple question types and conditional routes** - delegate question to subgroup from your study, setup conditional routes in survey, use one of six types of questions in your survey.
- **Privacy and data sharing** - respondents have access to shared sensor readings and locations and can limit the location sharing to specific hours of the day.

1.1. SYSTEM ARCHITECTURE

GeoSenEsm was designed as a multi-platform mobile system based on the Flutter framework. The mobile app connects to a server instance that should separately be created by the researcher when he/she wants to perform the study. The server instance consists of an admin application to manage the study, a database for data storage and an API for exchanging data between the server and mobile devices.

Below you can find a high-level schema illustrating GeoSenEsm architecture.

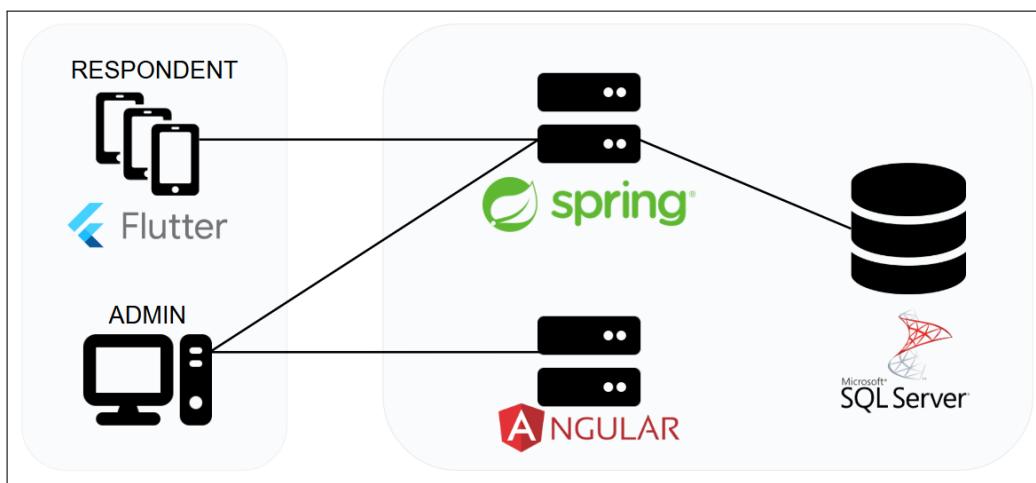


Figure 1.1. GeoSenEsm system architecture diagram.

Server deployment

To set up a server, researchers need to have Docker installed. Docker is an open-source platform designed to simplify the process of building and running applications <https://www.docker.com/>. It employs an approach called containerization, which packages an application together with its dependencies into a unit called a container. These containers can be efficiently run on any system that has Docker installed, regardless of differences in hardware or operating system. Thus, with a single definition text file (called docker-compose), you can run the application without any further knowledge of system deployment.

The components that can be deployed using Docker containers are:

1. JAVA API
2. Angular Admin Panel
3. Database

Details of the deployment are stored in the docker-compose.yml file, and the setup instructions are provided in the repository <https://github.com/GeoSenEsm/devops>. The only additional element required to configure a study is

a proper domain and traffic routing to the Docker container. This part might require consulting a network specialist. Example setup steps are also available in our repository.

CHAPTER 2

Supported sensors

Xiaomi Mi LYWSD03MMC



Figure 2.1. Xiaomi Mi LYWSD03MMC sensor

The Xiaomi Mi LYWSD03MMC device is a widely used temperature and humidity sensor, often integrated with home assistant systems. The device can be detected during the BLE scanning process by its device name, LYWSD03MMC (common for all sensors).

Since sensor shows up in bluetooth search under the same name, we allow to fill in MAC address of the sensor in the admin app, and mobile app to make sure given user is always using his/her sensor and not some other Xiaomi sensor (i.e. neighbour or colleague).

Kestrel Drop D2



Figure 2.2. Kestrel Drop D2 sensor

Another supported device is the Kestrel Drop 2. This device is much more complex than the Xiaomi sensor.

CHAPTER 3

Mobile application

First element that user sees in the mobile app is the login screen. User has to fill in the server address (*API Url*) and *username* and *password*. The *API Url* should be delivered by the survey creator and in some cases can be limited geographically (when survey data for given country should not be stored on servers outside of that country e.g. China). The user accounts are created by the survey administrator and should be delivered to the users outside of the application. Below you can find a screenshot illustrating this feature.

Notice: In our system users can not create accounts by themselves!

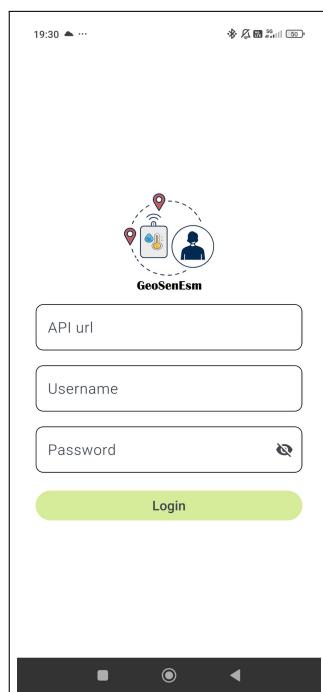


Figure 3.1. Field to enter an API URL in the mobile app on the application login screen.

3.0.1. First login setup

Upon first run user is presented the privacy policy and sensor setup where you can choose no sensor, Xiaomi or Kestrel.

The the so called initial survey is presented to user. You can use that survey to partition the respondents into group according to age, sex etc. You can also use it to save question in different language versions.

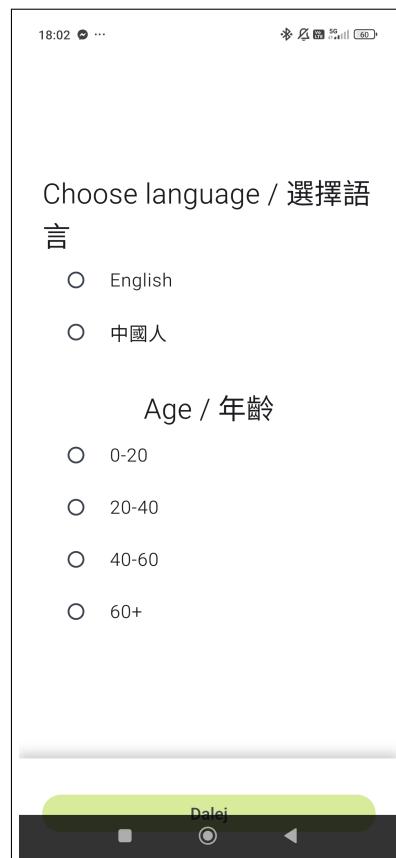


Figure 3.2. Initial survey example, user is asked to choose language and age.

User is also prompted to allow the app to read GPS data, use notification and bluetooth.

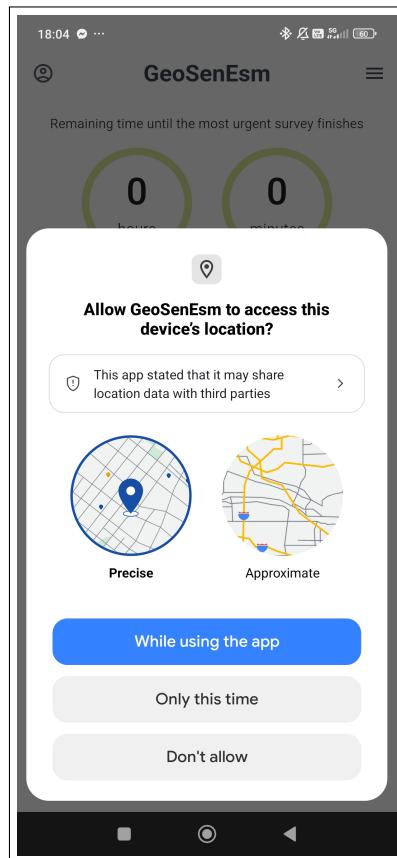


Figure 3.3. Location data request

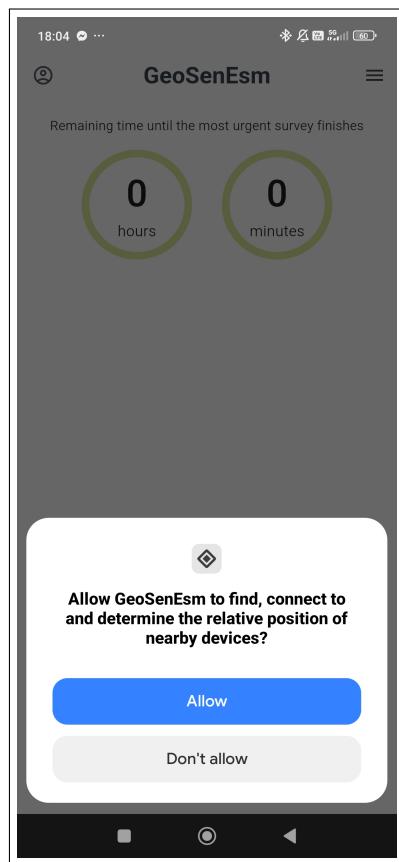


Figure 3.4. Bluetooth access request

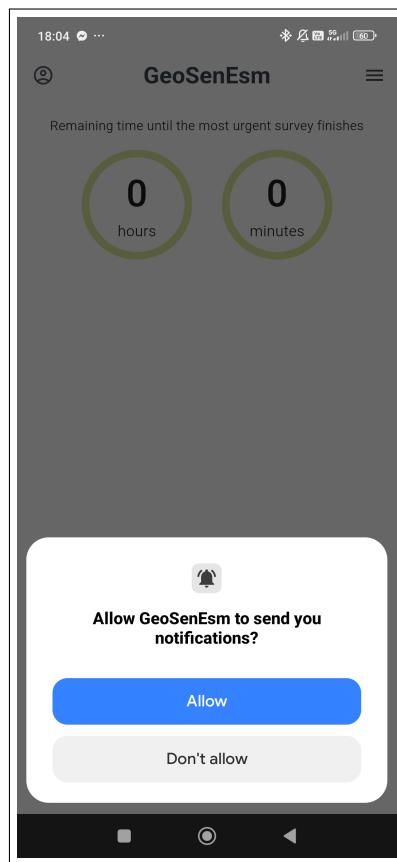


Figure 3.5. Notification access request

3.1. HOME SCREEN

The GeoSenEsm app is designed to be easy to use by elderly, ensuring the app is intuitive, clear, and easy to navigate. The main screen (Figure 3.6) is intentionally minimalist, featuring large, brightly colored orange buttons for easy access to available surveys. A clock on the screen displays the time remaining for the current survey, providing an intuitive visual cue that helps users track how much time they have left to submit their responses. Navigation from the main screen to the menu and user profile is straightforward, with clearly labeled buttons placed in the top left and right corners.

Active surveys are showed in the middle of the screen with Survey name and button that takes user to the survey view.

The app is designed to be accessible to a wide range of users by dynamically adjusting the font size based on the user's phone settings. This feature is especially helpful for older users who may prefer larger text for better readability. Additionally, the app is fully responsive, ensuring a seamless appearance and consistent usability across both iOS and Android devices, as well as various screen sizes.

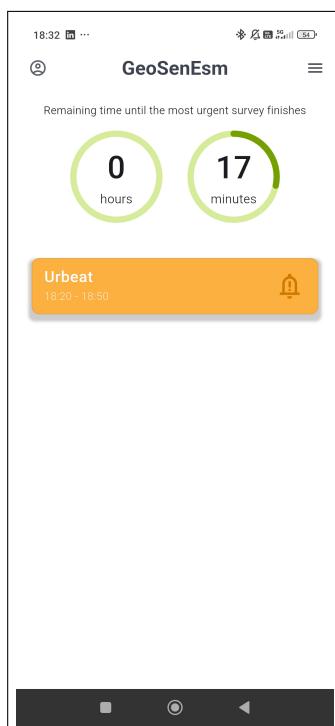


Figure 3.6. Home screen of the GeoSenEsm mobile app.

3.2. FILLING IN SURVEY RESPONSES

1. **Access the Mobile App:** Open the mobile app and tap the orange button with survey name. The button will display the time during which you can submit your responses. The application requires bluetooth to be on when filling in survey as it tries to request the temperature sensor measurements while user is filling in the survey.
2. **Survey Confirmation Screens:** Participants will encounter confirmation screens at both the beginning and end of the survey. The introductory screen (Figure 3.8) confirms the intent to start the survey, while the conclusion screen (Figure 3.9) confirms the submission of responses. Both screens notify participants that responses cannot be edited once submitted, ensuring transparency and minimizing confusion.
3. In case the sensor is not chose you will also be prompted with question are you sure you want to proceed without it.

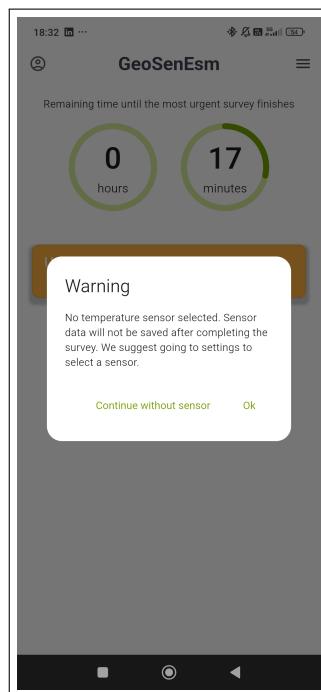


Figure 3.7. No sensor warning.



Figure 3.8. Survey introduction screen, confirming the start of the survey.

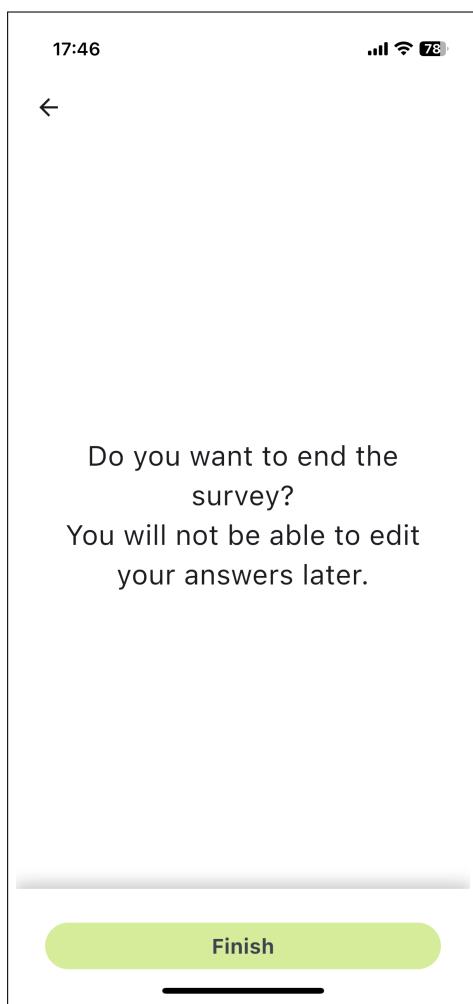


Figure 3.9. Survey conclusion screen, confirming the submission and saving of responses.

3.3. TYPES OF SURVEY QUESTIONS

The surveys support seven types of questions to accommodate diverse research needs. The examples are presented graphically below.

— Single Choice Question

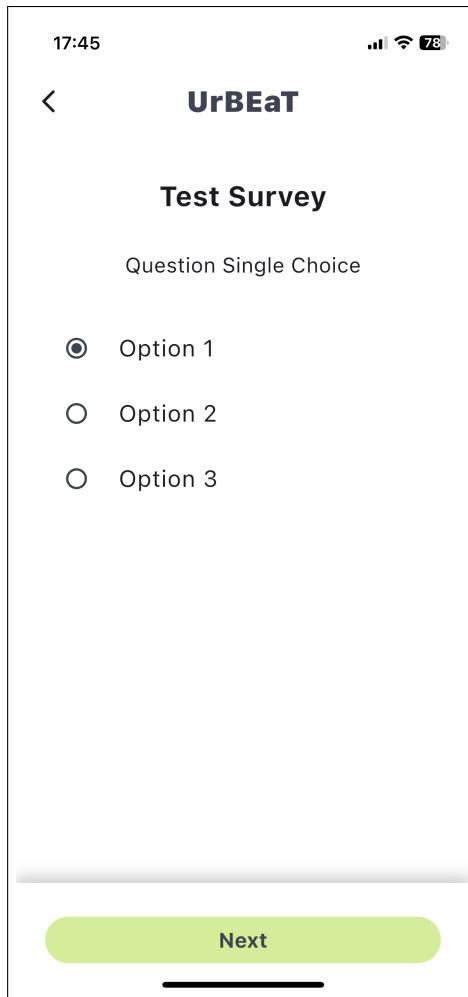


Figure 3.10. Single choice question, where participants select one option from a set of predefined choices.

— **Multiple Choice Question**

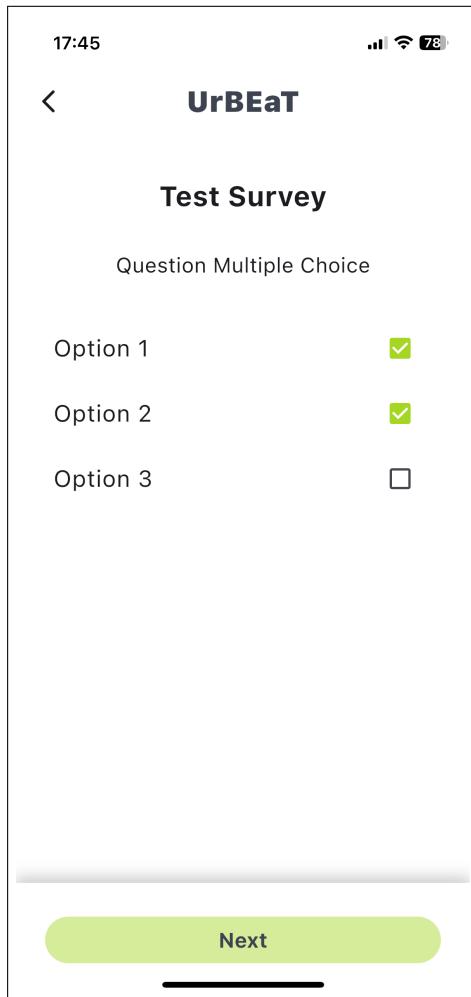


Figure 3.11. Multiple choice question, where participants can select more than one option from a list.

— Linear Scale Question

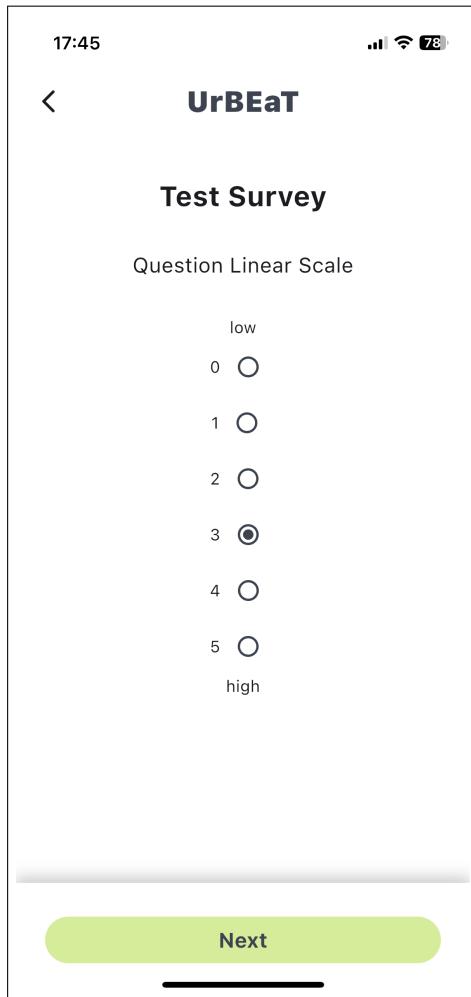


Figure 3.12. Linear scale question, where participants rate their response on a numerical scale.

— Yes/No Question

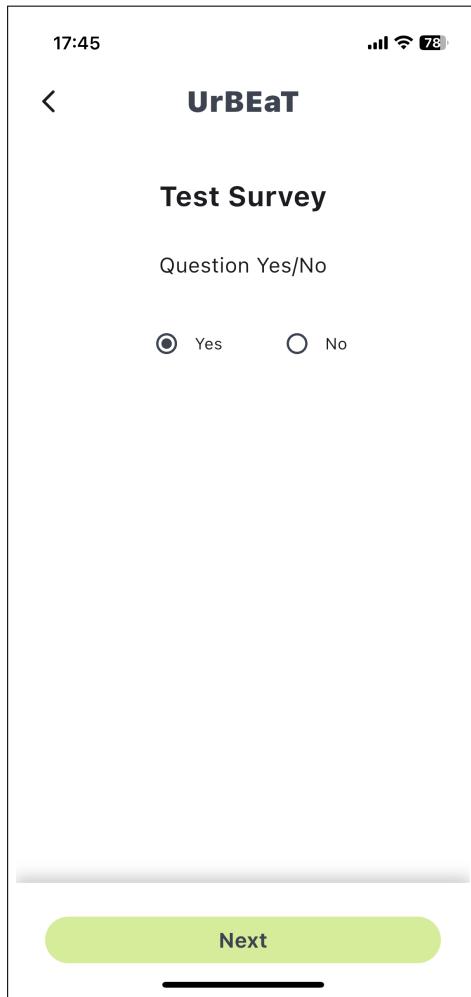


Figure 3.13. Yes/No question, where participants provide a simple yes or no response.

— Number Input Question

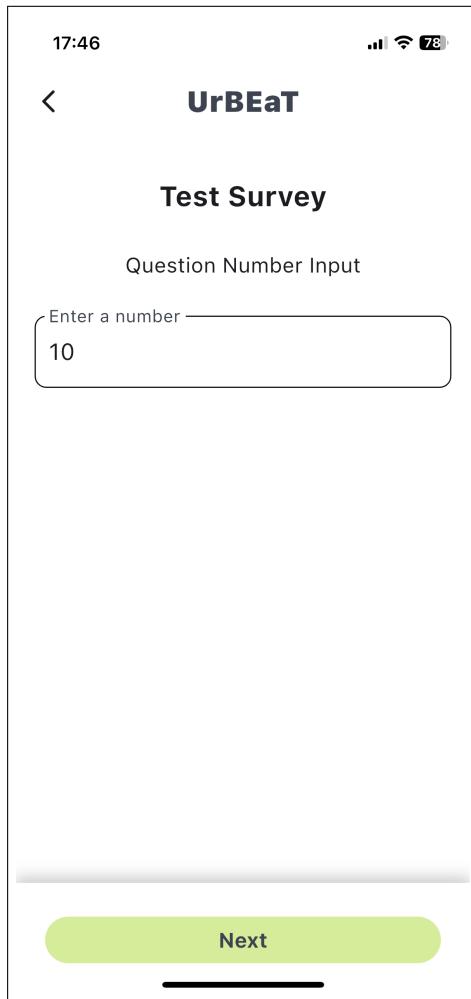


Figure 3.14. Number input question, where participants enter a numeric value.

— **Text Input Question**



Figure 3.15. Text input question, where participants provide a written response.

— Image Choice Question

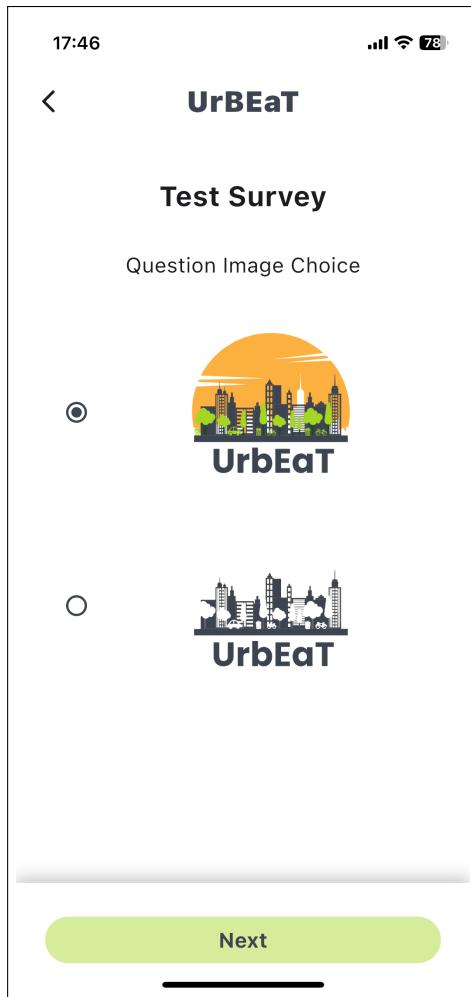


Figure 3.16. Image choice question, where participants select an image as their response.

On submitting the survey additional information on localization and sensor data reading will be sent to the server.

3.4. NOTIFICATION SYSTEM FOR SURVEYS

Participants receive notifications when a new survey becomes available (Figure 3.17) and a reminder 15 minutes before a survey closes (Figure 3.18). This notification system is carefully designed to strike a balance—avoiding an excessive number of alerts, which can be annoying or overwhelming, while ensuring users receive enough reminders to prevent missed surveys.

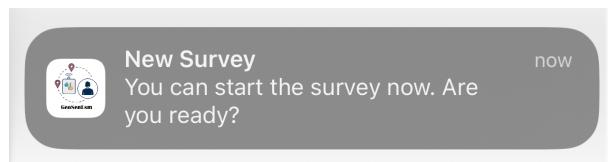


Figure 3.17. Notification indicating the start of a new survey.

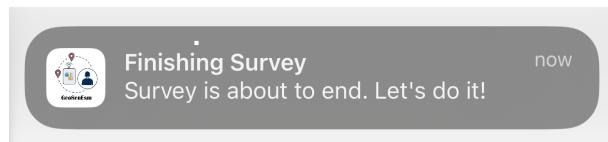


Figure 3.18. Notification alerting participants that a survey will soon.

3.4.1. Offline Functionality

The app is designed to function both online and **offline**, ensuring accessibility even in areas with limited or no internet connectivity. When the app is first downloaded and connected to the internet, all published surveys are preloaded onto the device. Participants can complete surveys *offline*, and the responses are automatically sent to the server once the device reconnects to the internet.

3.5. SURVEY INTERACTION AND DESIGN CONSISTENCY

To enhance usability, the application avoids complex gestures like swiping or drag-and-drop. Surveys present one question per page, navigable with a simple "Next" button. This approach contrasts with other apps that display multiple questions per page, requiring scrolling - a feature that can be confusing, particularly for older users. The design maintains brand consistency, incorporating signature colors: orange, green, and dark grey - across the app and admin panel. The survey logo is prominently displayed during surveys, reinforcing trust and identity, while the visual style remains consistent across all screens.

3.6. ADDITIONAL MODULES AND VIEWS

GeoSenEsm emphasizes transparency by granting participants access to research findings and data collected through the app. Key features include:

Map Module

The map module (Figure 3.19) displays submitted locations, providing precise coordinates, dates, and times for each entry. Additional location details can be viewed by selecting individual points on the map, as shown in Figure 3.20.

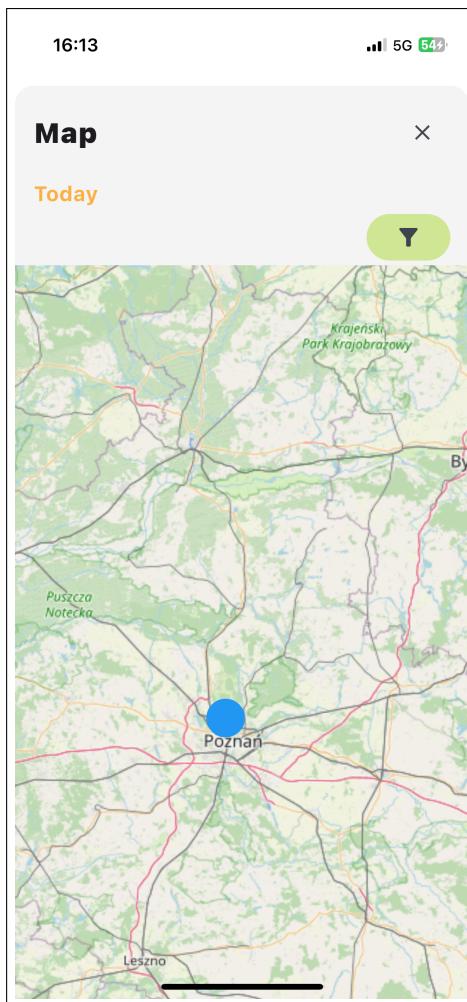


Figure 3.19. Map module displaying submitted locations.

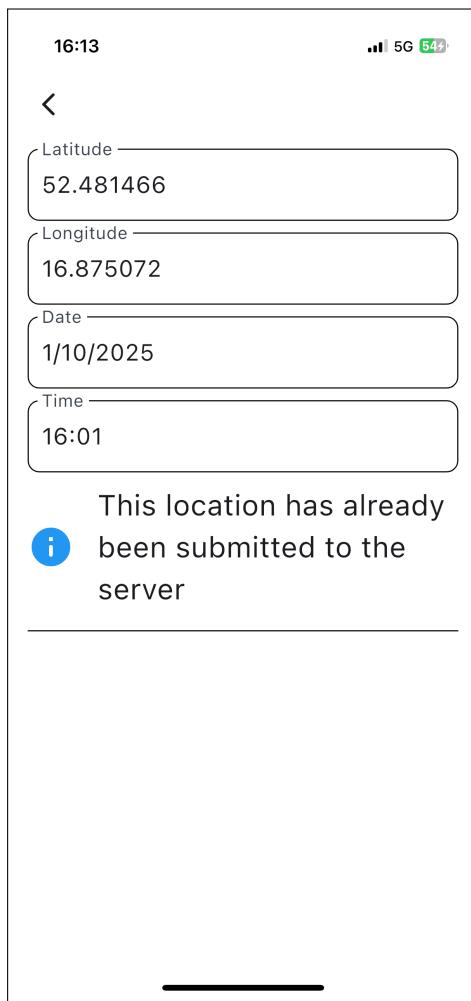


Figure 3.20. Location details for a submitted point.

Sensor Data and History Modules

A real-time sensor data module (Figure 3.21) displays live temperature and humidity readings, empowering users to monitor what data is being collected and transmitted. The sensor history module (Figure 3.22) provides a chronological record of past sensor readings, ensuring complete transparency.

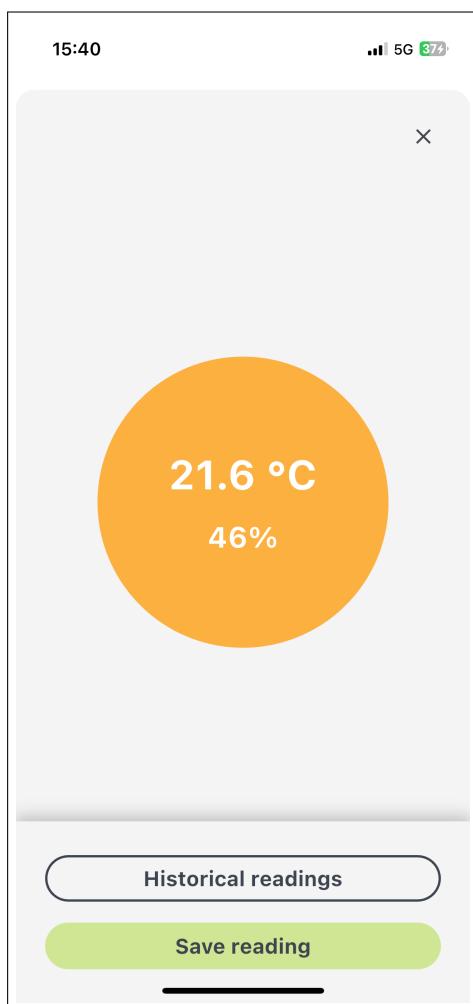


Figure 3.21. Real-time sensor data module.

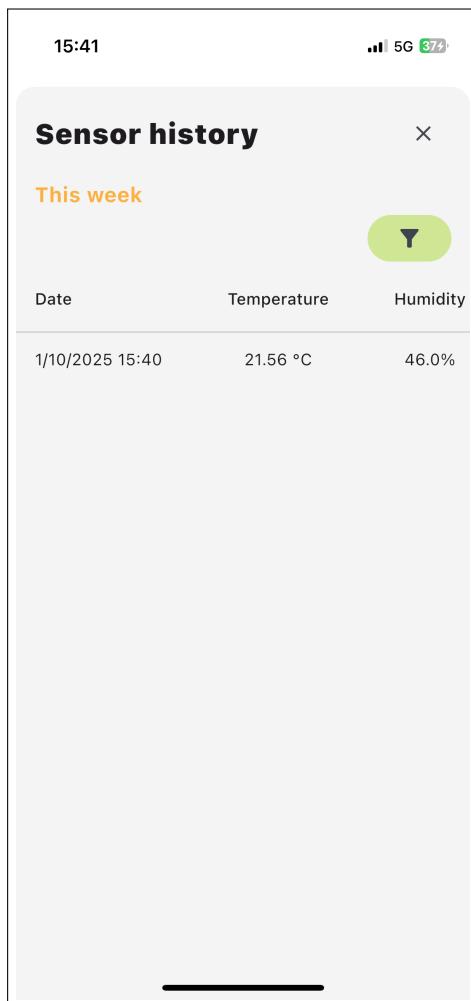


Figure 3.22. Sensor history module.

Color-Coded Calendar Module

The calendar module (Figure 3.23) provides a visual overview of survey progress using a simple color-coded system:

- Green: Completed surveys.
- Red: Skipped surveys.
- Yellow: Upcoming surveys.

This visual representation simplifies progress tracking and encourages consistent engagement.

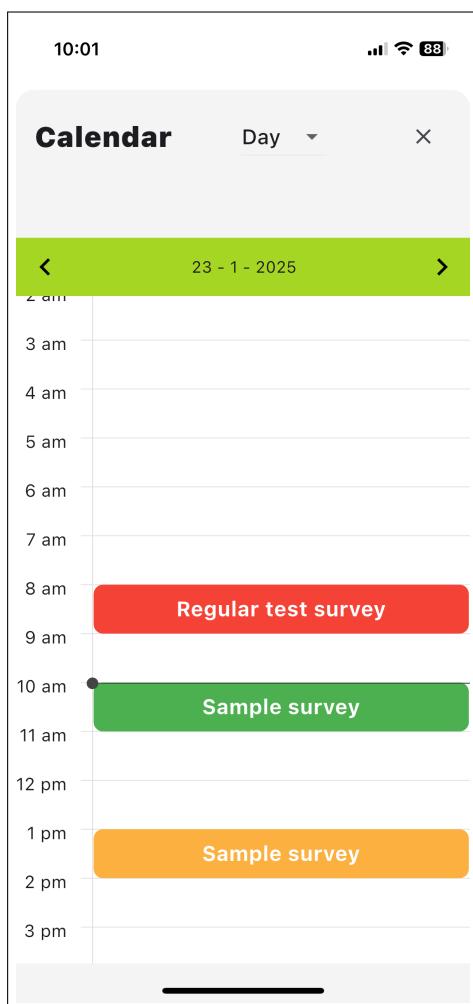


Figure 3.23. Color-coded calendar screen tracking survey progress.

3.7. CONCLUSIONS

These user-centered, accessible, and transparent design features effectively address the practical needs of older adults, fostering trust and engagement. By prioritizing usability and inclusivity, the app serves as a valuable tool for ethical and impactful research.

The Experience Sampling Method (ESM) integrates seamlessly with mobile applications, offering a powerful and efficient way to collect real-time data. This approach relies on participants providing multiple responses throughout the day, making mobile devices the ideal platform, as users typically carry their phones with them at all times. In addition to survey responses, the app collects localization and sensor data throughout the day. This continuous data collection provides valuable insights into participants' whereabouts and their thermal comfort over time, which can be cross-referenced with the survey responses to deepen the understanding of environmental and personal factors affecting comfort.

CHAPTER 4

GeoSenEsm - server admin application

Admin is a separate application that is hosted on server and is meant to be accessed via browser (desktop). Here you can create surveys, see the results, schedule surveys, and set up details on research area or contact details.

On the left side you can see the menu of the admin panel :

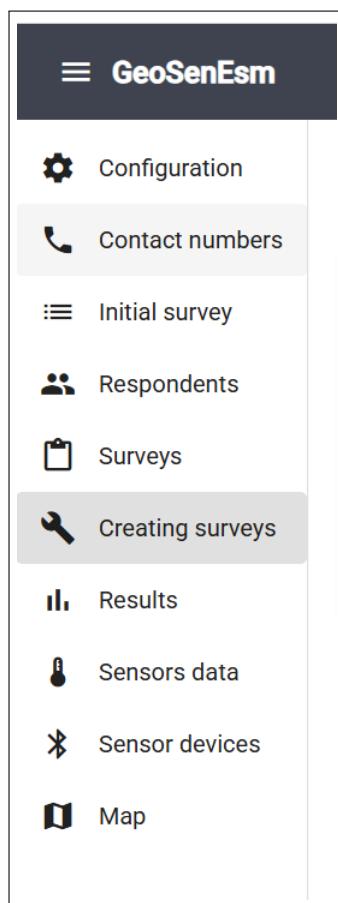


Figure 4.1. Admin app options tab.

The option are as follows :

- **Configuration** - here you define research area (not obligatory). All data filled outside of the research area would be automatically flagged and can be easily filter out from dataset.

Example of the research area bounds file (in csv):

A	B
1	longitude,latitude
2	16.811,52.47382065
3	17.038,52.48762081
4	17.015,52.35277971
5	16.785,52.3603283
6	16.811,52.47382065

Figure 4.2. Research are example of the file.

- **Contact numbers** - here you set app information on phone numbers for researcher that respondent can see in the mobile app.

Name	Number	Id	Edit	Delete
Admin	48484844	b9232f01-6cec-402f-8392-4c9zb2dc3bd3		

Figure 4.3. Adding phone number to study manage (or other person).

- **Initial survey** - Here you define initial survey. It is shown to the user on first login and is obligatory to fill in.

The initial survey elements are always single choice option as they are then columns in respondent data and can be used in survey to create conditional paths and questions to selected respondents group (as partition by initial survey).

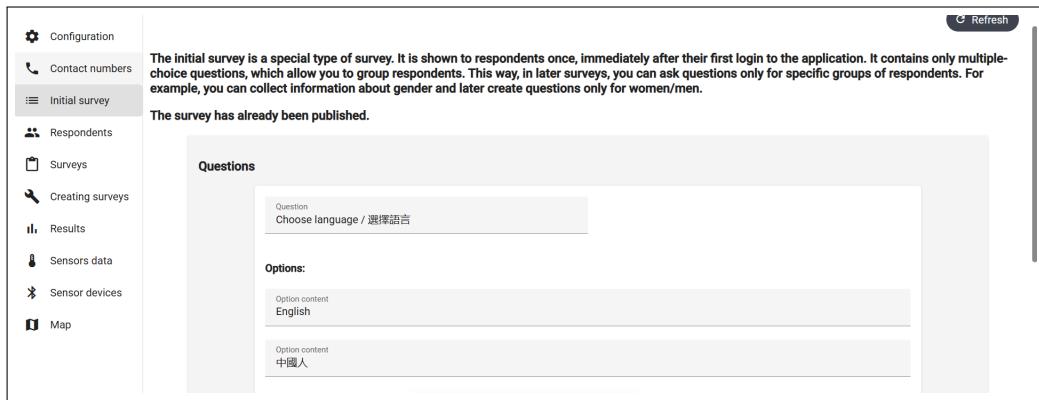


Figure 4.4. Initial survey screen (after submission).

- **Respondents** - here you can browse through respondents list, edit their password (or data if filled incorrectly). It is also the place where the respondents account are being created.

GeoSenEsm								
		Show respondents who	Amount	Date from	Time from	Date to	Time to	
			1	1/2/2026	7:00 AM	1/2/2026	8:00 PM	
Configuration	Contact numbers							
Initial survey								
Respondents		Username	Choose language / 選擇語言	Age / 年齡	ID	Actions		
Surveys		00001	中國人	20-40	bba56dfa-fae5-4caf-83c0-c80e7c65118d			
Creating surveys		00002			a64af3b8-8539-4304-94b7-dfe3056c633			
Results		00003			c4c282c2-a06d-4729-937a-f1ead514bb73			
Sensors data		00004	中國人	20-40	1d053231-3a20-44a7-a677-ea1234143c68			
Sensor devices		00005			f199d0f0-1975-42e7-8704-84050f5223de			
Map		00006			c9c19eb-d267-47d8-9c92-0e09f255f503			

Figure 4.5. Respondent list

To be able to easier filter respondents who are not filling the questionnaires actively there are three additional search options available.

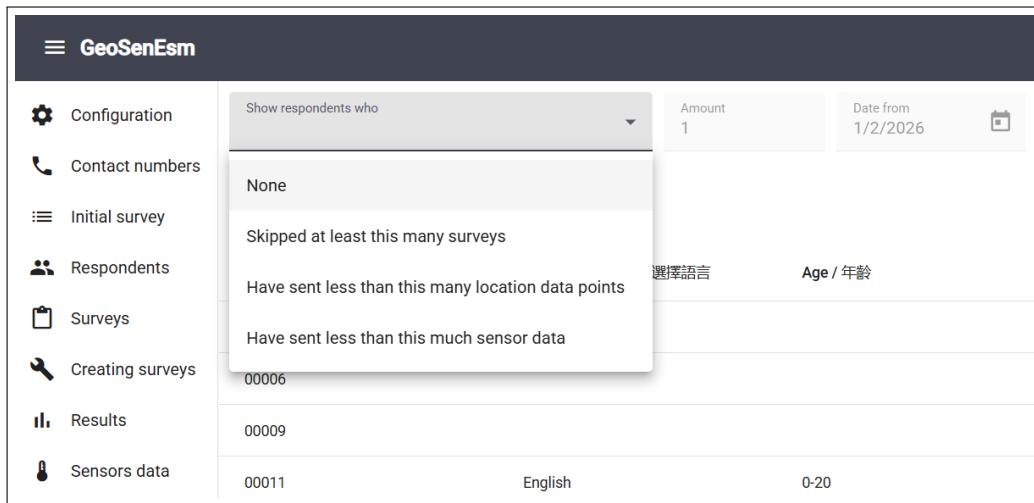


Figure 4.6. Respondent advanced filters

Once created copy the list of accounts names and password to safe place as it is impossible to recover that list in any other way!

Username	Choose language / 選擇語言	Age / 年齡	ID	Actions
00008		Quantity * — 1	fa8b4115-de3e-4fff-b38f-02e87d1dfb0b	
00006			c9c19eb-d267-47d8-9c92-0e09255f503	
00009			4d45bc61-ab0f-4a4b-9cd3-12844179e4b	
00011	English	0-20	200aa029-a151-46cf-b4a2-2a6cb91273bc	
00010			40e9ff11-2daf-4d53-adab-614074ba38a0	
00007			2779d6db-67cc-446e-8389-7bc48b29c307	
00005			f1a9d0f8-1975-42e7-8704-84050f5223de	
00004			bba56dfa-fae5-4caf-83c0- [REDACTED]	

Figure 4.7. Accounts creation

- **Creating Surveys** - The process of creating a survey within the GeoSenEsm platform involves several key steps.
 1. **Access the Admin Panel:** Begin by navigating to the admin panel within the GeoSenEsm platform. This is where all survey management tasks are performed.

2. **Navigate to the Survey Creation Tab:** In this tab (Figure 4.8), survey creators can add sections and questions. Each section has three visibility options (Figure 4.9):
- **Always visible:** The section will be accessible to all users.
 - **Group visibility:** The section will be visible to a specific group of participants, which can be determined based on their responses to the initial survey.
 - **Conditional visibility:** The section will be shown to users only if they provide specific answers in a preceding section.

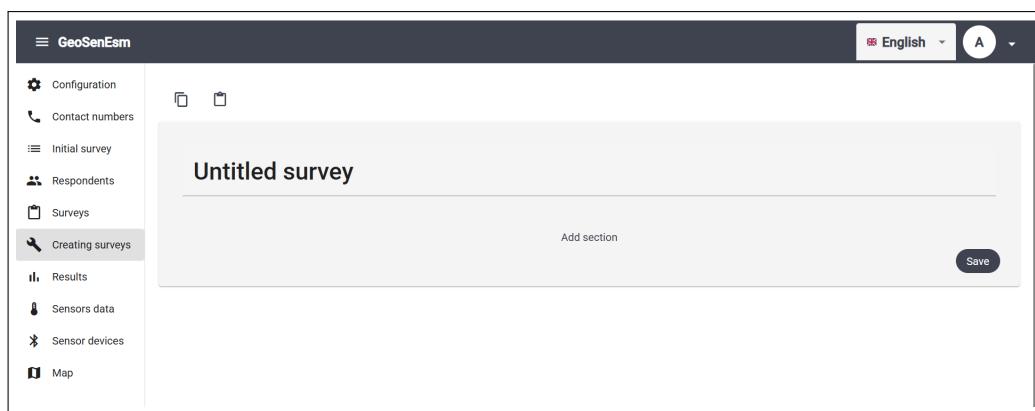


Figure 4.8. Creating surveys tab.

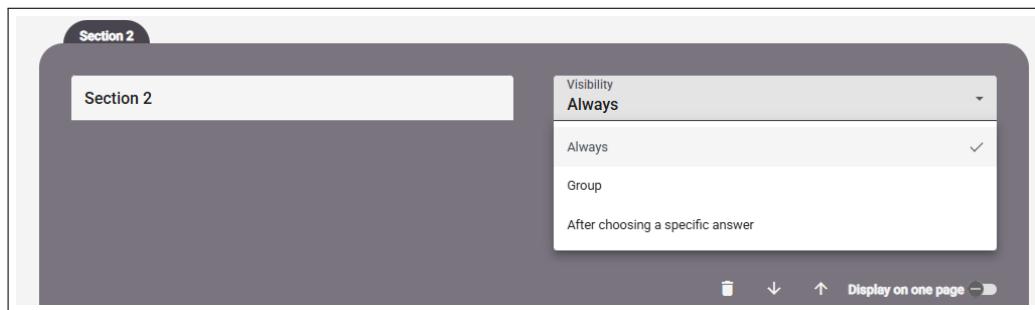


Figure 4.9. Visibility options for survey sections..

Seven question types are available for selection (Figure 4.10), offering flexibility to gather different types of data.

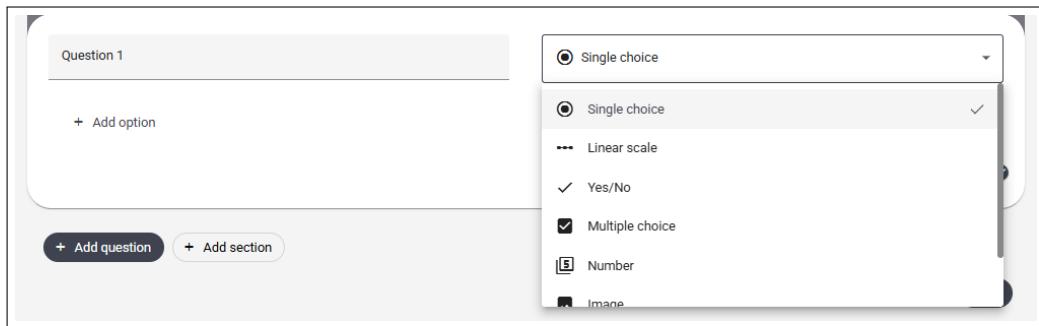


Figure 4.10. Available question types.

In order to create conditional paths (on given answer show section X) or separate paths (section X is only visible for man/women) we have to group questions into sections. Then sections are used as the big elements that create a survey based on user answers or user category.

3. **Define the Survey Sending Policy:** Once the survey is saved, you will be redirected to the **Sending Policy** screen (Figure 4.11). Here, you can specify the dates and times when the survey will be sent to participants (Figure 4.12). The sending schedule is visualized on the calendar, making it easy to manage.

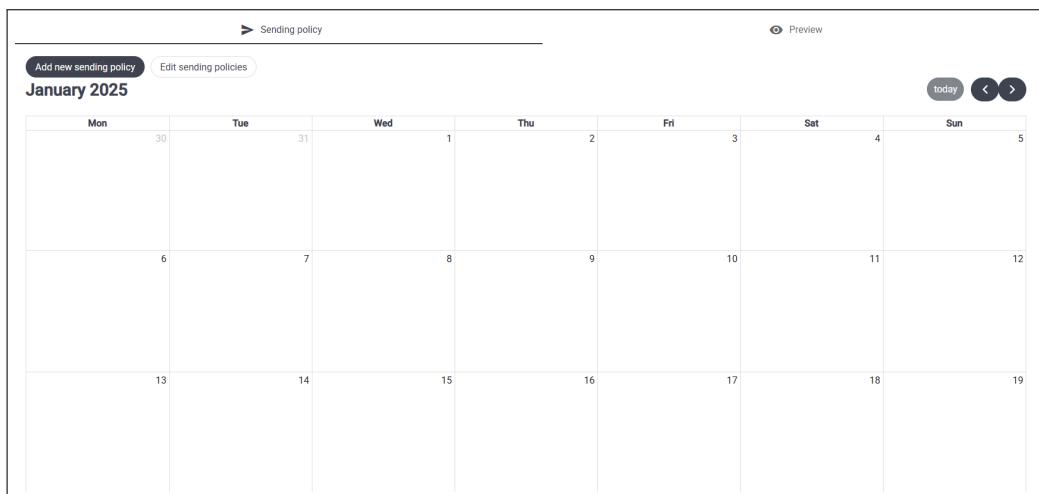


Figure 4.11. Survey sending policy calendar.

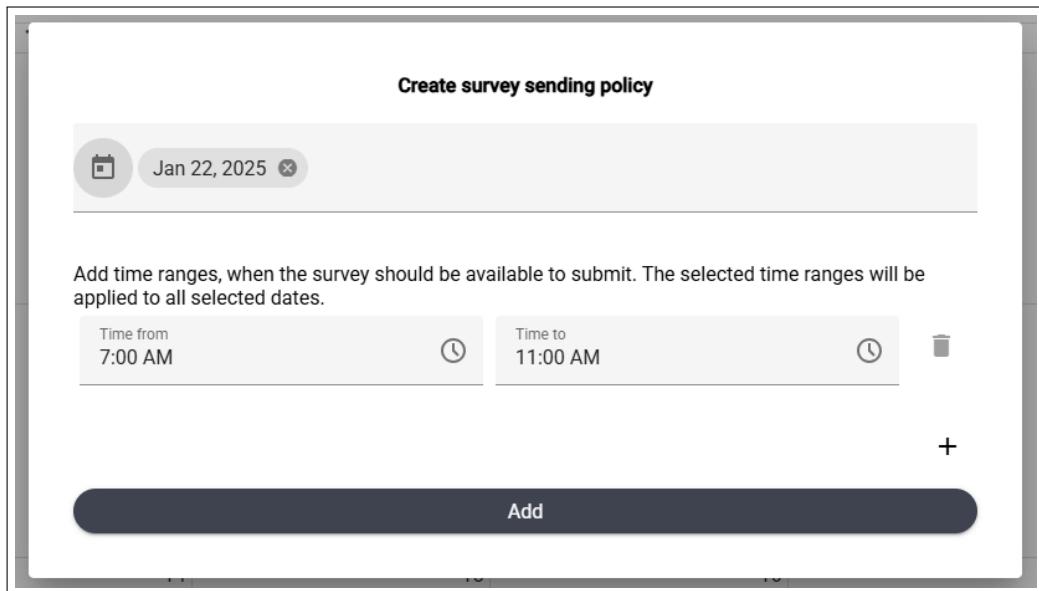


Figure 4.12. Survey sending policy configuration.

4. **Preview, Edit, and Publish the Survey:** In the Preview tab (Figure 4.13), you can review the survey, make any necessary edits, and finalize the creation process. Once published, the survey is sent to participants, and further edits will no longer be possible!

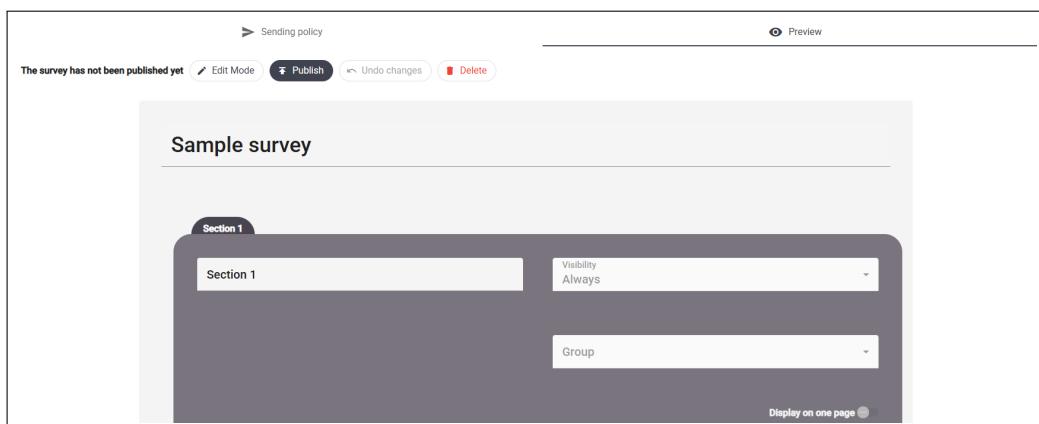


Figure 4.13. Survey preview screen.

- **Surveys** - is the place where you can see created surveys and edit the sending policies (schedules). Notice that in the preview you can also copy the survey, so in case it is

a complicated structure you would save time on setting it up again from scratch.

- **Results** - Admin users can view survey results in the Admin Panel under the results tab. Results can be filtered by survey title or specific respondents. You can also export the results to csv file.

Survey	Respondent	Date from	Time from	Date to	Time to					
Research area		Load	Export							
Survey name	Question	Answer date	Answers	Respondent Name	Longitude	Latitude	Outside Research Area	Temperature (°C)	Humidity (%)	Respondent ID
Regular test survey	Are you cold/hot at this moment?	1/18/25, 4:00 PM	I am cold	00125	16.855842	52.478662	true			8c449350-b517-4403-90de-c06348ab642
Regular test survey	Are you sleepy?	1/18/25, 4:00 PM	true	00125	16.855842	52.478662	true			8c449350-b517-4403-90de-c06348ab642
Regular test survey	Rate your happiness on a scale	1/18/25, 4:00 PM	10	00125	16.855842	52.478662	true			8c449350-b517-4403-90de-c06348ab642

Figure 4.14. Survey results tab in the Admin Panel.

- **Sensor data** - section, admins can access the sensor readings submitted by participants.

In this view, data from temperature sensors is available. If the respondents have the appropriate sensors and have synchronized them with the application, the data will be displayed in the table.						
Respondent	Date	Time from	Time to	Respondent ID	Load	Export
16.01.2025, 14:30	1.01.2025	7:00 AM	8:00 PM	78f07f0b-ba89-492d-82cb-2e1f1c431c0b		
11.01.2025, 12:00				78f07f0b-ba89-492d-82cb-2e1f1c431c0b		
7.01.2025, 18:03				78f07f0b-ba89-492d-82cb-2e1f1c431c0b		
15.01.2025, 10:20				78f07f0b-ba89-492d-82cb-2e1f1c431c0b		
10.01.2025, 19:45				c483199e-d3fd-490b-a621-13ac7f80a382		
12.01.2025, 16:04				78f07f0b-ba89-492d-82cb-2e1f1c431c0b		
16.01.2025, 17:42				78f07f0b-ba89-492d-82cb-2e1f1c431c0b		
				78f07f0b-ba89-492d-82cb-2e1f1c431c0b		
				78f07f0b-ba89-492d-82cb-2e1f1c431c0b		
				78f07f0b-ba89-492d-82cb-2e1f1c431c0b		
				78f07f0b-ba89-492d-82cb-2e1f1c431c0b		
				78f07f0b-ba89-492d-82cb-2e1f1c431c0b		

Figure 4.15. The Sensor Data tab, displaying detailed sensor readings collected by the app.

- **Sensor devices** allows you to connect sensor number with mac address. That functionality is only used for Xiaomi sensors as otherwise two different sensors are indistinguishable for the mobile app. In that case app can read data not from respondent sensor but from some other device. In case we put a mac address in the admin panel and put corresponding Id in the mobile app, then mobile app would only connect to our device. That functionality is not mandatory. For Kestrel devices as they have an unique id number that feature is not needed.

Here you can configure the MAC addresses of sensors, making it easier for respondents to synchronize them with the application.

ID	MAC Address	Update	Delete
1	00:00:00:00:00:00		

Figure 4.16. Adding MAC devices numbers (only for Xiaomi sensors)

- **Map** - tab provides a visual representation of all locations submitted by users.

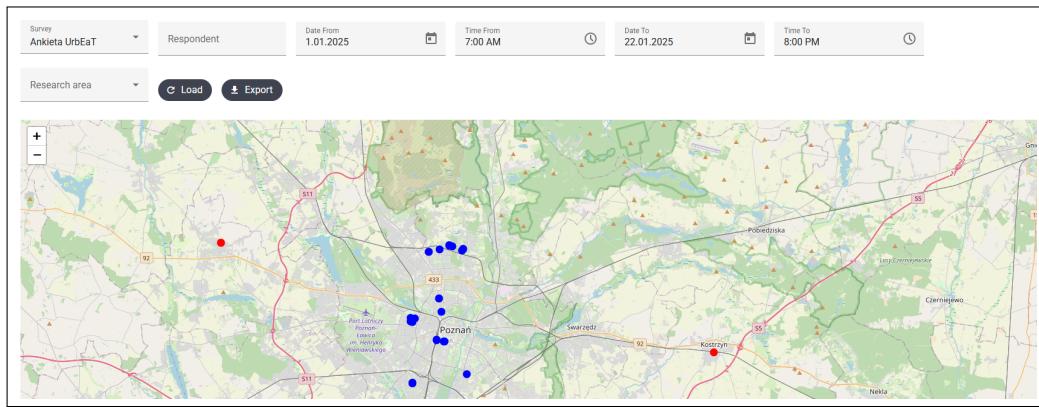


Figure 4.17. The Map tab, providing a visual representation of all user locations recorded by the app. Color shows if the location is within or outside the research area.