Curricula Enrichment delivered through the Application of Location-based Services to Intelligent Transport Systems

Co-funded by the Erasmus+ Programme of the European Union

Teaching & Learning Manual
Step-by-Step Guide:

Environmental Problem Mapping

Prepared by
Department of Town & Country Planning
University of Moratuwa, Sri Lanka
2024

Authors

1. Amila Jayasinghe
2. Harini Sawandi

Reviewed and edited by

1. Samith Madusanka
2. Chethika Abenayake

Reviewed by

1. XXXXX (University Name)
2. XXXXX (University Name)

This manual was produced by the Department of Town & Country Planning, with invaluable support of the Erasmus+ Capacity Building in Higher Education (CBHE) project 'Curricula Enrichment for Sri Lankan Universities delivered through the application of Location-Based Services to Intelligent Transport Systems' (LBS2ITS https://lbs2its.net/)

Project Number: 618657-EPP-1-2020-1-AT-EPPKA2-CBHE-JP
Programme: Erasmus+
Key Action: Cooperation for innovation and the exchange of good practices
Action Type: Capacity Building in Higher Education
Co-funding: Erasmus+ Programme of the European Union

Description

This manual serves as an essential educational resource for both undergraduate and postgraduate degree programs, offering a detailed, step-by-step guide to GPS and GNSS data collection using modern devices such as the Stonex S70 and S70G tablets. Designed to bridge the gap between theoretical knowledge and practical application, this guide is meticulously crafted to meet the needs of students, educators, and practitioners alike.

Within the manual, readers will find comprehensive instructions on setting up and configuring smartphone and GNSS devices, collecting high-accuracy spatial data, and employing GIS software to analyze this information. It covers various applications, including tree mapping, urban planning, environmental monitoring, and more. The manual not only enhances learning in academic settings by providing real-world applications and case studies but also equips industry professionals with the skills necessary to conduct advanced spatial analysis and contribute meaningful insights in their fields.

Key topics include detailed steps on initializing and configuring GNSS devices to ensure optimal accuracy and reliability, along with guidelines on effective field data collection to achieve high-quality GNSS data. The manual provides comprehensive instructions on downloading, processing, and managing collected data using GIS software. It features real-world examples and case studies that demonstrate the practical applications of GNSS data collection, as well as techniques for analyzing spatial data to derive meaningful insights and support decision-making processes.

Whether you are a student aiming to master GNSS and smartphone data collection and geographic information systems, a teacher looking for robust educational tools, or a practitioner in need of refining your technical expertise, this manual offers invaluable guidance and support. It ensures that users at all levels gain proficiency in leveraging modern technologies to explore and solve geographic challenges effectively.

TABLE OF CONTENT

LIST OF FIGURES

1. INTRODUCTION TO TRAINING MANUAL

This manual offers comprehensive guidance for individuals and groups engaged in evaluating and tackling environmental issues employing gathering and analyzing spatial information. This guidebook provides users with the required tools and approaches to map and comprehend environmental problems in their communities by utilizing GPS and GNSS technology, as well as open-source applications including QGIS.

Because of the growing environmental issues the world is confronting, such as climate change, biodiversity depletion, pollution, and habitat destruction, the demand for accurate and feasible data has become exceedingly crucial. Environmental problem mapping is an essential initial process in recognizing, ranking, and addressing environmental concerns, facilitating well-informed decision-making and focused solutions.

Smartphone / GPS (Global Positioning System) and GNSS (Global Navigation Satellite System) technologies are crucial for mapping environmental problems. They enable users to gather accurate position data while in the field. Through the utilization of GPS/GNSS data-gathering techniques, individuals can precisely record environmental observations, monitor variations over a period, and pinpoint areas of concern with spatial detail.

This manual is intended for a wide range of readers, who are interested in tackling environmental issues at the local, regional, or global level. Our goals are to equip users with the information and abilities needed to carry out efficient environmental problem mapping projects

The manual is structured into three chapters, each focusing on key aspects of environmental problem mapping:

1. Introduction to the manual and overview of environmental mapping.
2. Detailed methodology for data collection, analysis, and interpretation using GPS
3. Detailed methodology for data collection, analysis, and interpretation using GNSS technologies and open-source software.

2. OVERVIEW OF ENVIRONMENTAL MAPPING AND ITS SIGNIFICANCE

Environmental mapping involves the systematic **collection, analysis, and visualization of spatial data** to understand and address environmental issues.

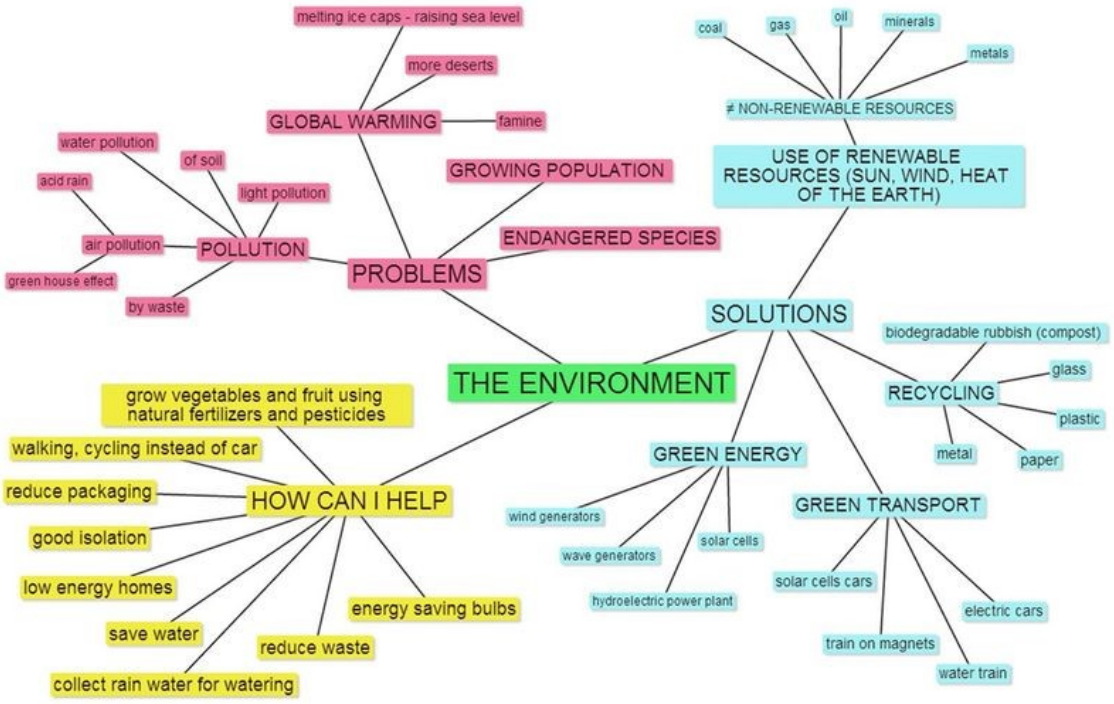


Figure 1- Overview of the Environment
Source - https://www.edrawmind.com/article/environment-mind-map.html

Environmental mapping provides a comprehensive perspective on environmental conditions and trends, including recording changes in land cover and vegetation, monitoring pollution levels, and assessing habitat loss. This comprehensive understanding allows us to pinpoint areas that cause concern, such as locations with high levels of pollution, the breaking up of habitats, and ecosystems that are at risk, and want immediate attention and intervention. Furthermore, environmental mapping facilitates evidence-driven decision-making and policy development by supplying policymakers with information and spatial analysis to inform the allocation of resources, land-use planning, and environmental management methods. Environmental mapping facilitates the communication of intricate environmental data in a visually comprehensible manner. Additionally, it encourages the involvement of stakeholders, enhances transparency, and encourages collaborative efforts towards achieving sustainable environmental management.

3. REQUIRED TOOLS / SOFTWARE AND EQUIPMENT

Category	GPS Data collection	GNSS Data Collection
Equipment	Smartphone (Android or iOS)	 Stonex S70 / S70G GNSS Receiver
Software/Apps	ODK Collect, KoBoToolbox: (These apps allow users to create custom forms, collect GPS coordinates, and input field data efficiently) QGIS (open-source GIS software used for data analysis and visualization post-data collection, offering powerful tools for spatial analysis and mapping.)	(Data collection is done with the device itself) QGIS (for data analysis)
Other Tools and Inputs	• Base Map of the Site: A base map provides contextual information about the area you are mapping, such as existing infrastructure, land cover, and topographic features • Field Equipment (If necessary): Depending on your project needs, you may require additional measuring tools such as tape measures, or surveying equipment for collecting site-specific data. • To ensure uninterrupted operation of your GPS/GNSS devices and smartphones, carry power banks or spare batteries for extended fieldwork sessions	

Table 1 -Required Items

4. DATA COLLECTION

4.1 Different between Smartphone (Global Positioning System) and Global Navigation satellite system

- What are GPS and GNSS?

GPS stands for Global Positioning System, which is a satellite-based navigation system that provides location and time information anywhere on Earth. GNSS stands for Global Navigation Satellite System, which is a generic term that encompasses all satellite navigation systems, including GPS.

GPS receivers determine their location by utilizing a constellation of GPS satellites that orbit the Earth. The GPS was first developed for military applications, but it has since become accessible to civilian users. GPS has a wide range of applications, such as navigation, tracking, and mapping.

GNSS, short for "Global Navigation Satellite System," refers to any satellite navigation system utilized for positioning. GNSS, or Global Navigation Satellite System, encompasses various satellite navigation systems, of which GPS is one example. Additional Global Navigation Satellite Systems (GNSS) encompass the Russian GLONASS system, the European Galileo system, the Indian Regional Navigation Satellite System (IRNSS) known as NavIC (short for Navigation with Indian Constellation), and BeiDou, the Chinese system. Many GPS receivers are compatible with multiple GNSS systems, allowing them to utilize the unique benefits offered by each system.

- What are the disparities between the two?

GPS and GNSS are satellite-based technologies used to ascertain the precise location of a receiver on Earth. The Global Positioning System (GPS) is widely recognized as the most renowned navigation system, with a user base of millions of individuals who rely on it daily. GNSS is an all-encompassing system that encompasses GPS as well as other satellite constellations.

The number of satellites in a system can affect the accuracy of location information provided to users. GPS currently has 31 operational satellites in its network, while GLONASS has 24, Galileo has 30, BeiDou has 35, and QZSS has 7. Consequently, GNSS exhibits greater precision than GPS and can be employed in situations when GPS would be unsuitable. GNSS is commonly employed in aviation navigation to provide accurate positioning data of the aircraft. GPS is utilized in numerous consumer items, such as automotive navigation systems and mapping applications for smartphones. GNSS exhibits better resistance to disruption, making it a preferred choice for scenarios where GPS would be unsuitable.

- How can they be used in different applications?

GNSS/GPS applications include Tracking/Mapping Devices, Industrial Machinery, Sea vessels, Air Navigation etc.

Automobile GPS devices are becoming more and more common, whether they are separate from a phone or built into it. This gives them a very accurate idea of where they are. GPS can be used for a wide range of applications, such as navigation, tracking, and surveying. GNSS is a similar system that uses a network of satellites to figure out where something is. However, GNSS systems typically use more satellites than GPS, providing greater accuracy and coverage. GNSS is often used in mission-critical applications where high accuracy is required, such as aircraft and missile guidance systems.

- Pros and cons of GPS and GNSS

There are several pros and cons to GPS and GNSS. One advantage of GPS is that it is relatively inexpensive to set up and maintain. GPS is also widely available, with most smartphones now featuring GPS capabilities. Another advantage of GPS is that it can be used in a variety of settings, including urban and rural areas. One thing that can go wrong with GPS is that buildings and other things can interfere with it. A GPS signal can also be blocked by bad weather conditions. GNSS systems cost more than GPS systems, but they work better and are more accurate. Also, interference or bad weather is less likely to mess up GNSS systems.

In summary, while GPS is a specific satellite navigation system, GNSS encompasses multiple satellite navigation systems, including GPS. Many smartphones utilize GNSS technology, allowing them to access signals from multiple satellite systems to determine their precise location on Earth's surface. Therefore, smartphones with GPS functionality are a subset of devices that utilize GNSS technology for location determination

- *https://www.linkedin.com/pulse/differences-between-gps-gnss-santosh-kumar-bhoda/*
- *https://globalgpssystems.com/gnss/the-difference-between-gnss-and-gps-explained/#:~:text=Number%20of%20Satellites%20and%20Accuracy&text=Due%20to%20the%20larger%20number,of%20any%20interference%20or%20obstructions.*

4.2 Data Collection using Smartphones (Global Positioning System)

4.2.1 Overall Data Collection Process

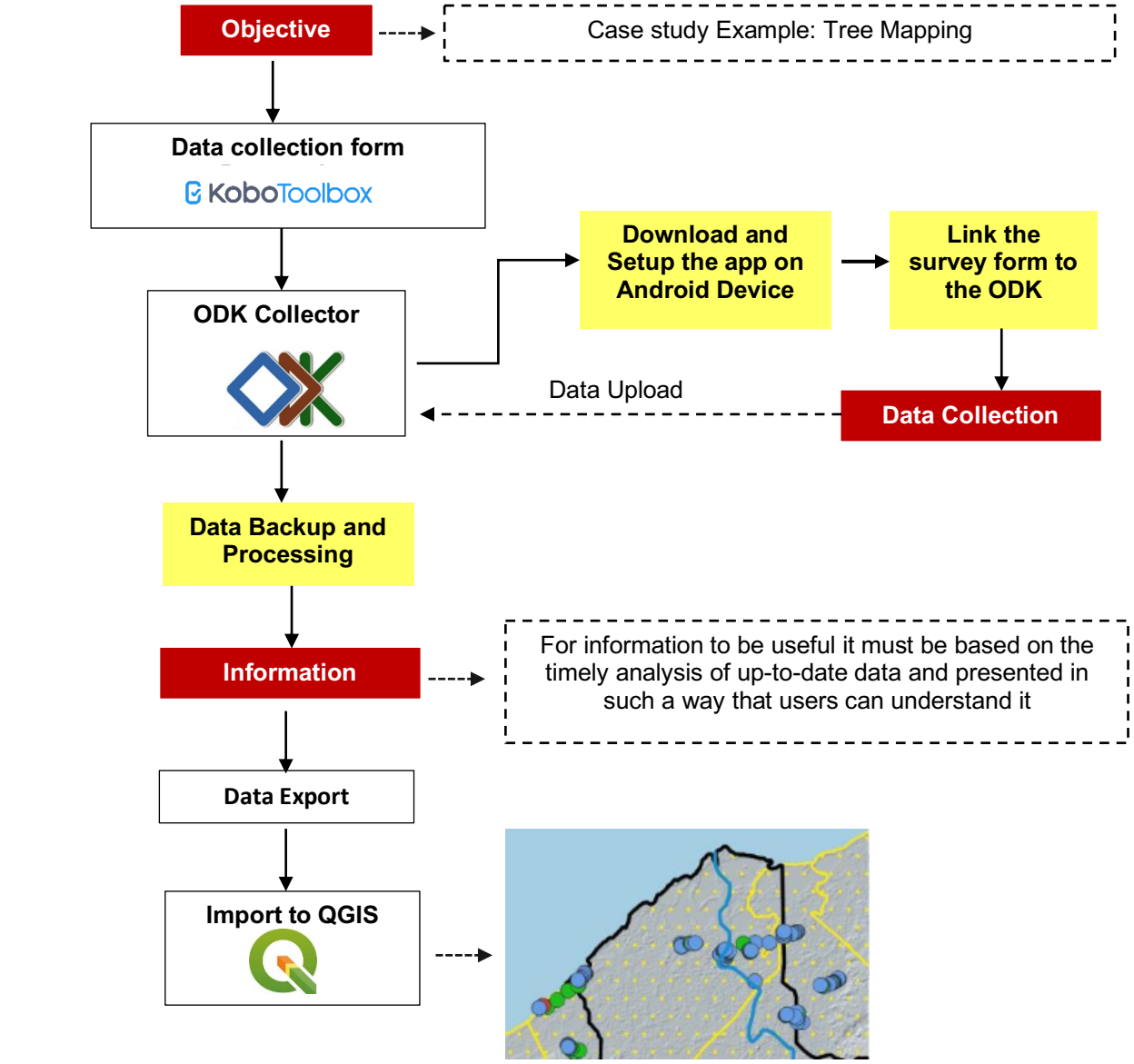


Figure 2 - Process of Data Collection

The collection of urban trees served as the main dataset for this example. Data collection followed a systematic technique, as shown in Figure 3. At first, the data-gathering forms were created using the KoBoToolBox application. Later on, these forms were connected with the ODK data gathering application, which is available for download on the Google Play Store. The data-gathering approach entailed performing field surveys utilizing the ODK program and the associated data collection forms. After gathering all the essential data, it was downloaded and imported into the QGIS application for data cleaning, processing, analysis, and mapping, if needed. This is a comprehensive overview of the complete process used to acquire data. In the next part, all the specifics are explained for each data type in data collection, accompanied by relevant photos and information.

Alternative Data Collection Methods:

KoBoToolbox & KoBoCollect: Utilize KoBoToolbox for both form creation and data collection by designing forms directly within the KoBoCollect mobile app. This approach streamlines the process by eliminating the need for integration with external applications.

ODK Build & ODK Collect: Design custom data collection forms using ODK Build, a user-friendly form designer tool, and collect data in the field using ODK Collect. This method offers flexibility in form design and customization while leveraging the robust data collection capabilities of ODK Collect.

Paper-Based Surveys: In scenarios where digital data collection tools are not feasible, traditional paper-based surveys can be employed. Design paper forms to capture relevant tree data and manually record observations in the field. Once completed, data can be transcribed into digital format for analysis.

Mobile Apps with GPS Functionality: Explore alternative mobile applications with GPS functionality for data collection, such as GeoODK Collect or Epicollect5. These apps offer similar features to ODK Collect but may have different user interfaces and additional functionalities.

Crowdsourcing Platforms: Consider leveraging crowdsourcing platforms like OpenStreetMap (OSM) for tree mapping initiatives. Engage volunteers and community members to contribute tree data through OSM-based mapping projects, fostering collaboration and community involvement.

Alternative Mobile Application for Data Collection:

App	Platform	Text	Photo	Audio	Video	Shapefile
ODK Collect	Android	✓	✓	✓	✓	✗
KoBoCollect	Android	✓	✓	✓	✓	✗
GeoODK Collect	Android	✓	✓	✓	✓	✗
Epicollect5	Android, iOS	✓	✓	✓	✓	✗
OpenMapKit	Android	✓	✓	✓	✓	✗
Fulcrum	Android, iOS	✓	✓	✓	✓	✗
iFormBuilder	Android, iOS, Web	✓	✓	✓	✓	✗
SurveyCTO	Android, iOS, Web	✓	✓	✓	✓	✗
Field Data Collection	iOS, Web	✓	✓	✓	✓	✗
KoBoToolbox	Web	✓	✓	✓	✓	✗
ODK Build	Web	✓	✗	✗	✗	✗
Add to Shapefile	Android	✗	✗	✗	✗	✓
GeoPaparazzi	Android	✓	✓	✗	✗	✓

Table 2 - Other Mobile Applications for Data Collection

4.3 Steps (Mobile Phones)

4.3.1 Prepare data collection form.

Step 1

The KoBoTook box is the platform that we used to prepare the data collection form. The following weblink and Figure 4 show the interface of the KoboTool Box application.

Web Link: https://www.kobotoolbox.org/

Figure 3- Interface of the Kobo Tool Box

KOBO TOOL BOX :

Kobo Toolbox is a free and open-source suite of tools for field data collection. The web KoboToolbox application allows user design complex forms, deploy and download submitted data.

KoboToolbox makes it easy to develop forms for data collection. It also has features for managing projects, visualizing data, and building complex forms.

Step 2

Prepare the account in the KoBoToolBox: To begin the process, it is essential to create an account on the KoBoToolBox application, which allows us to allocate space on their servers for storing the collected ground data. By following the provided link, you will be directed to the registration page.

2.1 Click on the **"Create new account"** option.

2.2 Then select “Global KoboToolbox Server” and then create an account.

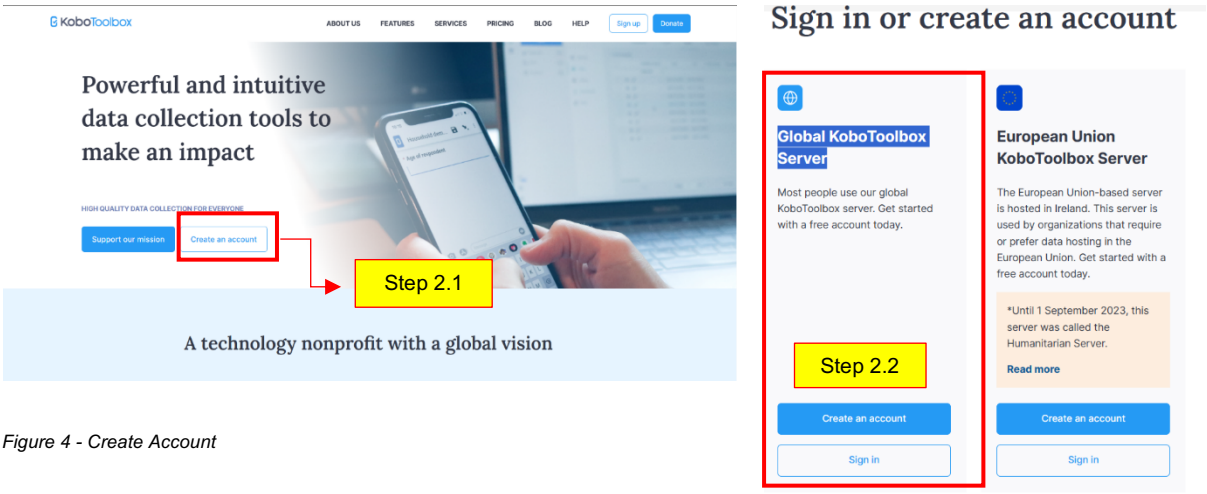


Figure 4 - Create Account

Then it will prompt the following interface to appear:

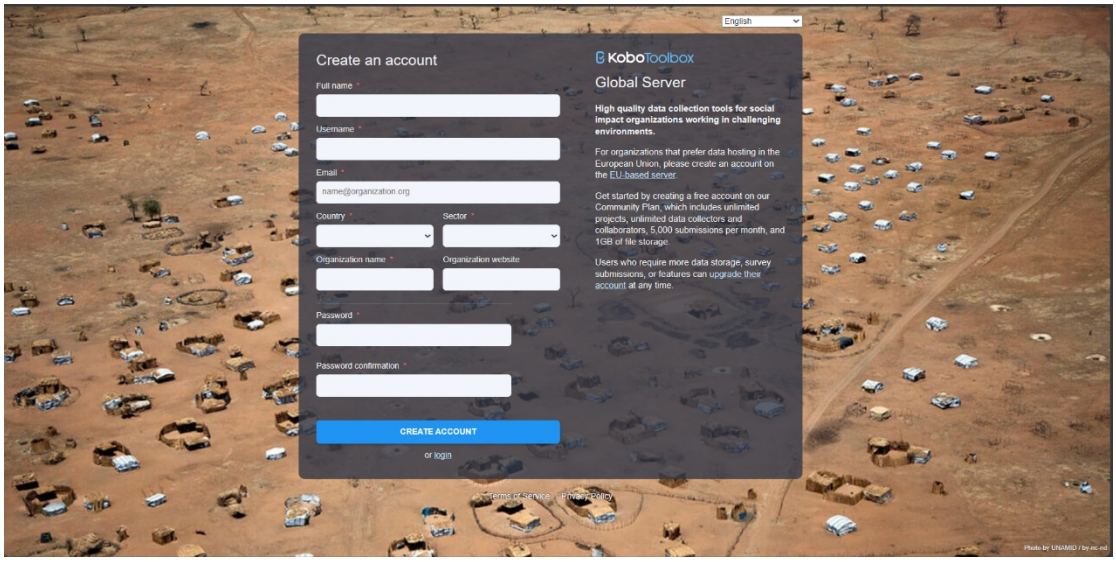


Figure 5 - Registration Process

Provide all the necessary information and complete the account registration process. Once your account setup is complete, you will receive an email to confirm your account. Click on the received link and confirm your account. Once your email is confirmed, you will be directed to the login page where you can enter your username and password.

.

Step 3

Create a new data collection form: Upon successful login, you will be directed to the following interface. Then as shown in Figure 7 click the "new" option.

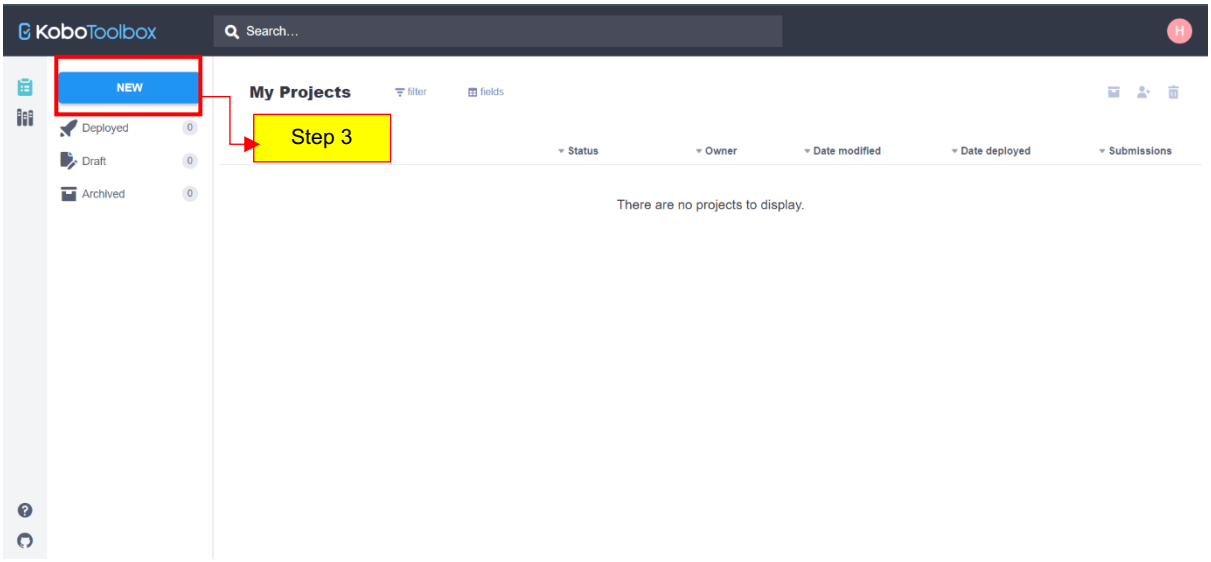


Figure 6 - Create a New Data Collection Form

Step 4

After clicking on the option " new" the following interface will appear as shown in Figure 08.

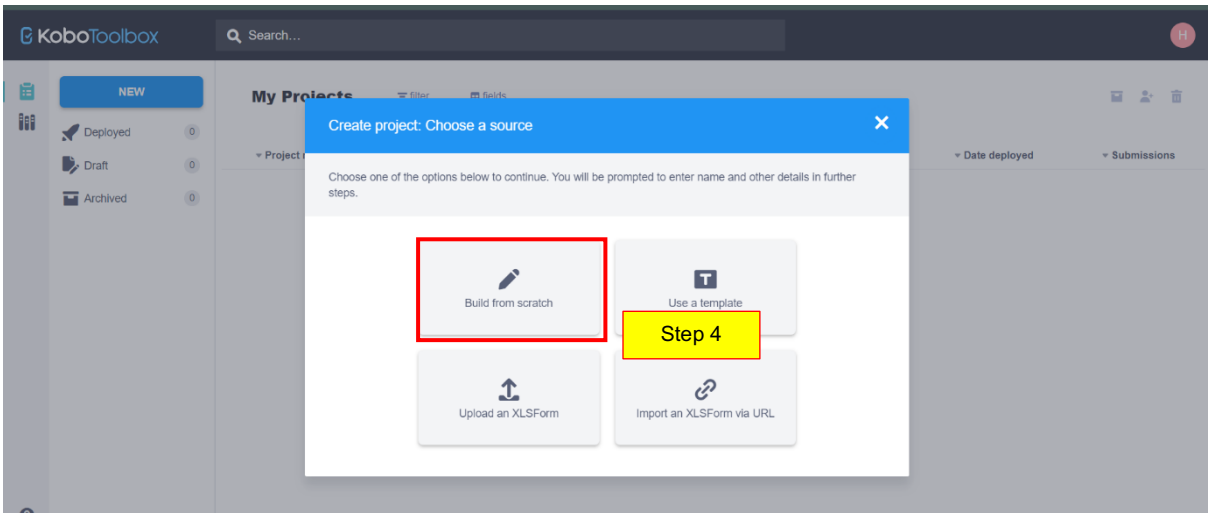


Figure 7 - Interface of Create a new project

Users can use inbuilt data collection form templates if user need to use those templates by selecting the **"use a template"** option. If not select the "**Build from scratch**" option to create our template for our data collection forms. Here for this study, Buidl from Scratch has been selected.

Step 5

After selecting the templates, it will display the following box and then it will ask following information as Figure 9. Place the appropriate project name **(1)** and a short description **(2)** of the project. Specify the sector **(3)** and country **(4)** of the project. After that select **"Create Project (5)"**

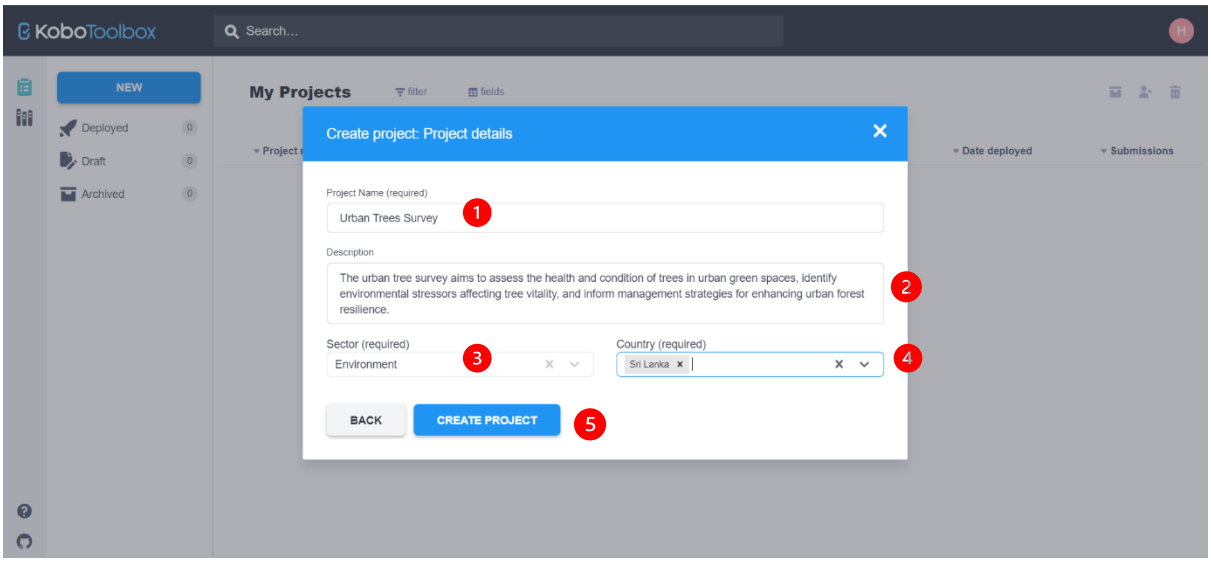


Figure 8 - Create Project

After that following interface will appear as shown in Figure 10

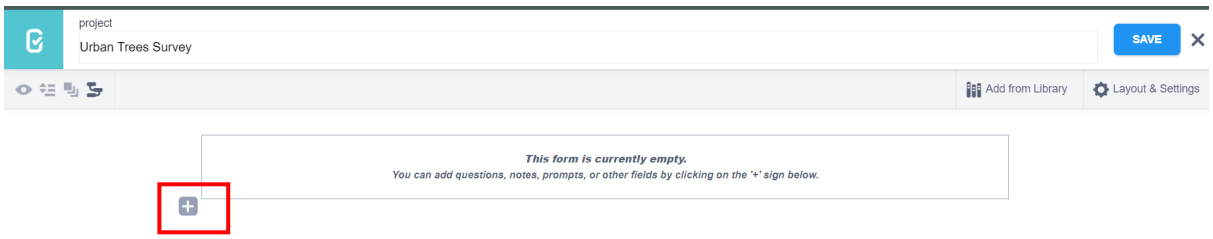


Figure 9 - Project Interface

The user now can create a data collection form for data collection. To initiate this process, the user should click on **the plus symbol** as depicted in the above figure which will open the interface displayed below.

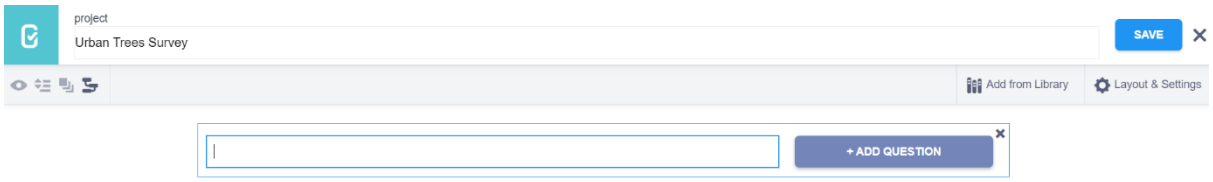


Figure 10 - Add Question Interface

Step 6

Figure 12 illustrates the interface where the user can input the first question.

6.1 So for that click on “Add Question”

6.2 Select the type as your Question type as shown in the figure below

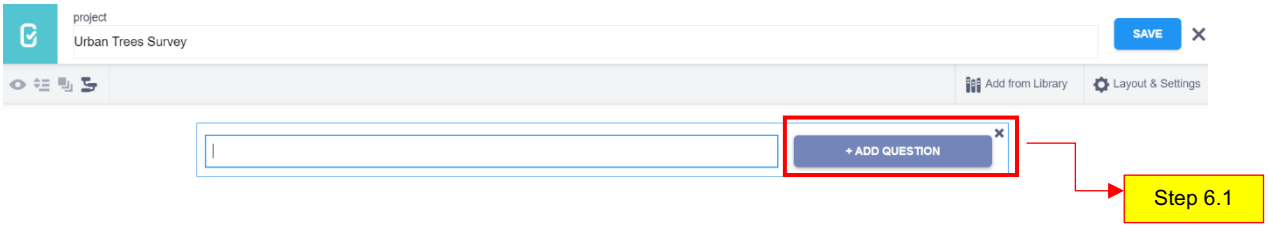


Figure 11 - Insert Questions

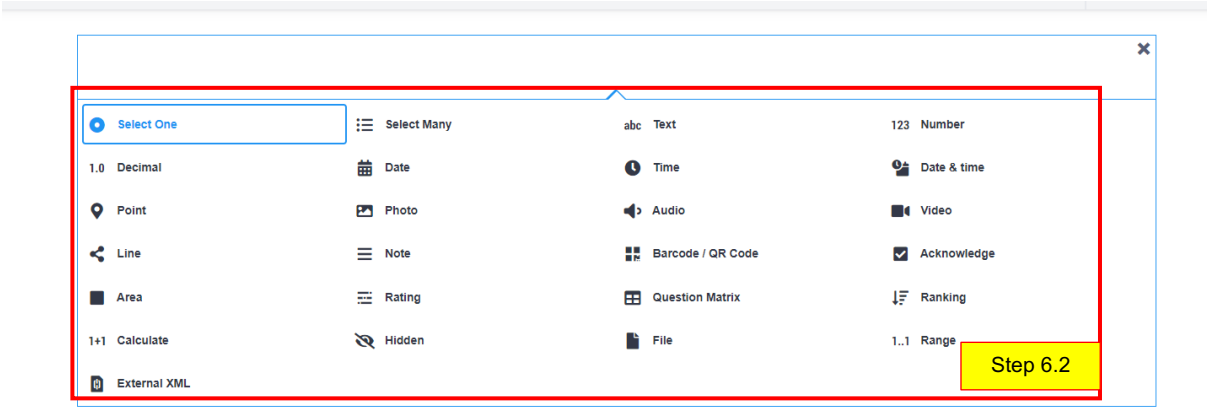


Figure 12 - Selecting Type of the Questions

The objective of this example is the carry out the urban tree survey aims to assess the health and condition of trees in urban green spaces, identify environmental stressors affecting tree vitality, and inform management strategies for enhancing urban forest resilience.

In this case, the first question is designated as Tree ID. As this data collection form pertains specifically to tree data, it is essential to gather information on each tree individually. This unique identification number serves as a reference for data collection, allowing the data collector to gather information for each tree by associating it with its respective identification number. Subsequently, after the data collection process is complete, the collected data can be linked with the corresponding Geographic Information System (GIS) layers by utilizing the identification numbers. The inclusion of the identification number in both the GIS layer and the collected database ensures seamless integration between the two, enabling efficient data management and analysis.

This section serves as the user interface where the user can select the appropriate data type for the desired field. Here tree ID is to be entered as a numerical value. Therefore, it is necessary to choose the "number" data type from the provided list. Alternatively, if the user intends to capture a visual representation for this particular question, the data collection form creator should assign the data type as "photo." This will enable the data collector to access a camera option specifically designed for this question, allowing them to capture and save an image. Once the user has selected the appropriate data type for the initial question, a subsequent interface will be displayed. To proceed with entering the second question into the form, the user needs to click on the plus symbol (+), as illustrated in Figure 14. This action will provide a designated space to type the second question. The same process should be followed to prepare all the questions about road data collection.

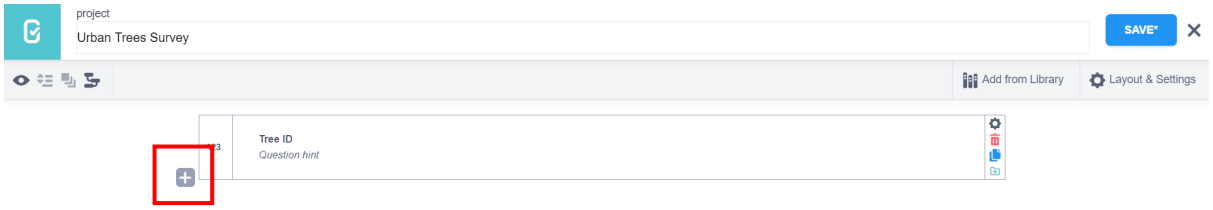


Figure 13 - Proceed to the next Questions

Step 7

Save the project: Figure 15 shows an example data collection form for tree data collection prepared under this project. The data collection form has included **only 11 variables for this example**. After including all the questions click on the save button and then click on the close button located near the save button.

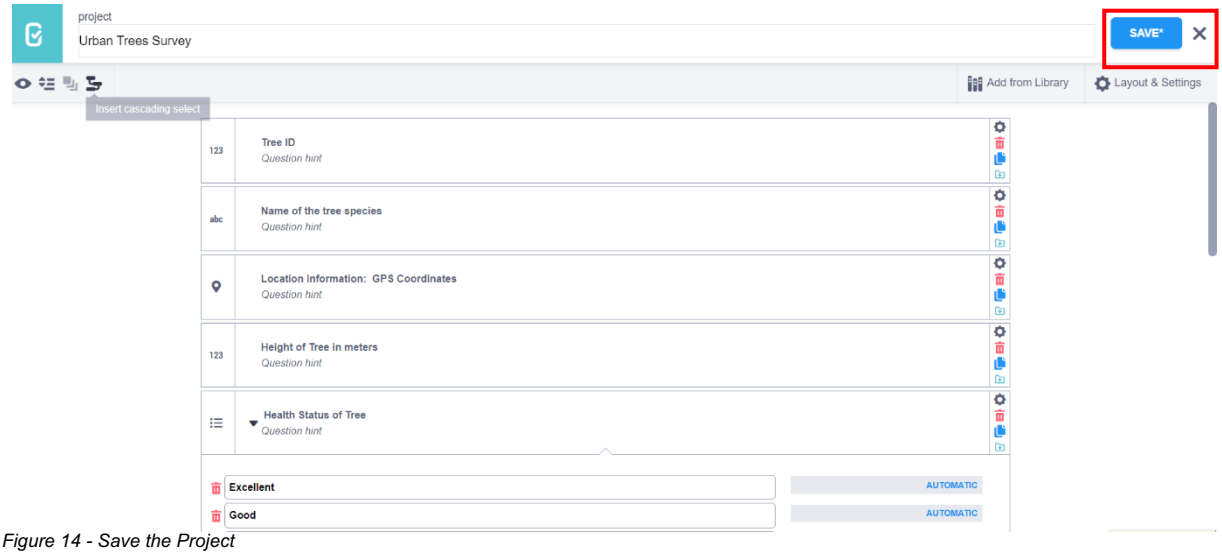


Figure 14 - Save the Project

You can preview how your survey will look after entering your questions by clicking the eye icon in the top left-hand corner. To check for errors, enter some information and click on the 'Validate' button.

Figure 15 - Preview the Project

To return to the default project page, click the Kobo icon in the upper right-hand corner. You will be redirected to the project page.

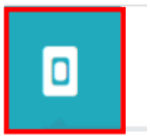


Figure 16 - Redirected to the project page

After saving the project then it will be directed to the below section as shown in Figure 18.

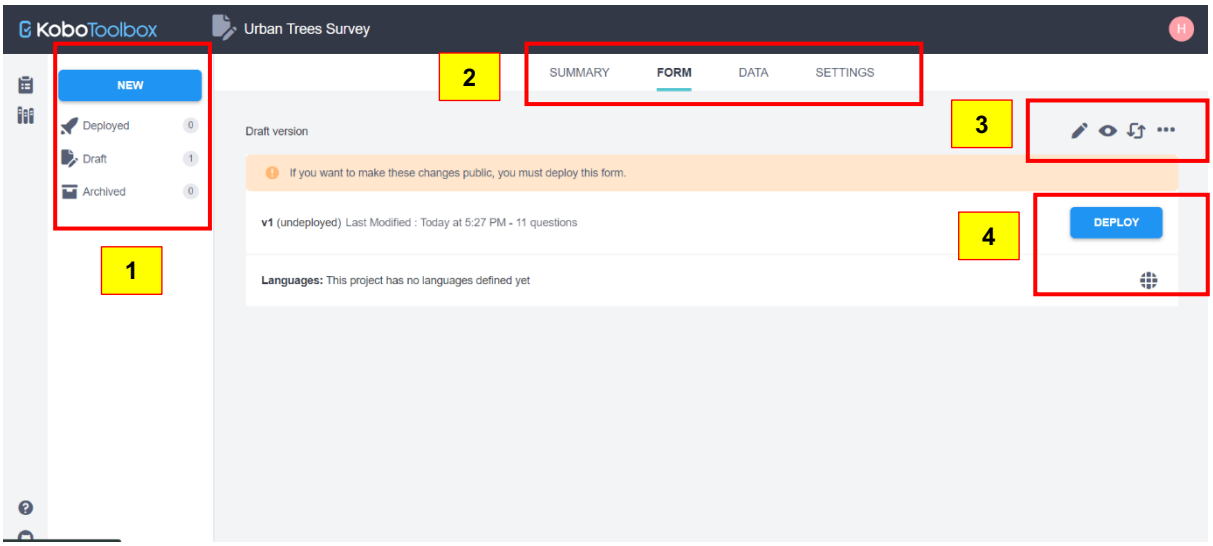


Figure 17 - Created Form

① Under number 01, three tabs are visible: "Deployed Forms," "Draft Forms," and "Archived Forms." Currently, The data collection form we have prepared is listed under the "Draft" tab, indicating that it has not yet been deployed. Once deployed, it will be listed under the "Deployed" tab.	② The second section encompasses the metadata section of the forms, which consists of four tabs: "Summary of Collected Data," "Form," "Collected Data," and "Settings" for the selected form. Presently, only the "Settings" and "Form" tabs are active since the form has not been deployed or used for data collection. These tabs allow for customization and configuration of the form's settings and structure
③ The third section offers options for editing, previewing, replacing the form, and additional functionalities for downloading the form. Users can make modifications to the form, preview its appearance, replace it with an updated version if necessary, and access various download options	④ The fourth section features the "Deploy" button. Once all the necessary work on the form has been completed, clicking on the "Deploy" button will publish the form on the KoboToolbox server. This enables data collection applications to link to the form, allowing collected data to be sent directly to the KoboToolbox server through this specific form.

Table 3 - Tabs in Form Interface

Step 8

8.1 The subsequent procedure entails the deployment of the meticulously prepared form. It is essential to identify the correct form from the options available under the "Draft" tab and proceed by clicking on the deploy button. Subsequently, the deployed form will be listed under the "Deploy" tab. **Once the form is deployed, it can be accessed through an external application such as Open Data Kit (ODK).**

8.2 After you deploy the form, you can select **'Online-Offline (Multiple submissions)'** under collect data. You can copy the link by clicking the 'COPY' icon to share with your team or paste the link into a search engine to open the questionnaire in a browser.

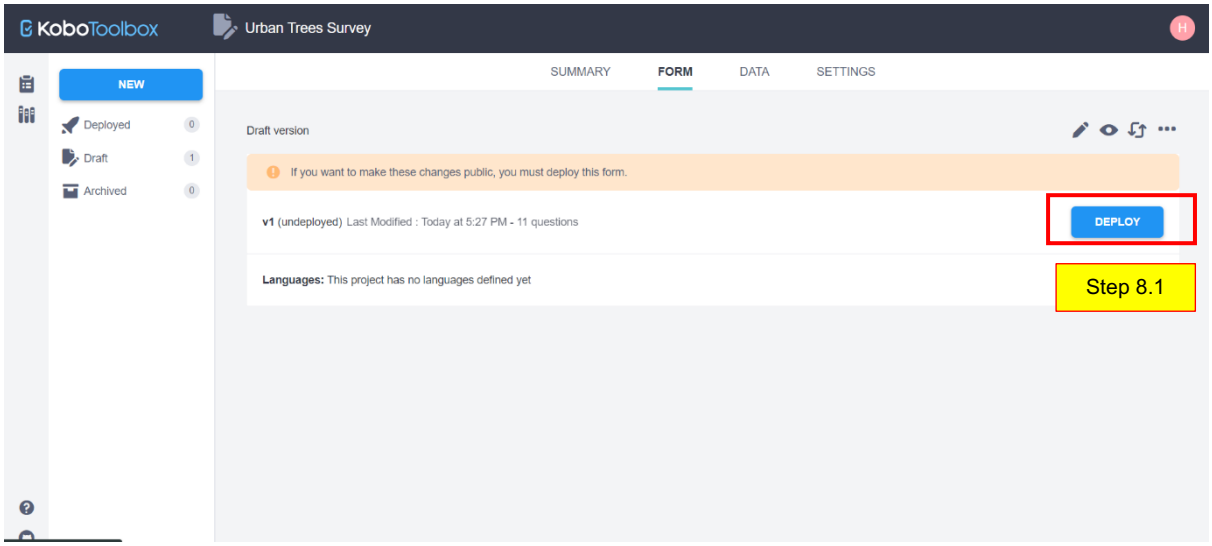


Figure 18 - Deploy

4.3.2 Download and Install ODK Application

Step 1

Download and install the ODK application: Figure 20 provides a detailed methodology that outlines the step-by-step process for downloading and installing the ODK application.

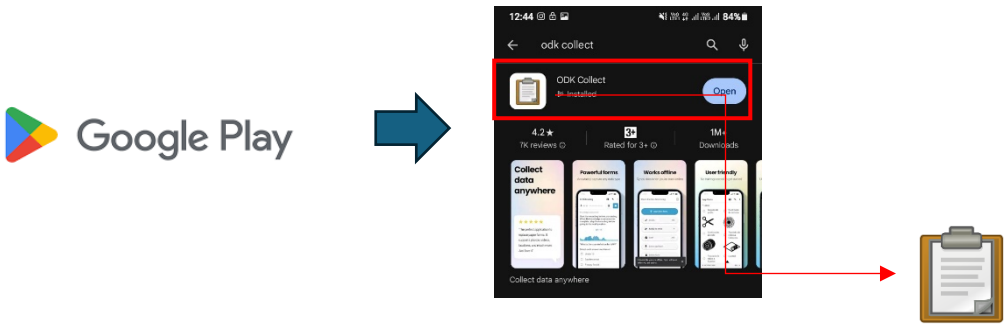


Figure 19 - Download and Install the app

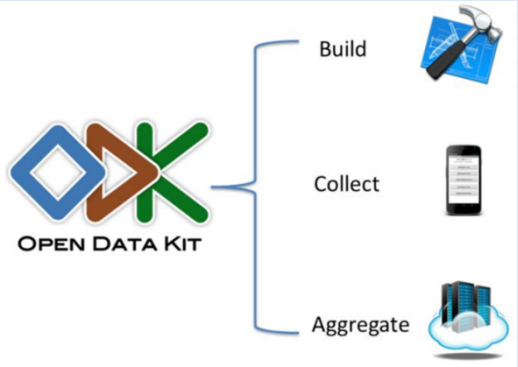
ODK

Open Data Kit (ODK) is an open-source software suite designed for data collection using mobile devices. It provides a flexible and customizable platform for creating digital forms, collecting data, and managing the collected data efficiently. ODK is widely used in various fields such as research, humanitarian aid, public health, and environmental monitoring. ODK consists of several components that work together to facilitate the entire data collection process. These components include:

ODK Build: A web-based form designer that allows users to create forms using a drag-and-drop interface without requiring programming skills. It enables the easy creation of digital forms for Android devices that serves as the data collection tool. It allows field workers to download the digital forms created with ODK Build and collect data using their mobile devices, even in offline or low connectivity areas. ODK Collect supports GPS location capture, image and audio attachments, and can handle complex skip logic within forms.

ODK Aggregate: A server application that acts as a central repository for collected data. ODK Collect syncs with ODK Aggregate to upload the collected data securely. ODK Aggregate provides data management features like data storage, data export in various formats, data visualization, and user access control.

ODK Briefcase: A desktop tool that allows users to pull data from ODK Aggregate and export it to a local machine.



Step 2

Setup ODK and link prepared data collection forms to ODK application

2.1 The initial interface encountered upon opening the ODK application for the first time is depicted in Figure 22.

2.2 Subsequently, users need to click on “**Manually enter Project Details”** as shown in Figure 22.

2.3 The ODK application necessitates three essential pieces of information: URL, Username, and password. As illustrated in Figure 24, the URL can be obtained from the KoboToolbox platform. Additionally, after deploying all the forms, users need to navigate to the **"Collect Data"** section located at the bottom of the webpage. Within that section, there is a dropdown arrow that, when clicked, displays a list of options for linking the data collection form with other third-party applications. To proceed, users should select the "Android Application" option from the list and copy the link of the KoboToolbox platform, Subsequently, the username associated with the KoboToolbox profile, under which the data collection forms were prepared, needs to be appended to the link.

2.4 Then paste it in the ODK as shown in Figure 25.

2.5 After that, you will proceed to the new interface as shown in Figure 26. Click on “**Download Form”**.

2.6 After you see the form, you prepared and then follow the steps in Figure 27.

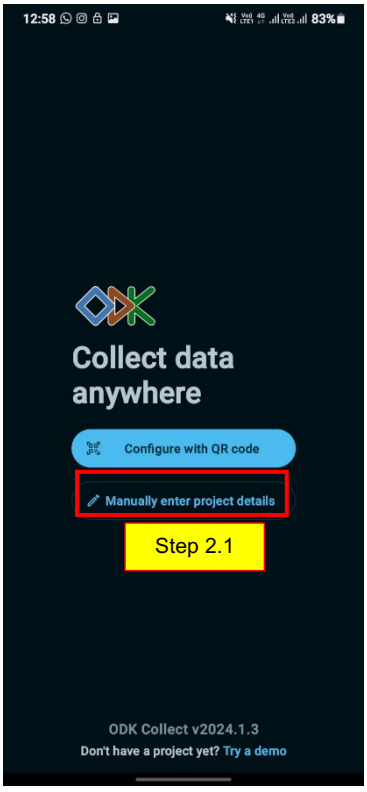


Figure 20 - Interface of the ODK

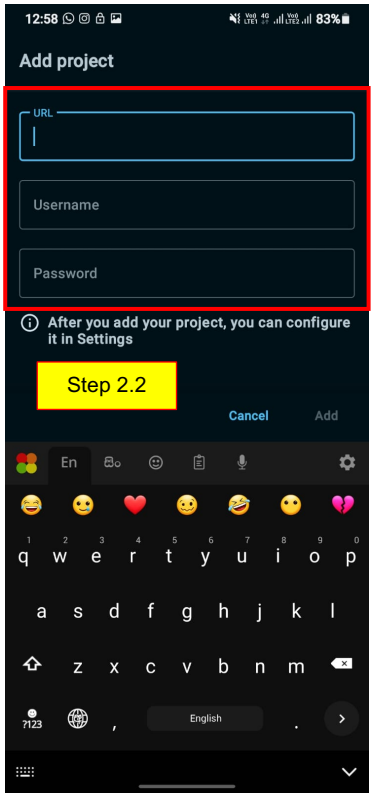


Figure 21 - ODK Details

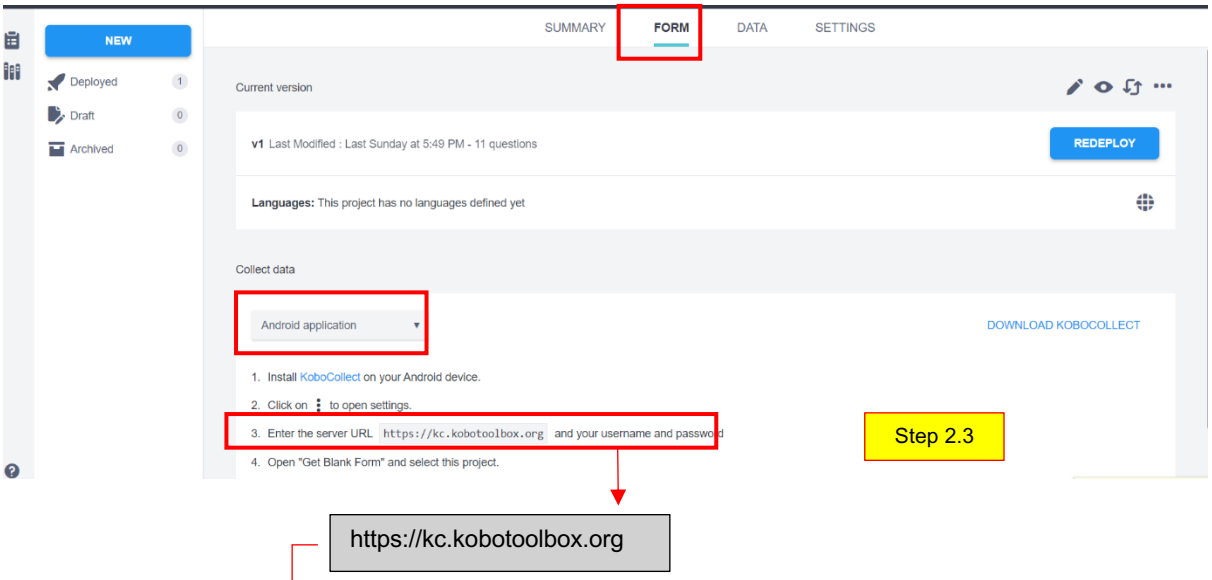


Figure 22 - Kobo Toolbox

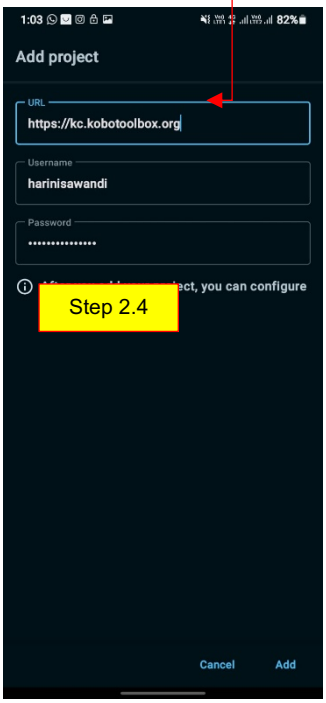


Figure 23 - Link the Form

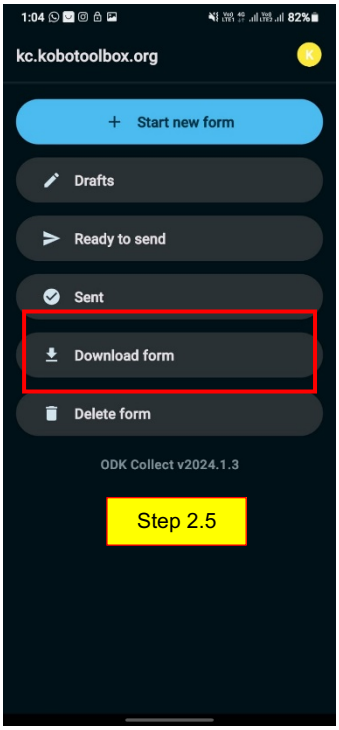


Figure 24 - New Interface

Step 2.6

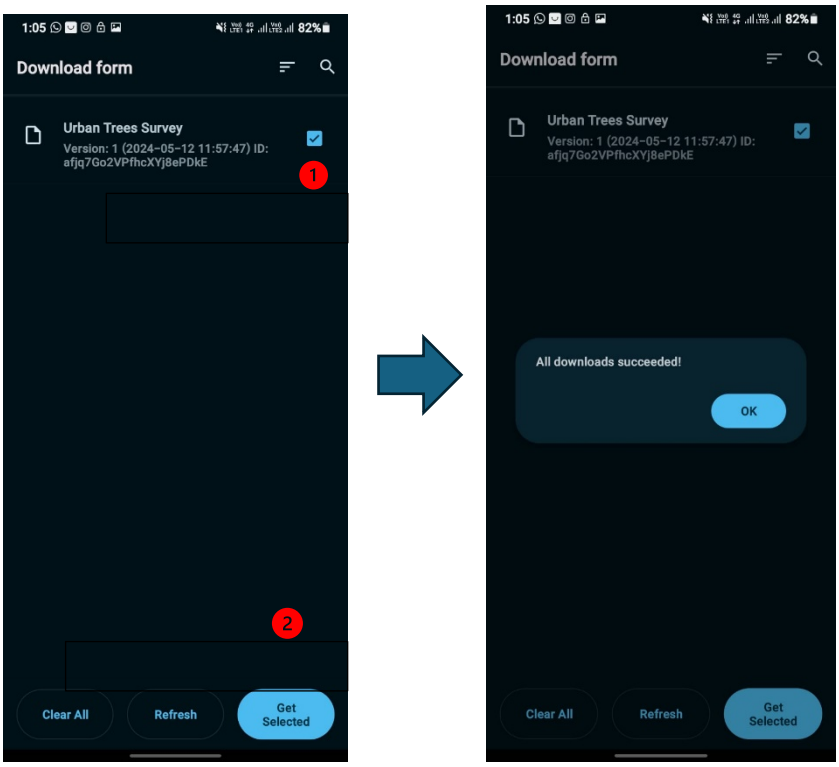


Figure 25 - Download the Form

Step 3

Data collection using ODK application: Click on "**Start new form**" as shown in Figure 28.

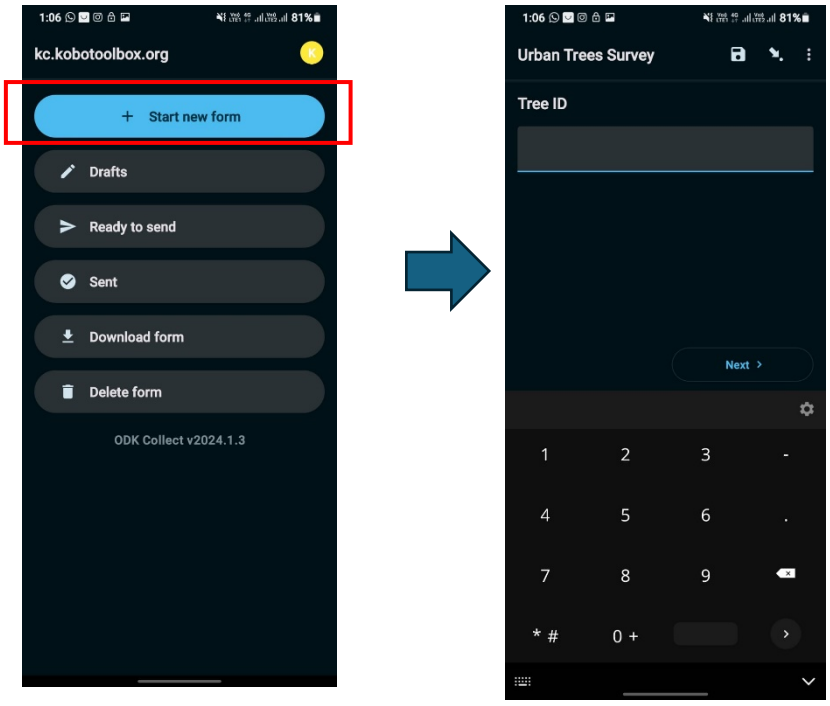


Figure 26- Collect Data

Step 4

Export data: After completing the data collection process, as shown in the figures below follow the steps.
4.1. Go to the "**Ready to Send**" tab and select all the collected data.
4.2. Click on the "**Send**" button and allow time for the sending process to complete.
4.3. Once the sending process is finished, click "**OK."**
4.4. Return to the main interface. As depicted in Figures 32 and 33, the sent data will now be displayed under the "**Sent**" tab.

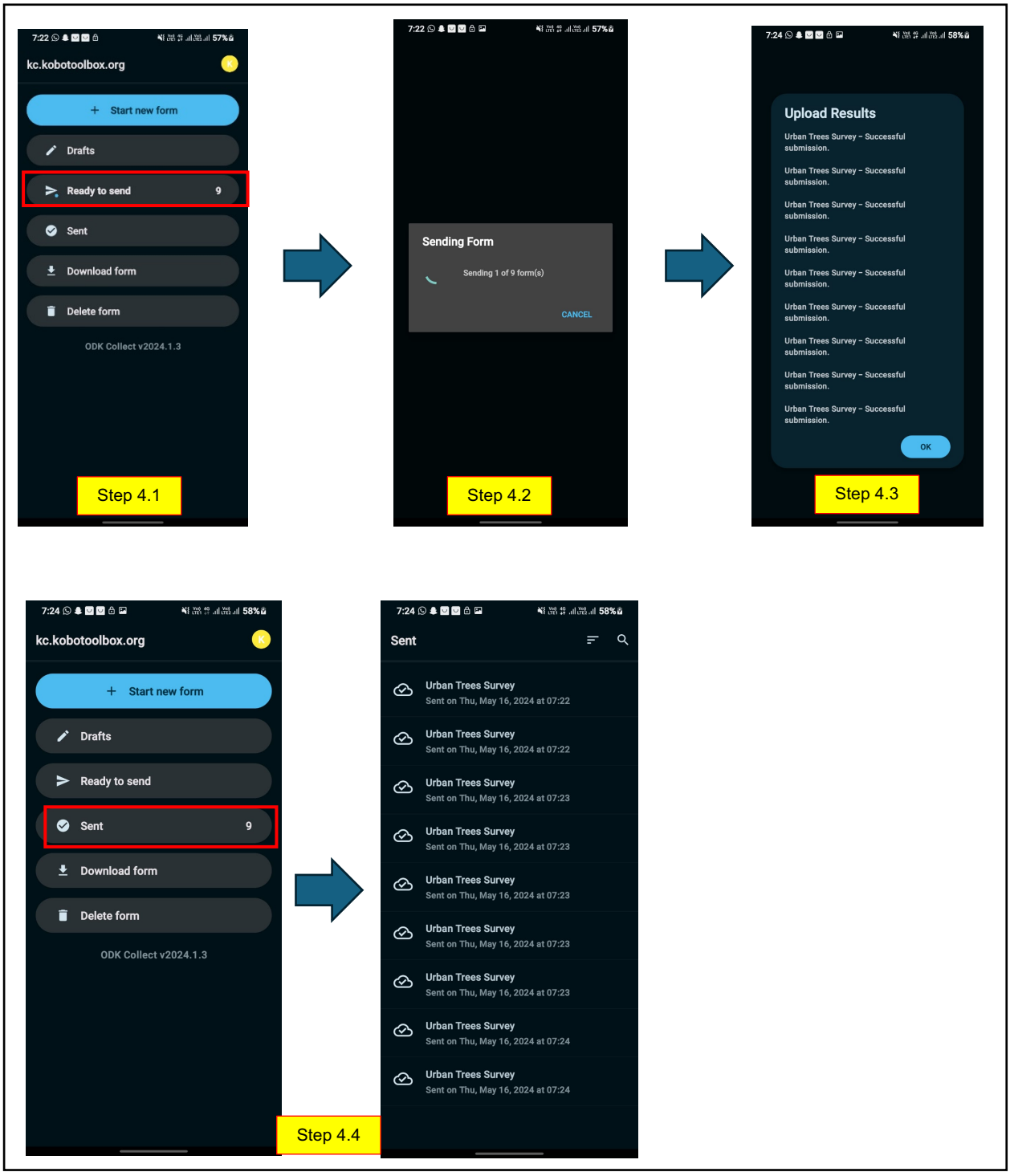


Figure 27 - Data Exporting Process

Step 5

Downloading data from Kobo Toolbox: Once the data collection process is complete, follow these steps to download the collected dataset:

5.1 Proceed to the "**Data**" tab within KoboToolbox.The list of data can be found in a table as shown in figure 30.
5.2 Next, click on the "**Download" option**, and within the ensuing step, ensure that the data type selected for download is "**CSV Legacy**."
5.3 Click on the "**New Export"** option. This will generate a link (this will take some time), which you can utilize to download the data associated with the selected data collection form.
5.4 Once the link is prepared, simply click on it to initiate the download of the data for the specific data collection form.

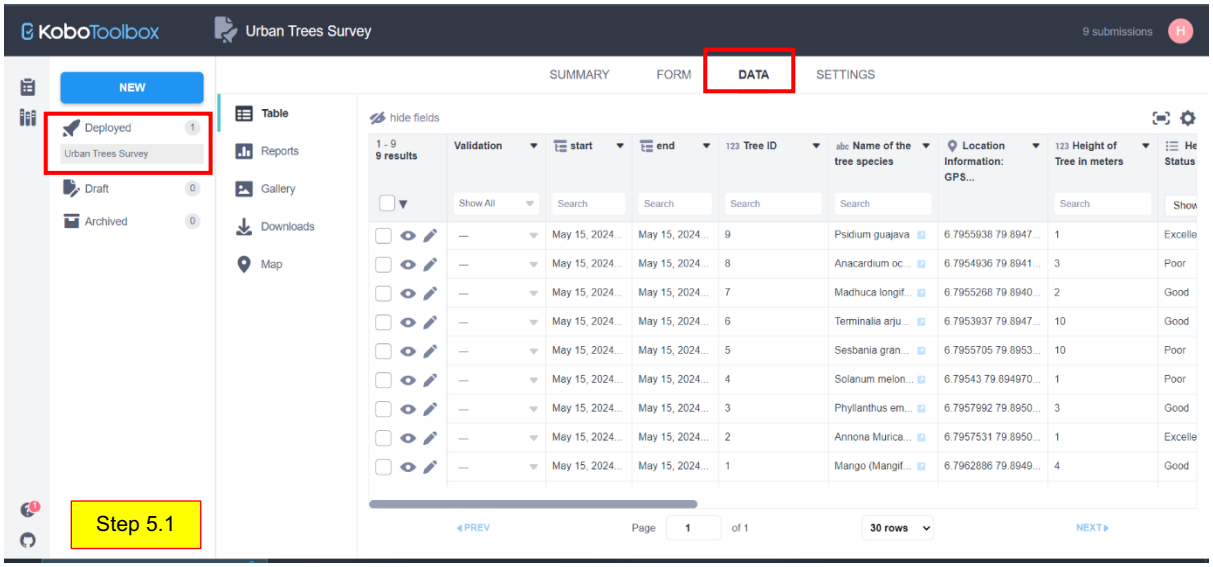


Figure 28 - Collected Data

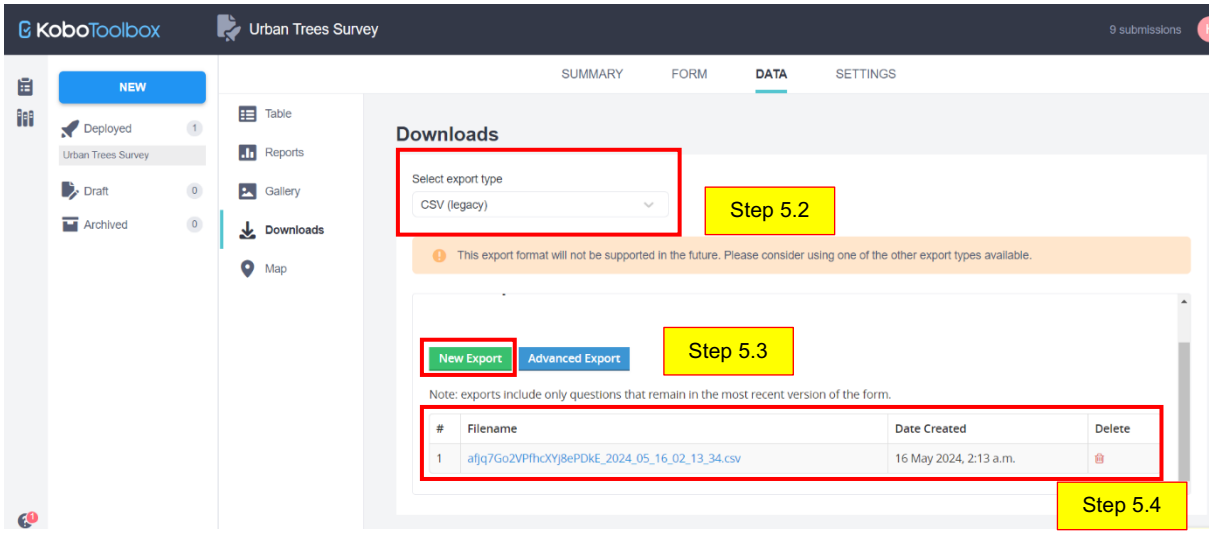


Figure 29 - Data Downloading

4.3.3 Data Analysing

Step 1

Import those data to QGIS: After downloading data normally it downloads as a CSV file type which opens directly via Excel as shown in Figure 31.

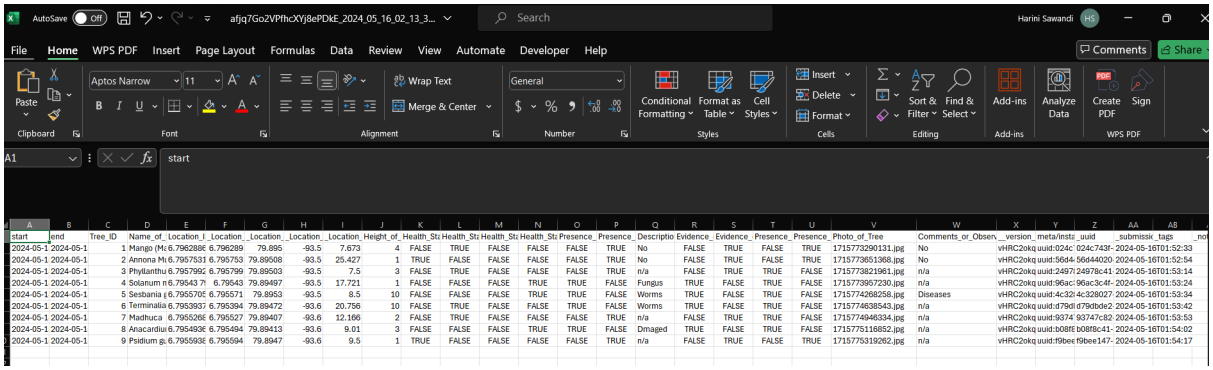


Figure 30 - Excel File

Step 2

To begin working with the downloaded data in QGIS, please follow the steps illustrated in Figure 33.

2.1 Firstly, open QGIS software (Refer to the link below to download and learn the basics of Qgis), and go to the new map template. Then, to the "**open data source manager**", select the "**Add Delimited Text Layer**" option, which will prompt the corresponding tool to open. Within the tool, click on the "Browse" button to locate and select the downloaded CSV file. Provide a suitable name for the file in the designated field.

2.2 The next step involves assigning the x and y fields. Under the "Geometry Definition" section, ensure the correct x and y coordinate fields are selected. These fields should correspond to the specific x and y coordinate information mentioned in the CSV file that you intend to import into QGIS. As you make the appropriate selections, a preview of the data will be displayed in the empty area of the tool.

2.3 Once you have confirmed the correct assignment, click "Add." The data will then be displayed within the QGIS interface, allowing you to process and utilize it for various purposes, such as creating customized maps and facilitating informed decision-making.

2.4 If you want to add a base map Click on the "Plugin > Manage and Install Plugins > search bar of the dialog box, type "QuickMapServices" and press Enter > Install" or "Update" button next to the "QuickMapServices" > After installing the "QuickMapServices" you should see a new window appear on the right side of the screen. If you don't see the QMS window, you can open it by going to the "Web" option > search for a suitable base map

https://www.youtube.com/watch?v=CLuSZB95ly0

How to install QGIS on a Windows 10 compute

https://www.youtube.com/watch?v=kCnNWyI9qSE

This video is a basic look at QGIS for Absolute Beginners.

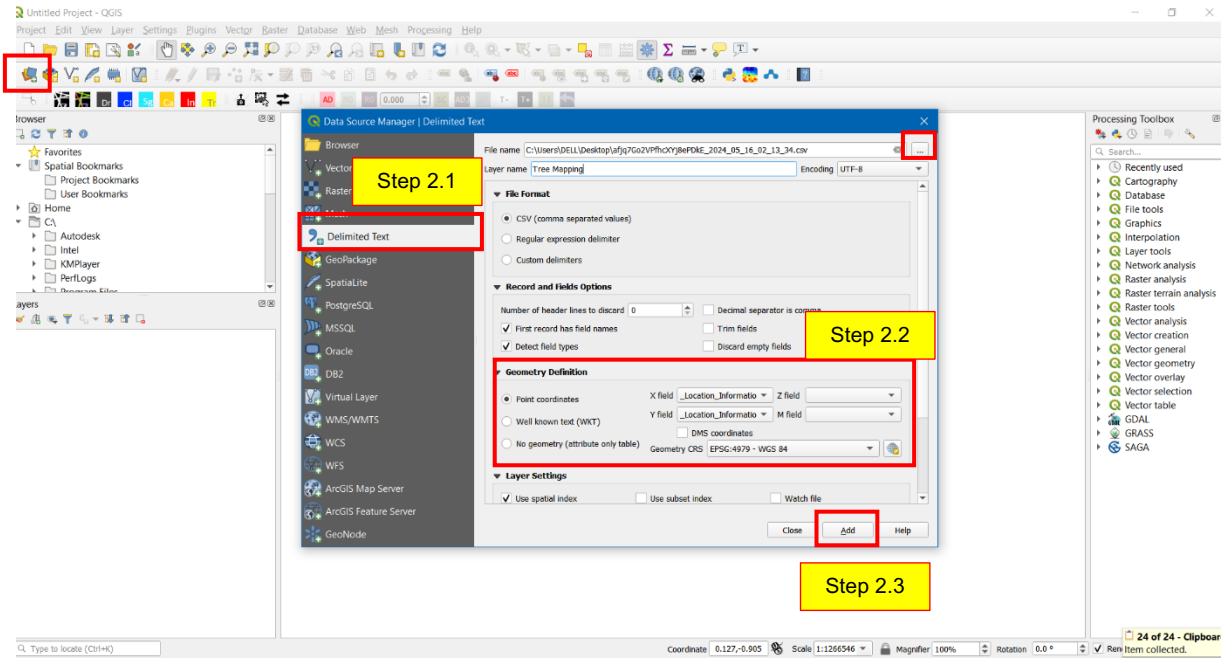


Figure 31 - Add Data to QGIS

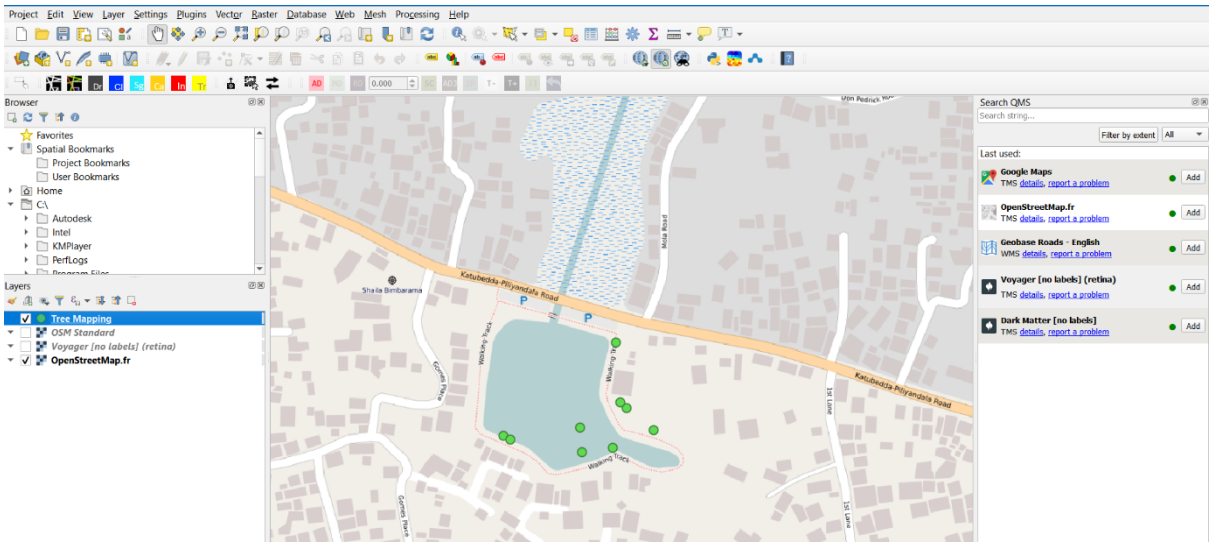


Figure 32 - Collected Data point of trees

Step 3

To update existing data using Google My Maps, follow these steps: Access Google My Maps through this link [https://www.google.com/mymaps].

3.1 Import the CSV file into Google My Maps by clicking on the "Import" option.
3.2 Select the GPS coordinates and Tree ID from the CSV file. Once imported, the points will be displayed on the map.
3.3 Click on any point to view its details, and you can edit them as needed. After editing, save the changes.
3.4 You can share the map with others by using the sharing options, as shown in Figure 36

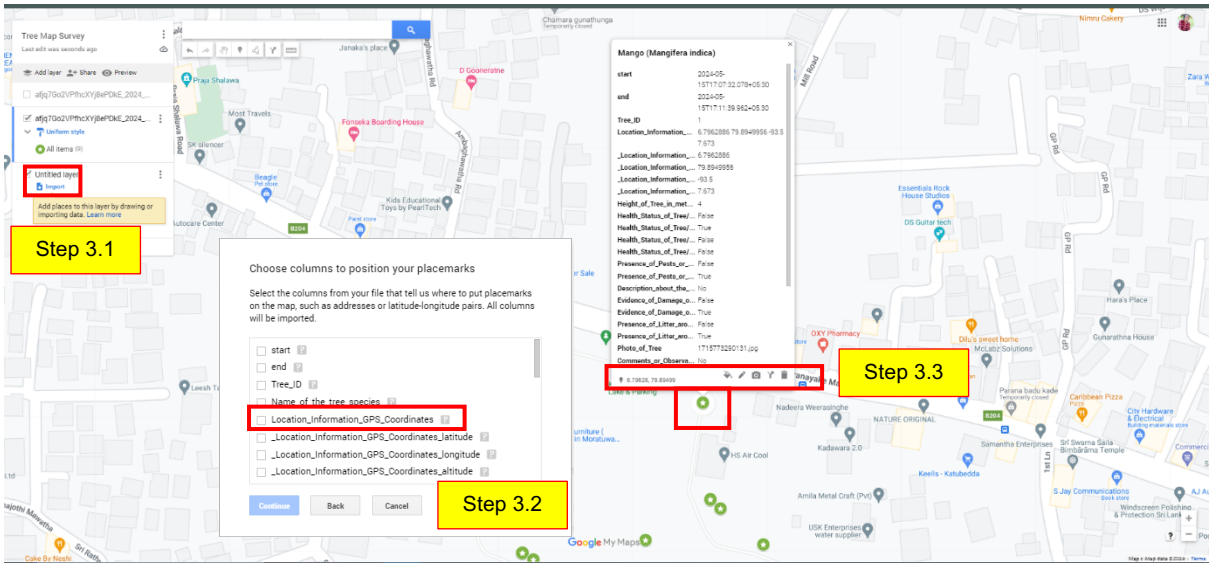


Figure 33 - Edit the Data

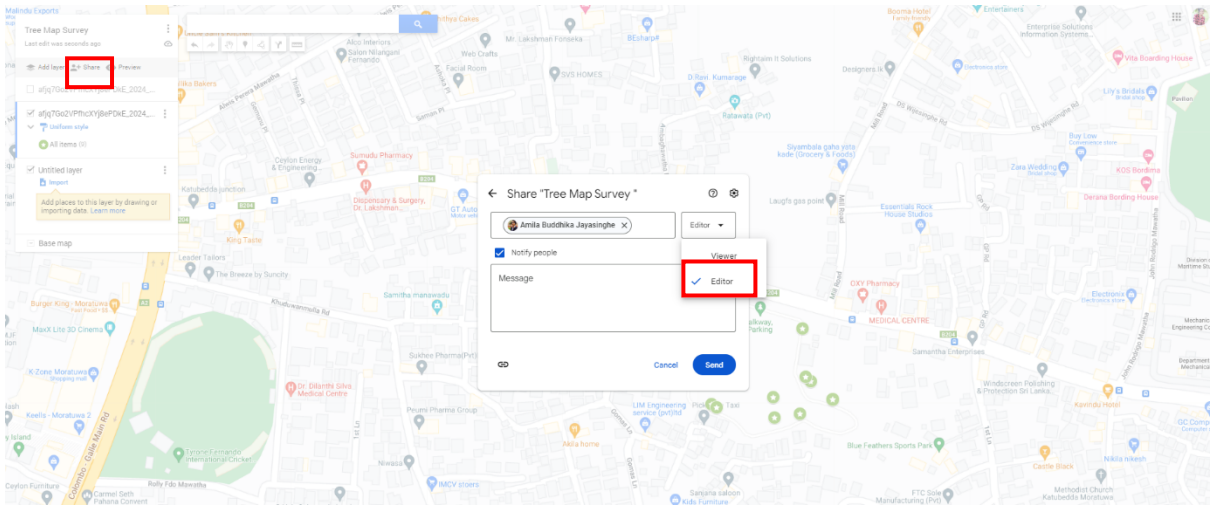


Figure 34 - Share the Details

4.4 Data Collection using GNSS (Global Navigation Satellite System)

Global Navigation Satellite Systems (GNSS) have revolutionized surveying and mapping by providing accurate positioning data. GNSS surveying methods employ satellite signals to determine precise coordinates, enabling professionals in various industries to carry out accurate measurements

4.4.1 Overall Data Collection Process

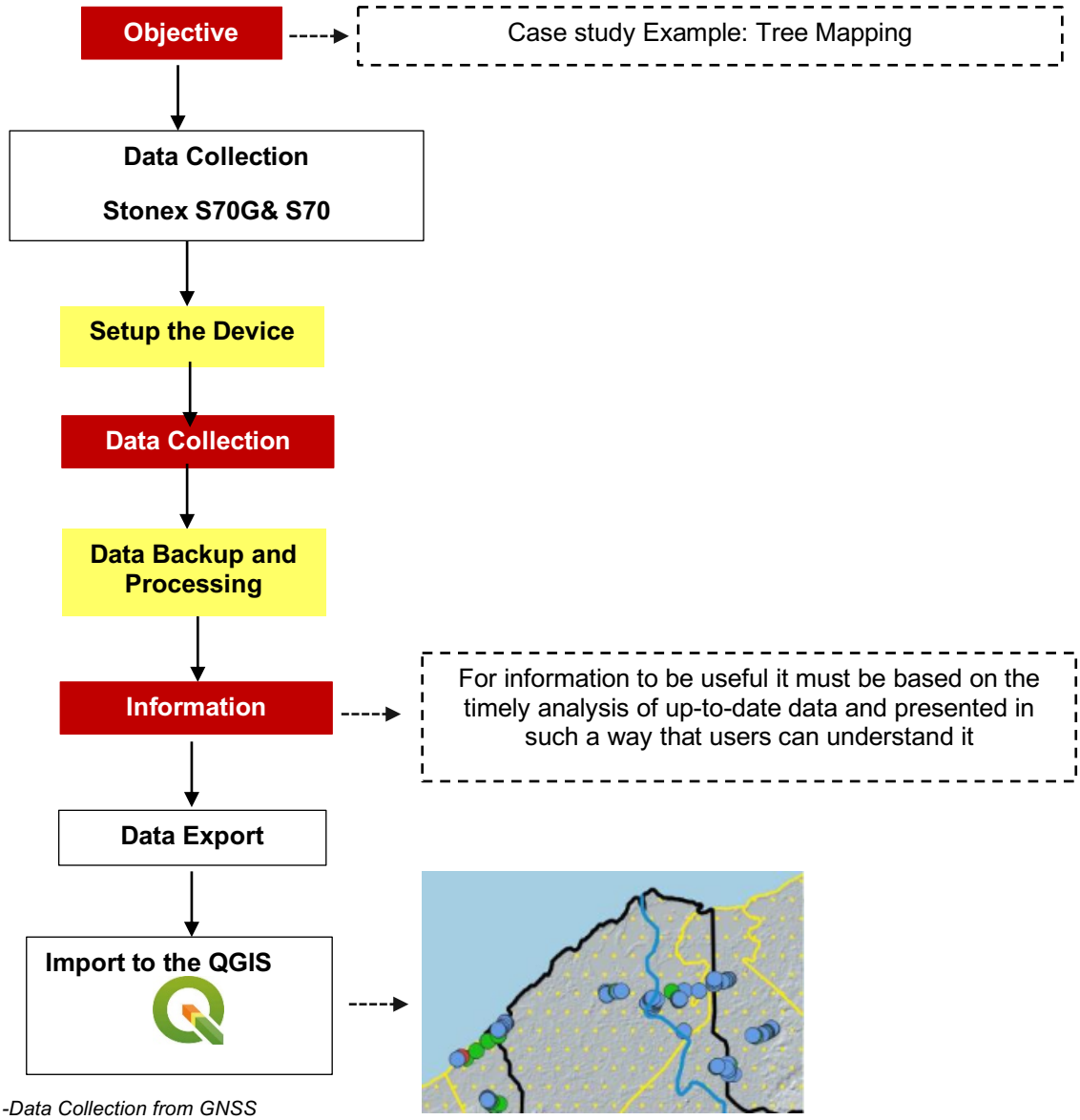


Figure 35 -Data Collection from GNSS

The primary difference between the Stonex S70 and S70G lies in their capabilities: the S70G is an RTK (Real-Time Kinematic) device, offering high-precision positioning with superior accuracy, ideal for demanding surveying tasks. In contrast, the S70 functions as a standard GNSS receiver, similar to the one in your mobile phone, providing basic positioning capabilities suitable for general applications.

4.4.2. S70 G Data Collection

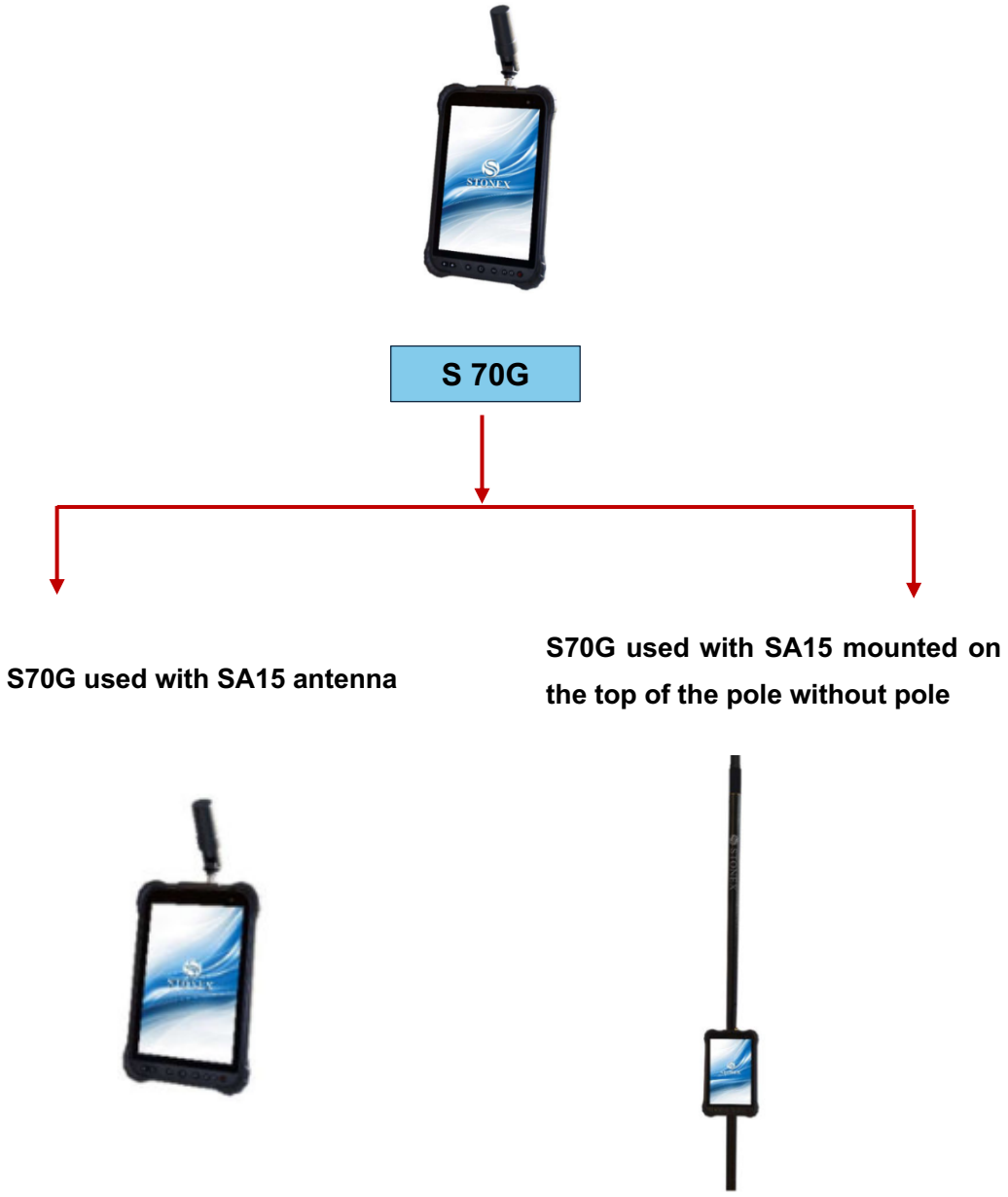


Figure 36 - Two types of S70G

Step 01

Click on the below icon (Cube a v6) to start.

Figure 37 -Cube a v6

Step 02

2.1 - Go to the Project tab.

2.2- Click on Project Manager to create a new file.

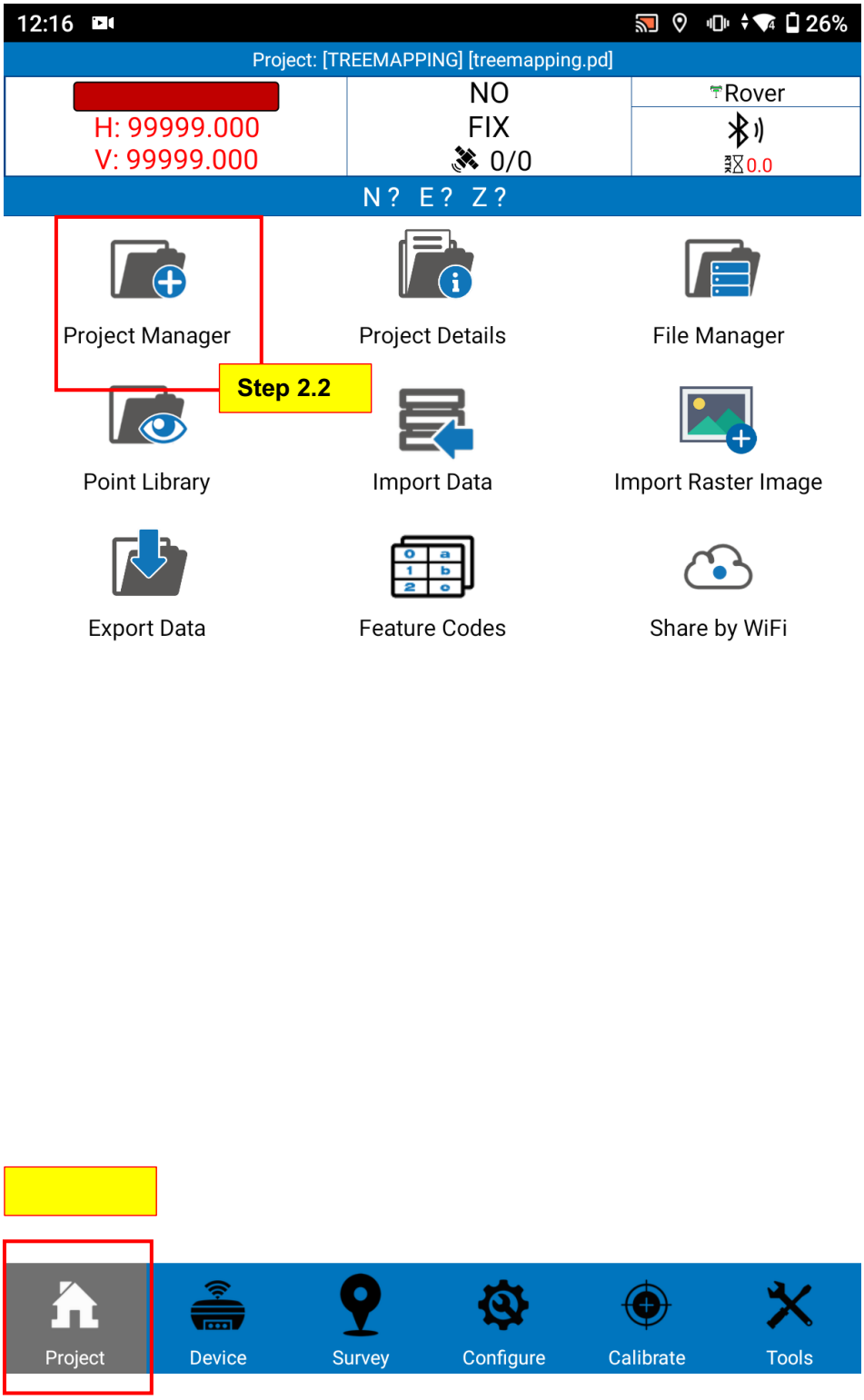


Figure 38 -Project Manager

Step 03

Then you will get the below interface and then go to the “New”

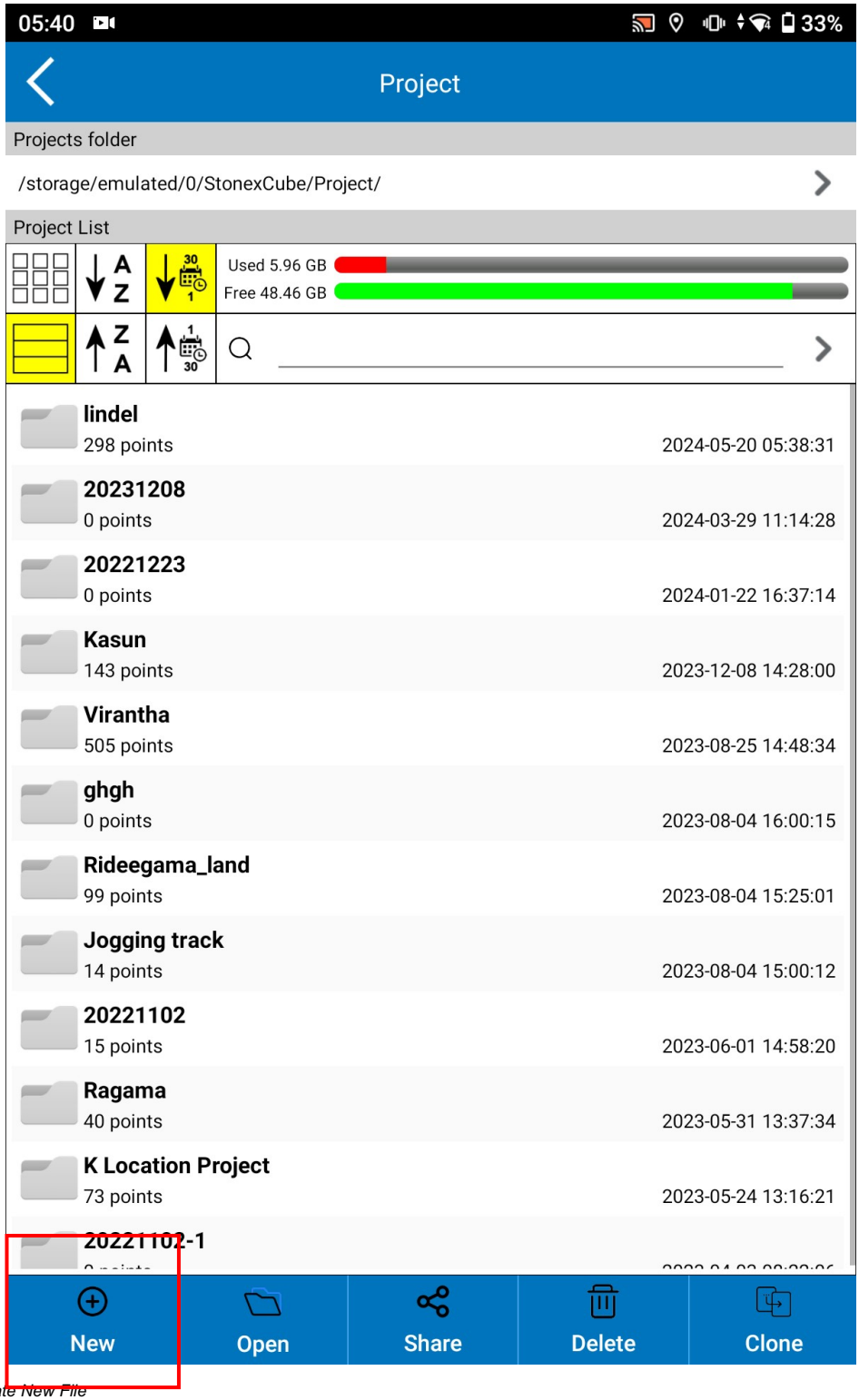


Figure 39 - Create New File

Step 04

Then give the project name as per the study and click on next.

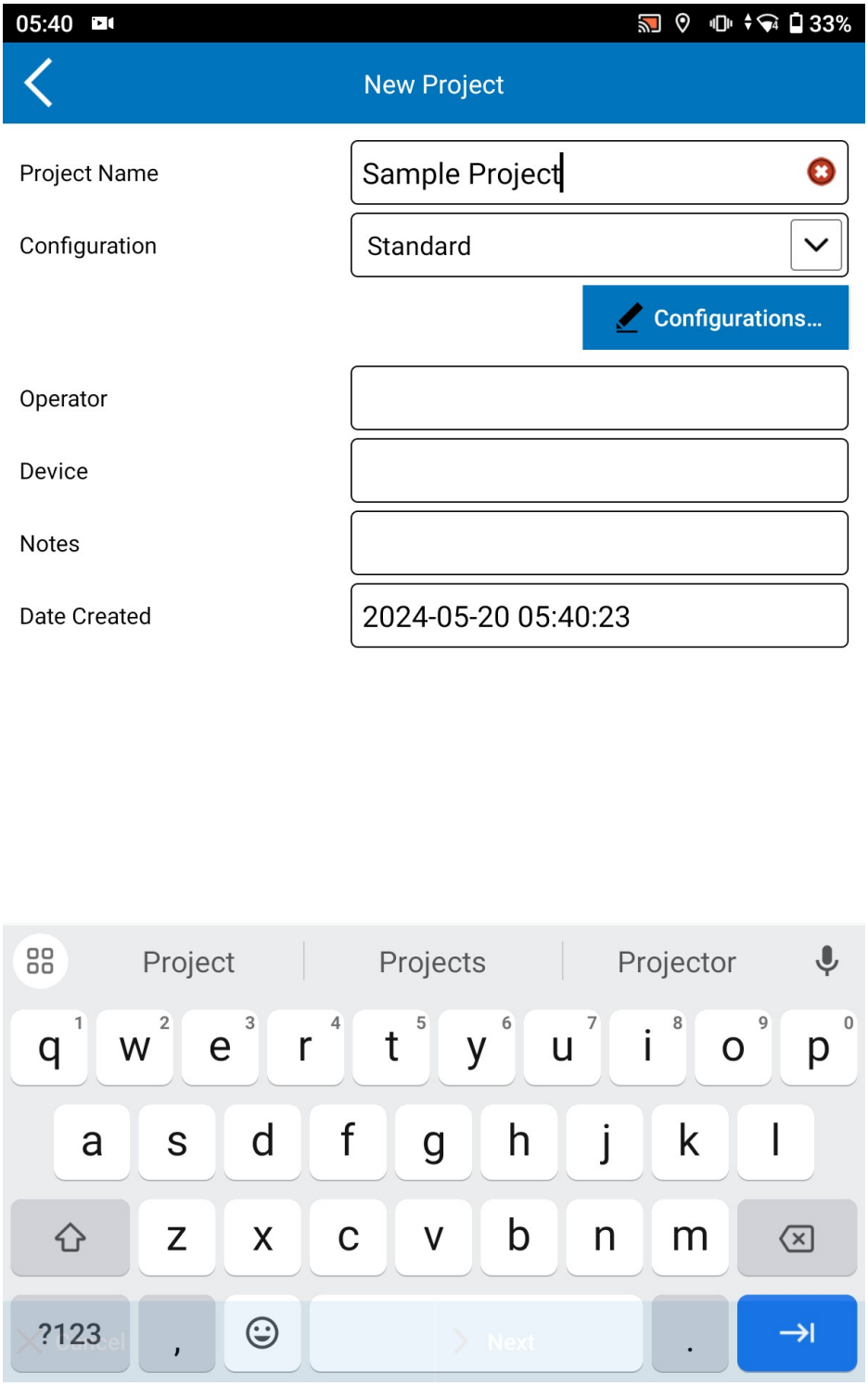


Figure 40 -Create Project

Step 05

Then you will get this interface and click on “ file”.

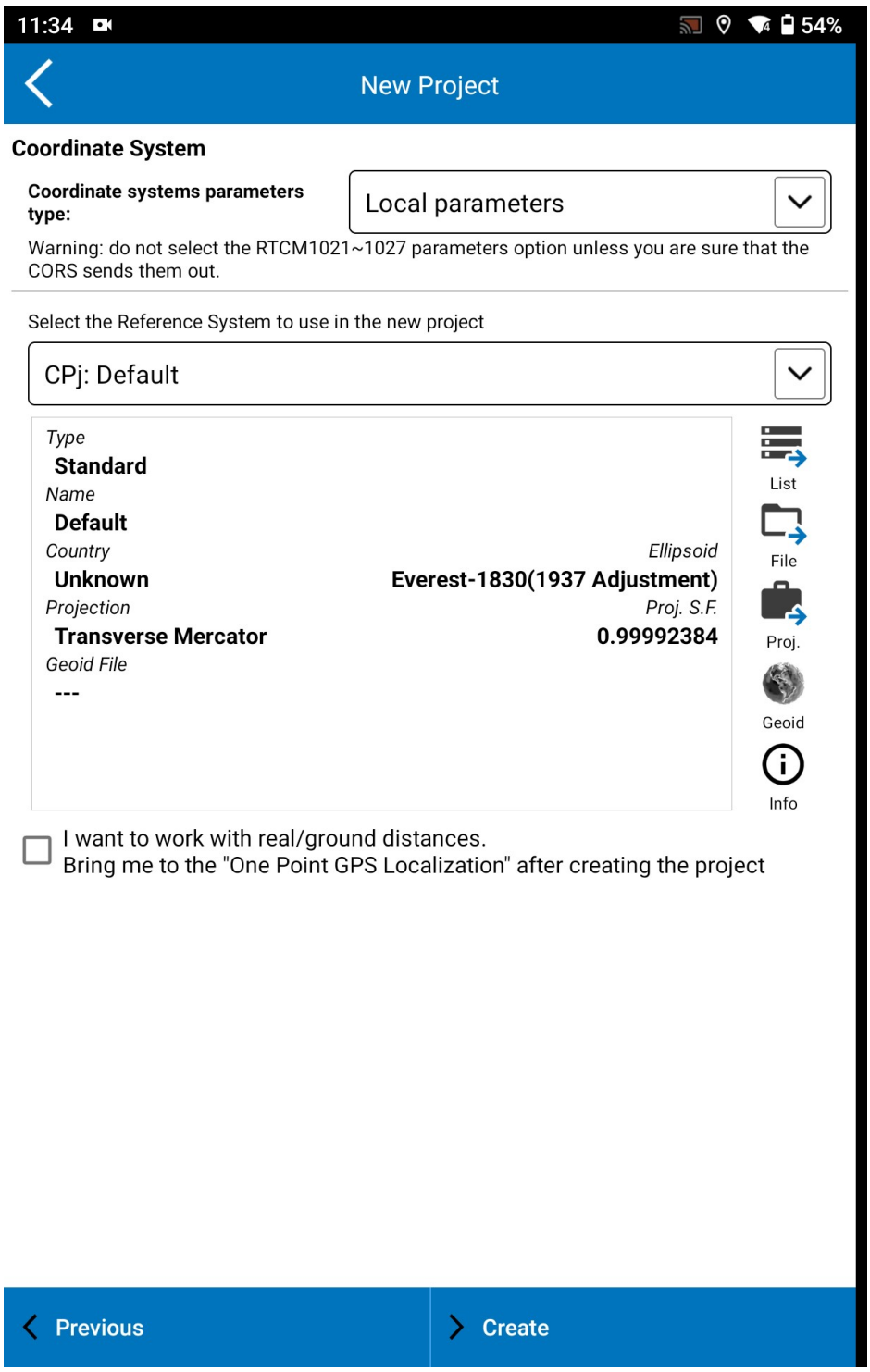


Figure 41 - Set Coordinates

Step 06

Then you will get this interface and in there click on "**Stonex cube"**

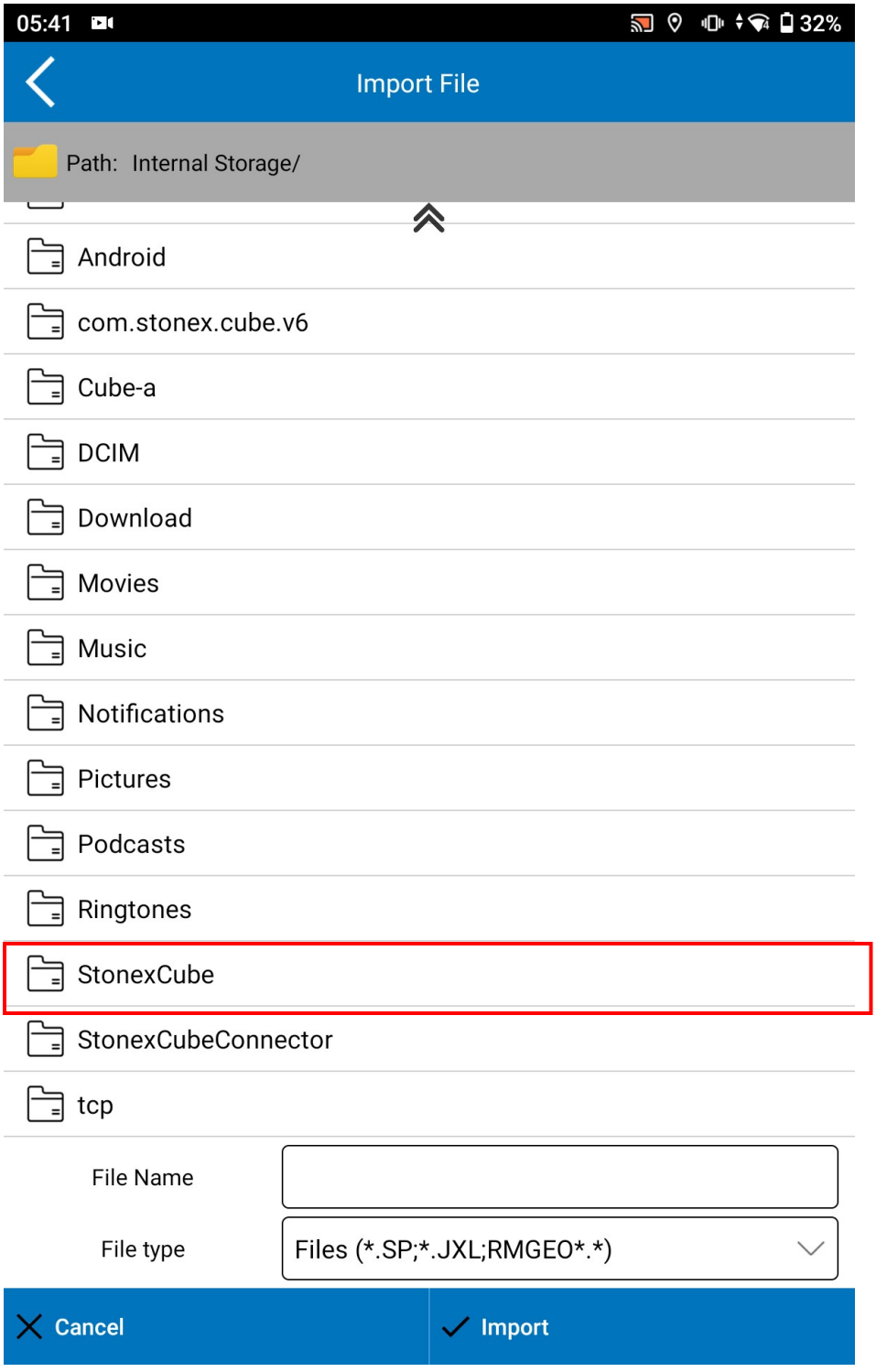


Figure 42 -Stonex Cube

Step 07

Click on the “ Coordinate” to set the coordinate system

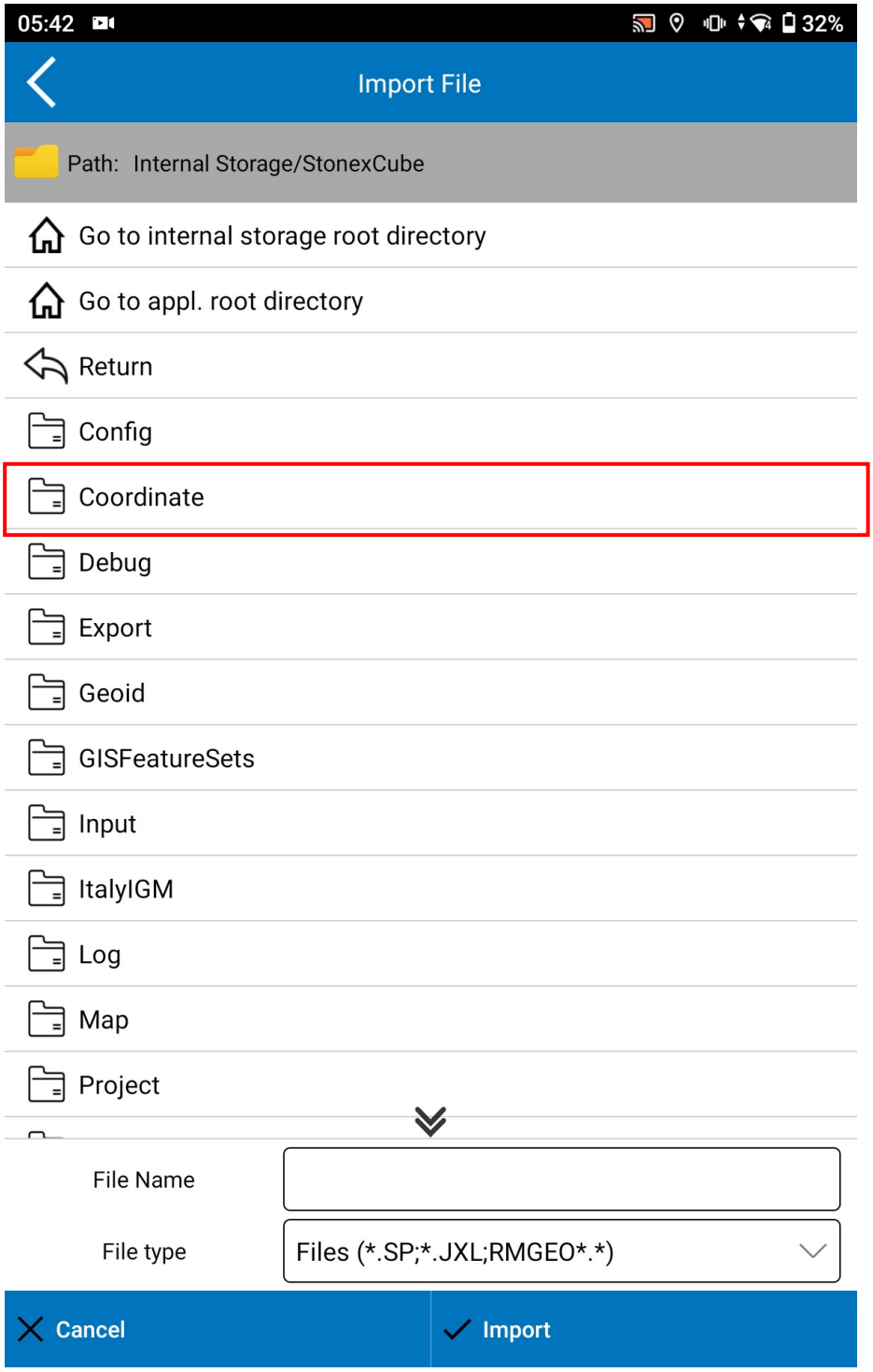


Figure 43 - Coordinate Systems

Step 08

Click on the Coordinate System and select the import.

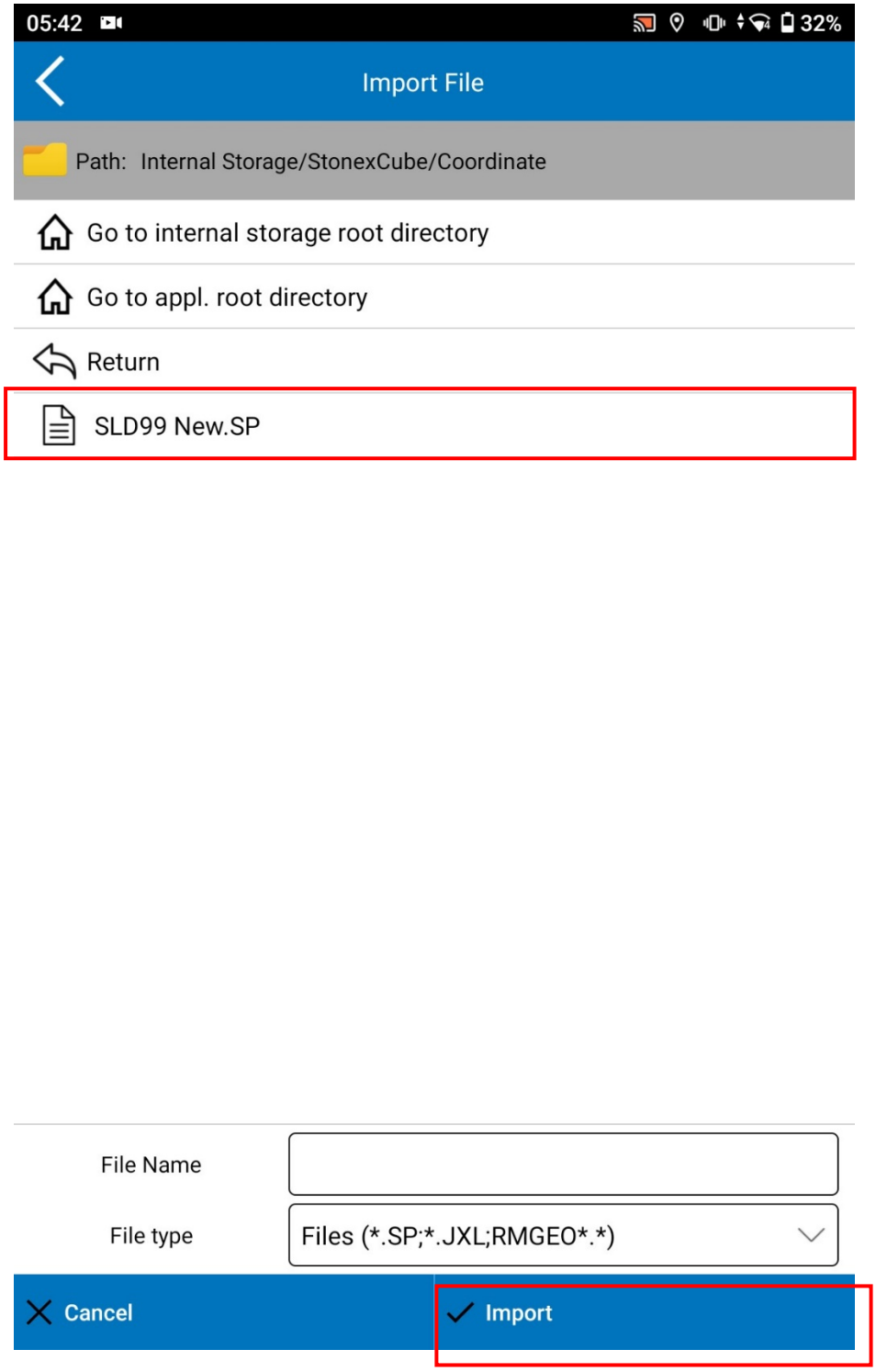


Figure 44 - Set the Coordinates

Step 09

9.1 – Then go to the main page and click on the “Device Tab”

9.2 – Then select on Communication

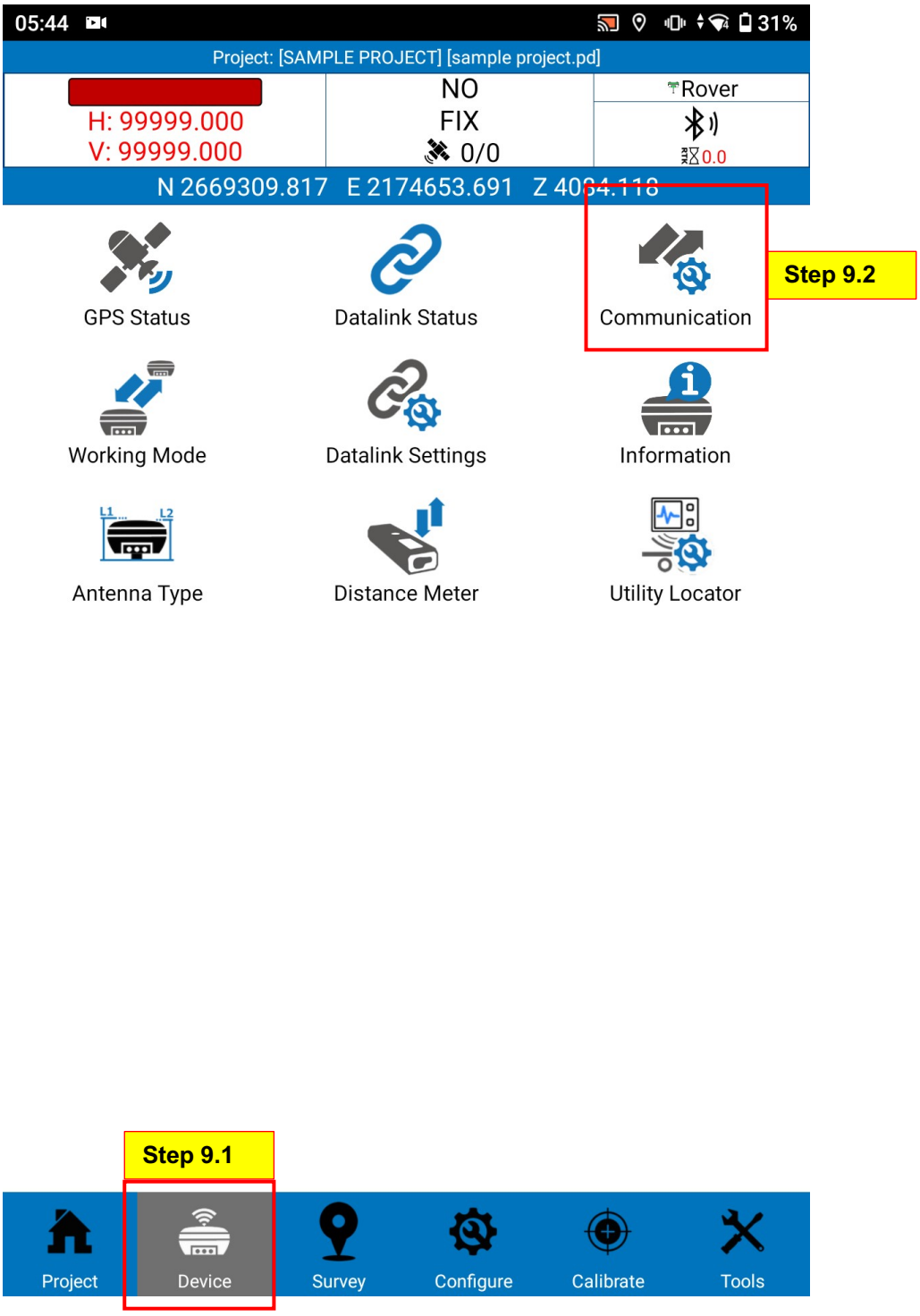


Figure 45 - Set up the Device

Step 10
Then you will see the interface below. Click on the Disconnect button first, which belongs to the previous task

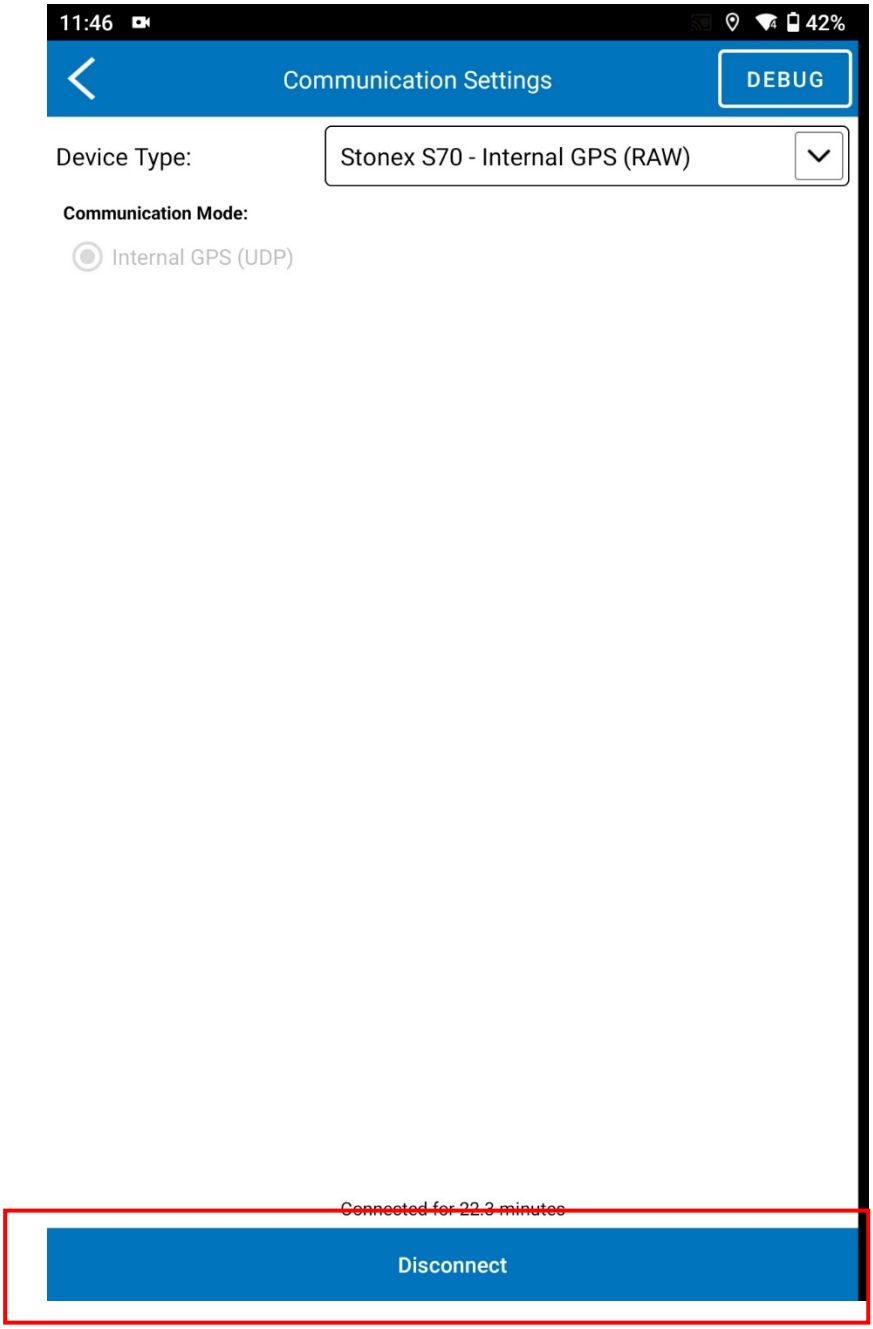


Figure 46 - Disconnecting

Step 11
11.1-Then, click on the drop-down menu, select "Stonex 70G,"

11.2 - Then click on "Connect."

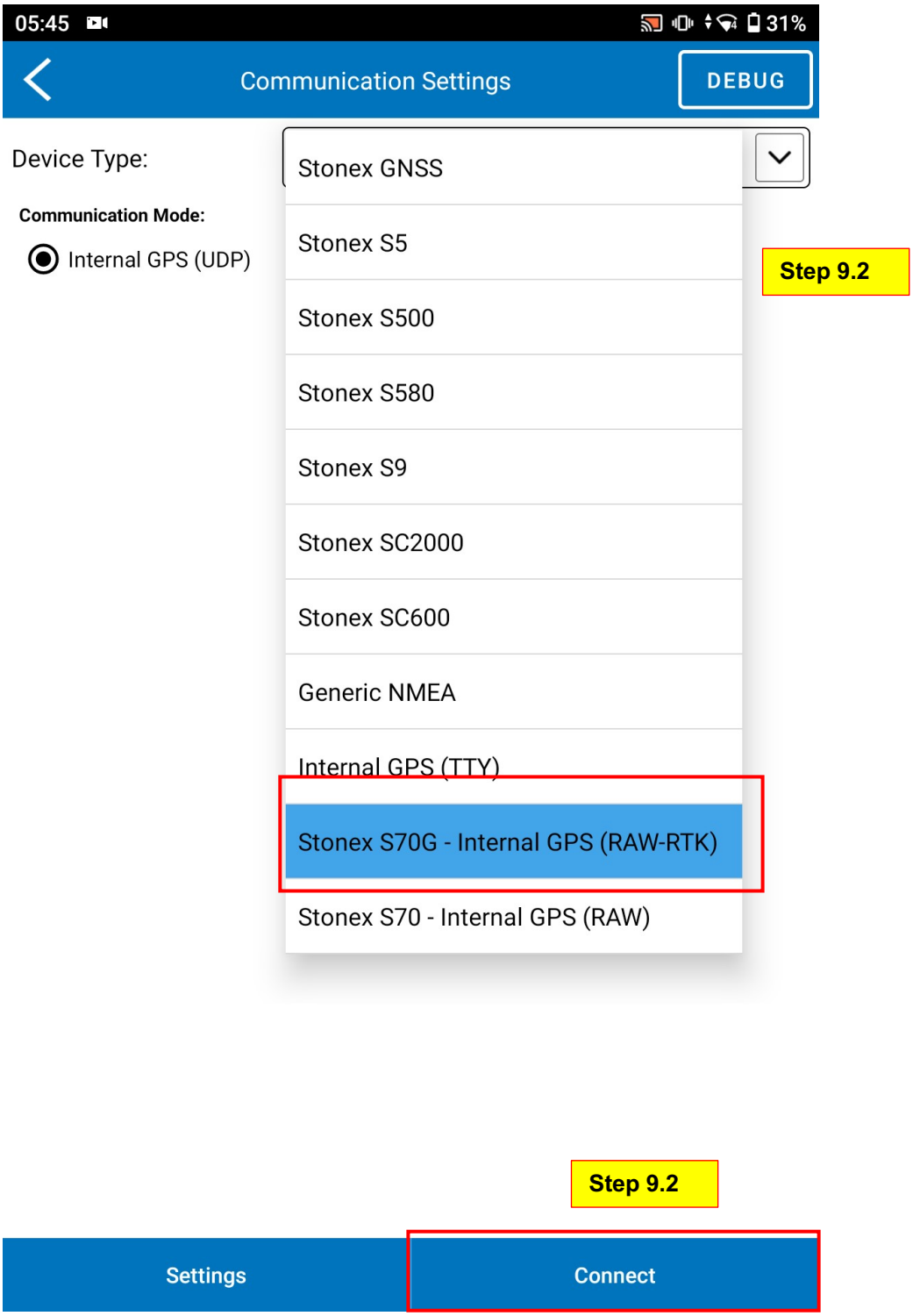


Figure 47 - Connect the Device

Step 12

Then go back and select the “Working mode” under the device tab

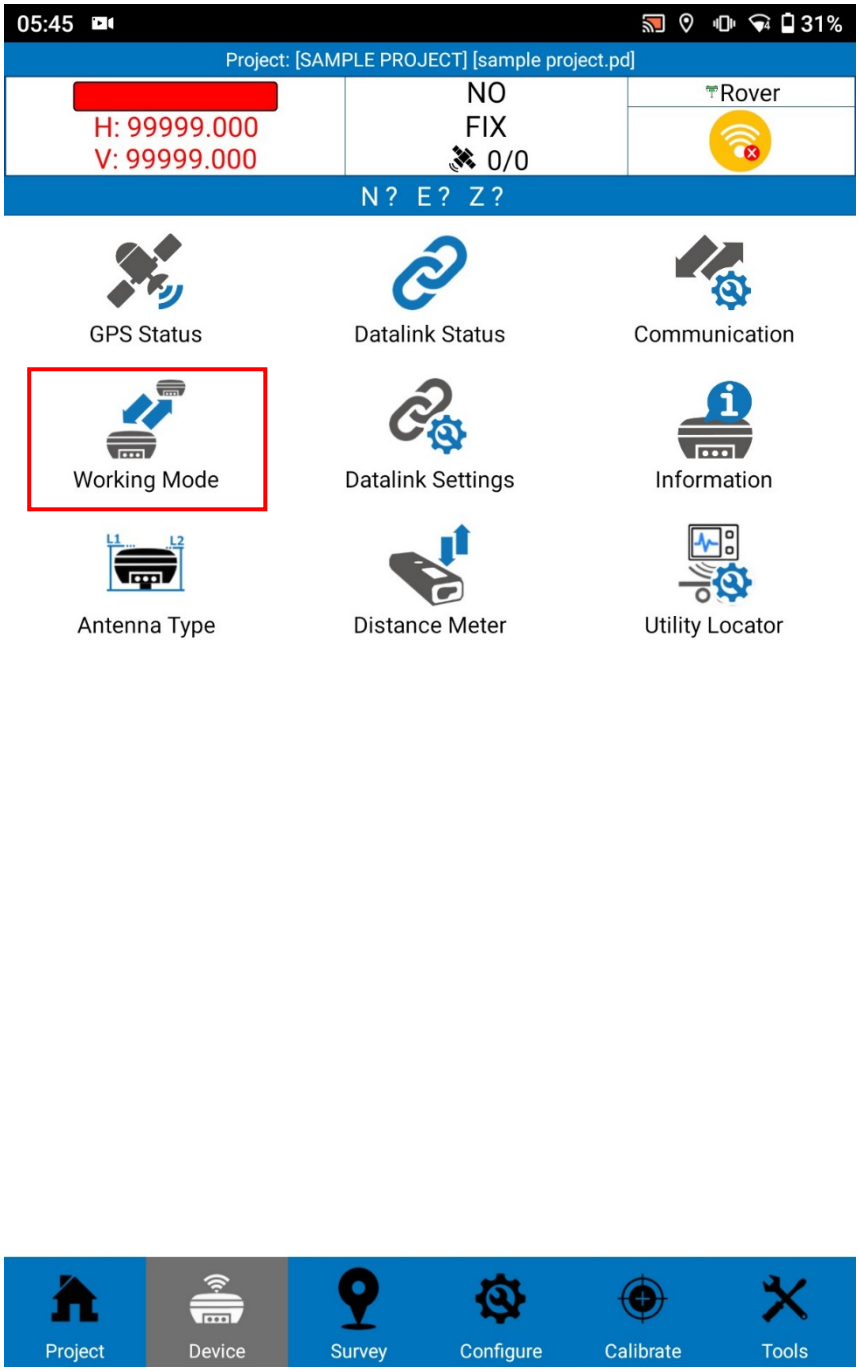


Figure 48 -Working Mode

Step 13

Select **"Rover"**

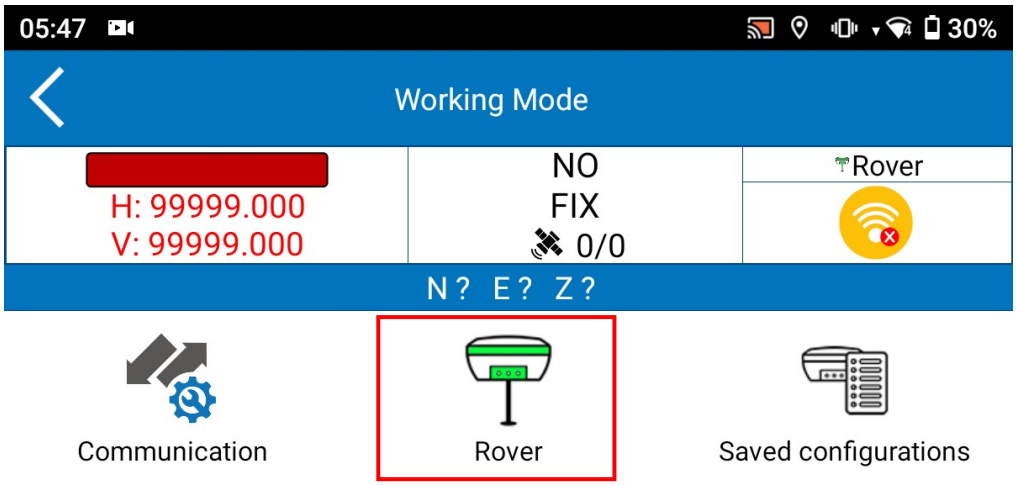


Figure 49 - Select Rover

Step 14

Set the following parameters:

13.1 Elev. mask: Set it between 10 and 15.

13.2 Communication mode: Select "Phone network."

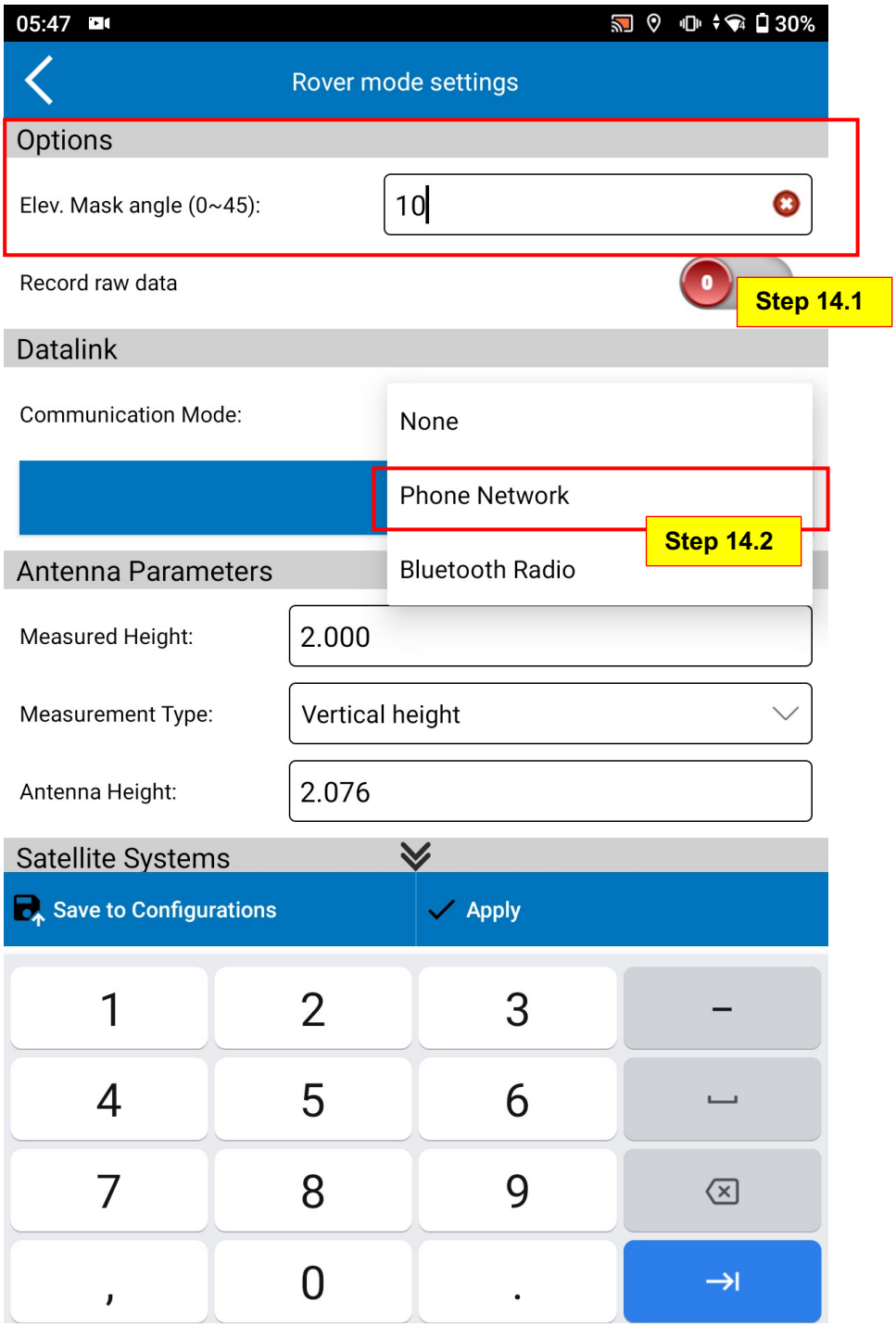


Figure 50 - Setting the Rover

Step 15:

then enable the following “satellite system” options and select apply.

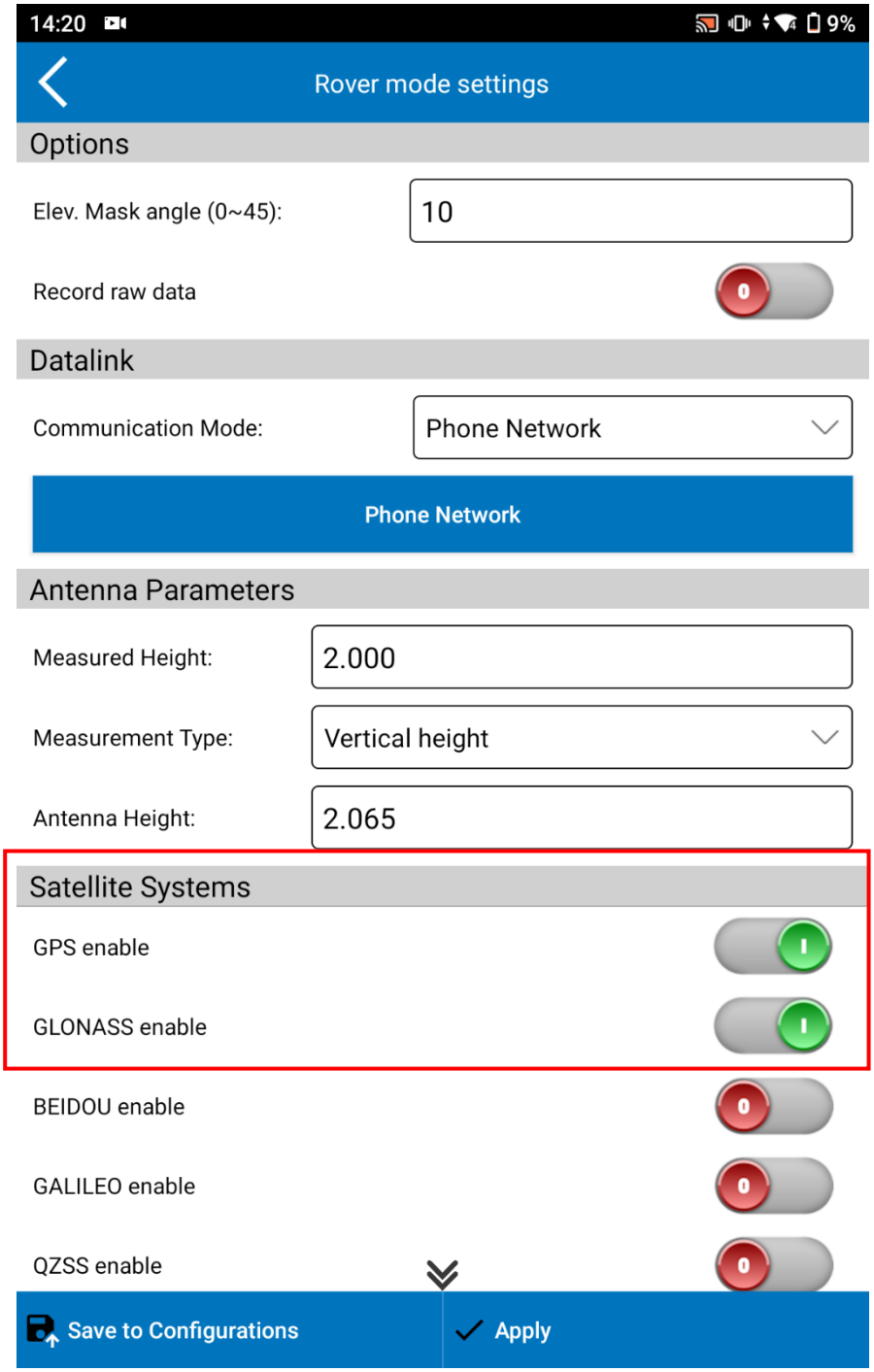


Figure 51 -Enable the GPS

Step 16

Then, this interface will appear. Click on "Mount Point" and select "Get Access Point."

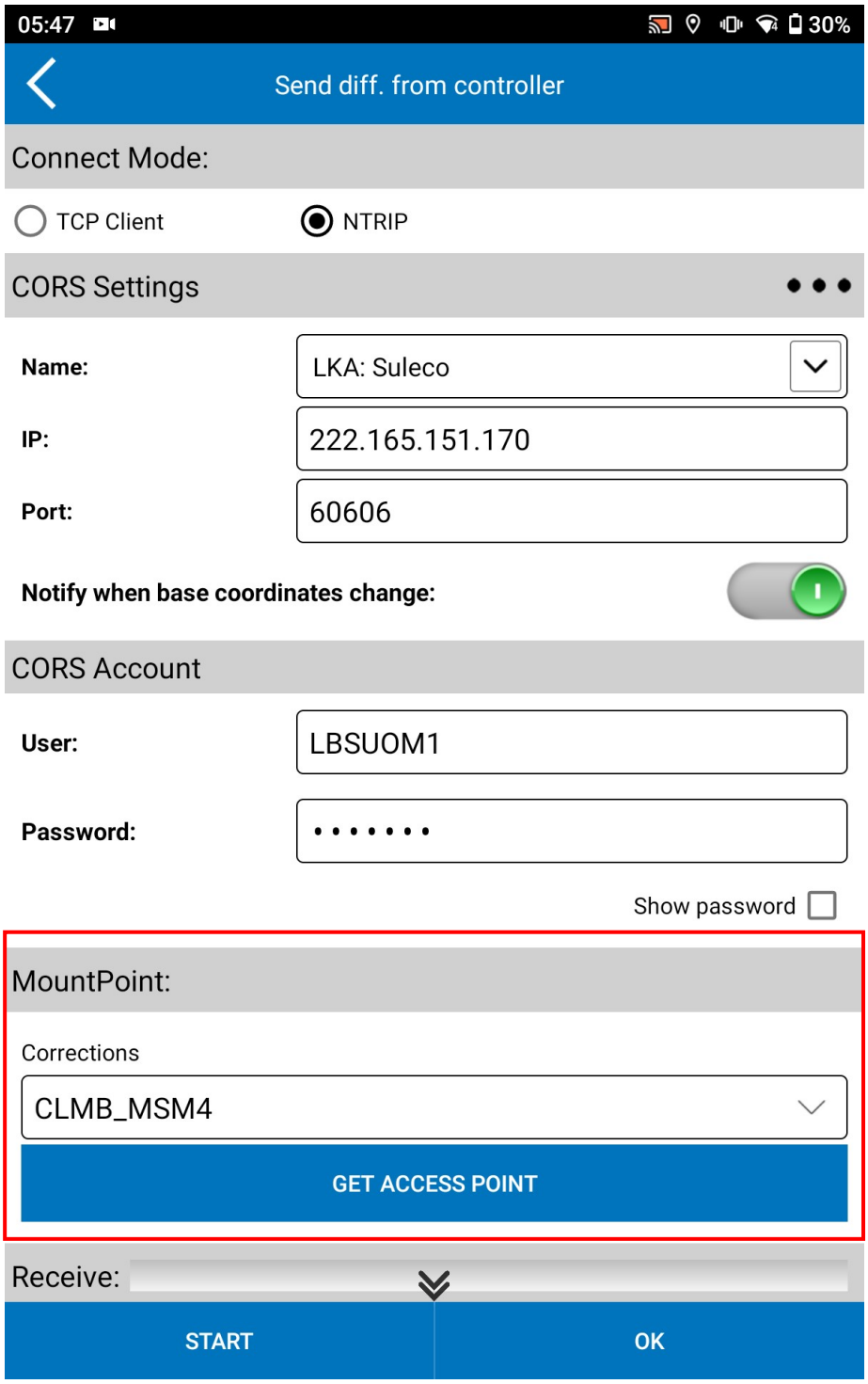


Figure 52 -Get Acess Point

Step 17

Then, from this drop-down menu, you need to select the point. Since this project is done in Colombo, select "Colombo," and always select "MSM4”

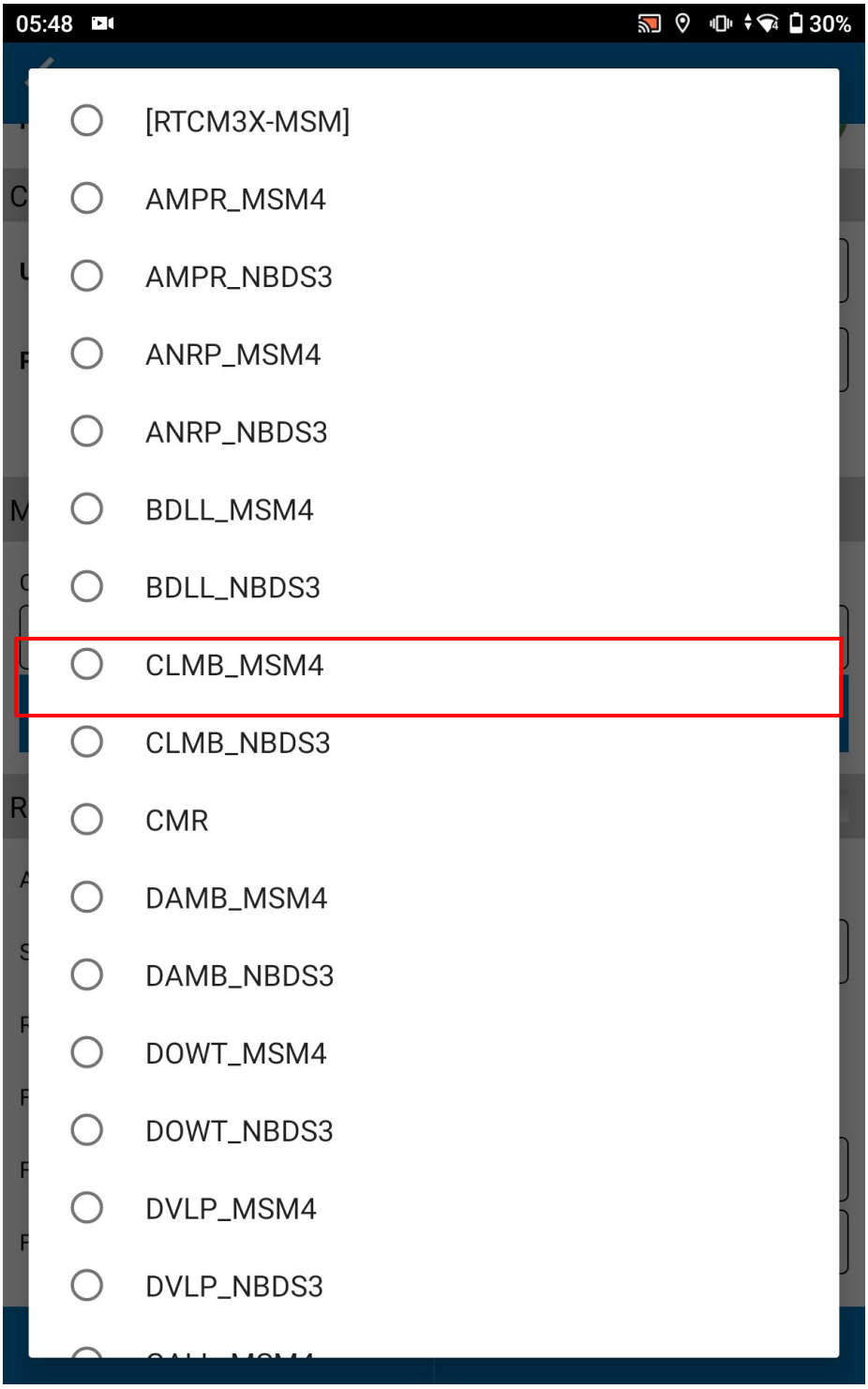


Figure 53 -Select the point

Step 18

Select Apply

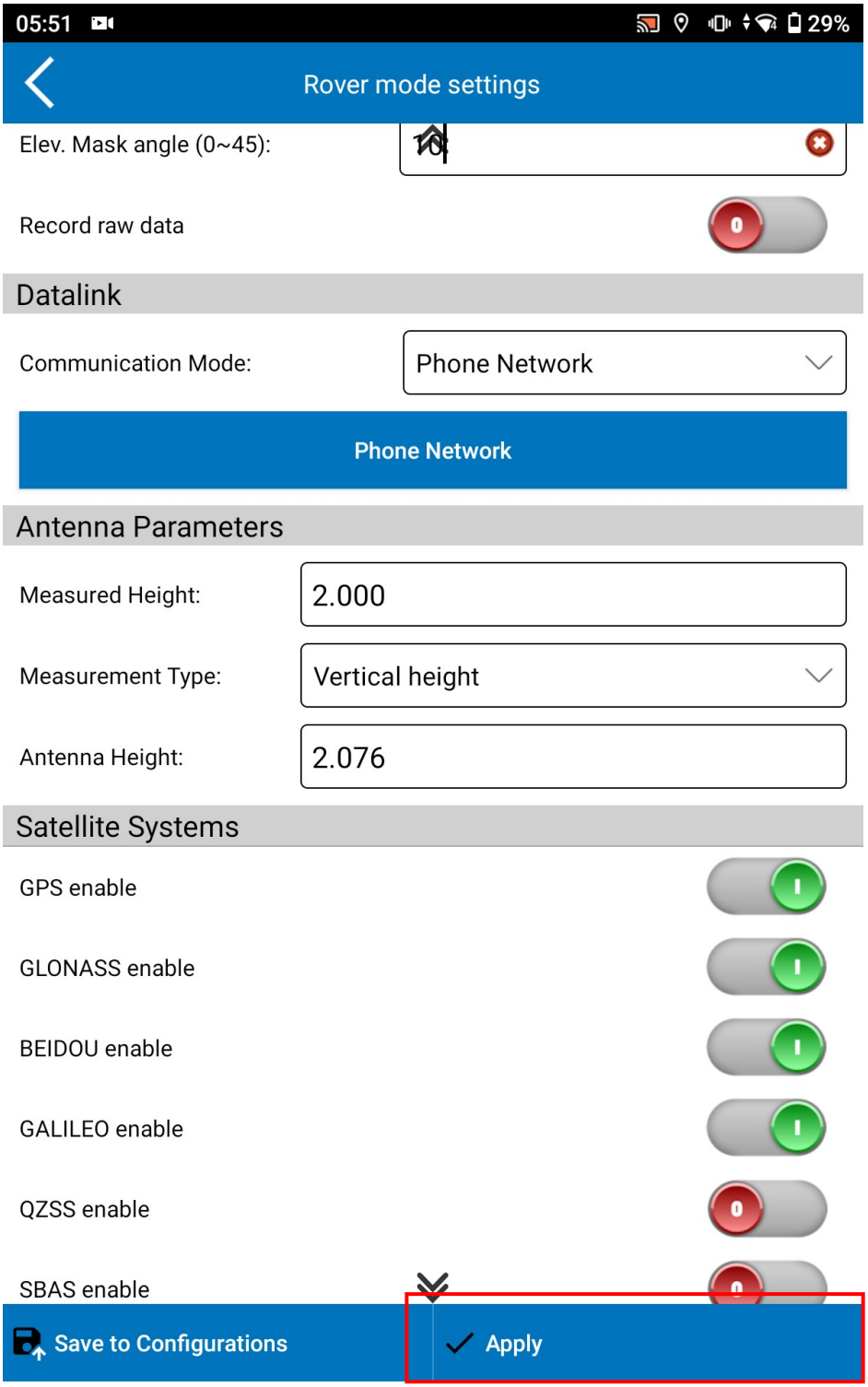


Figure 54 - Finalize the Rover Setup

Step 19

Then it will direct to the main page.Then click on “Antenna Type”

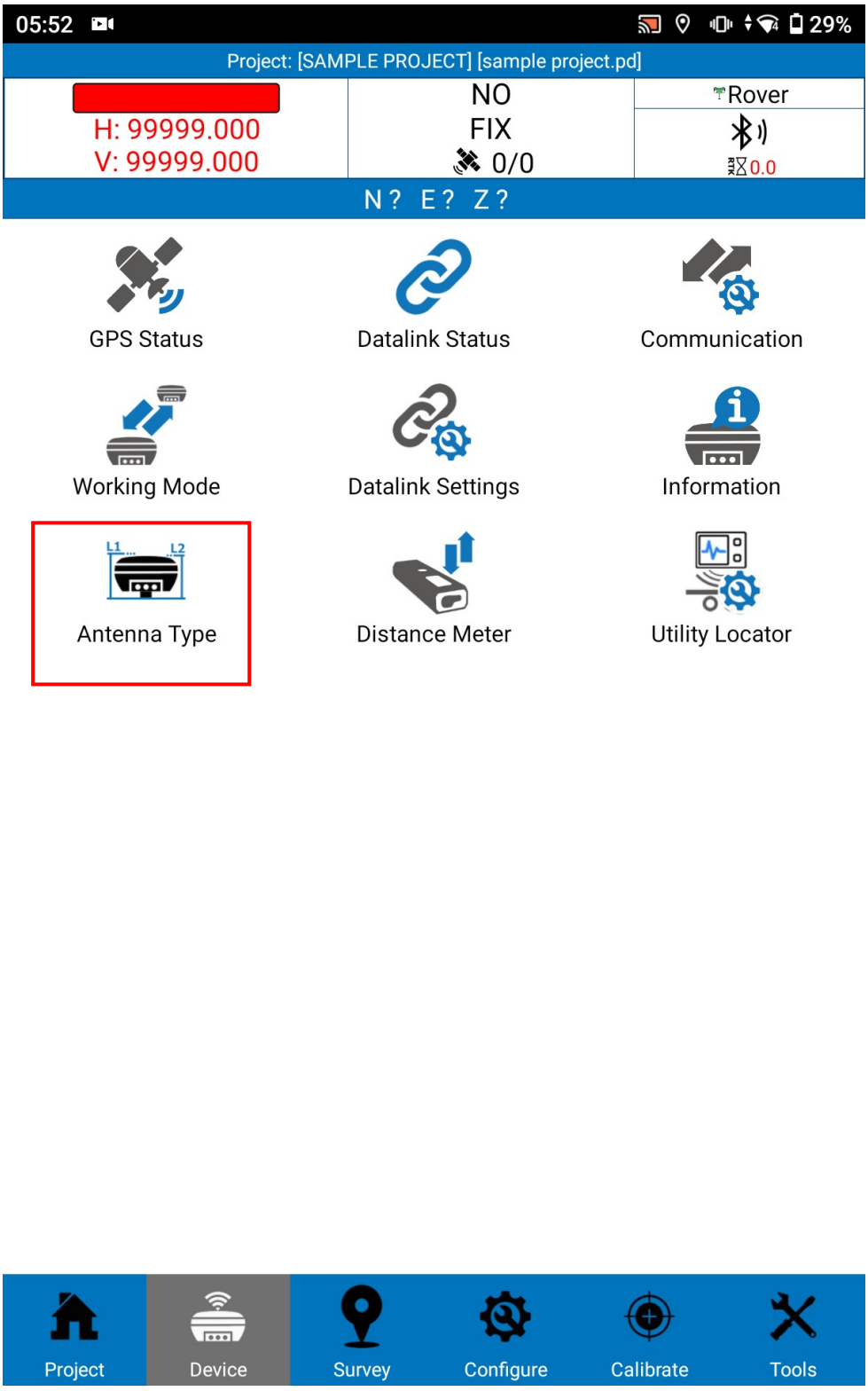


Figure 55 -Setup the Antenna

Step 20

Then, select the antenna type as "S70G on a tablet." The other option is "on pole," but for this study, since it connects to the tablet, select the "S70G on tablet" option

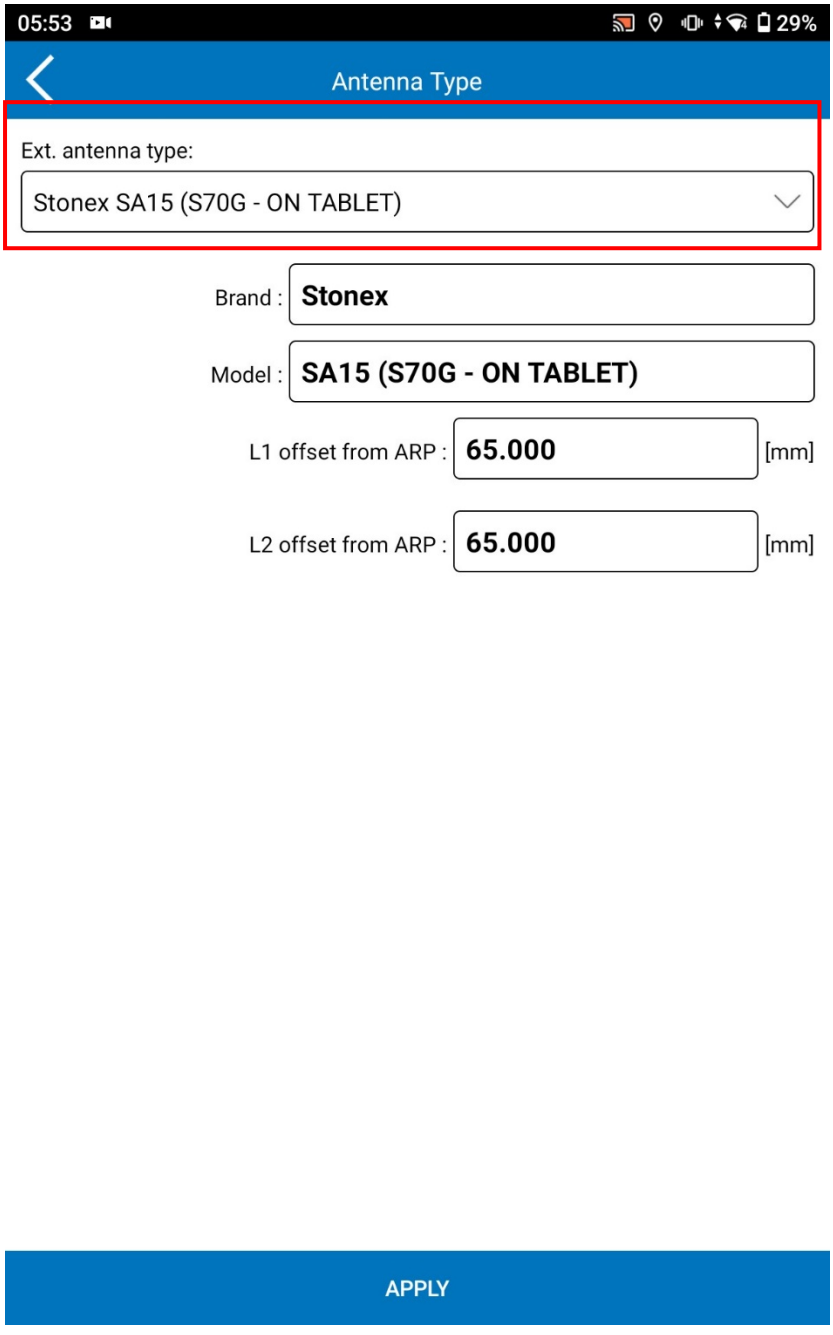


Figure 56 - Select the Antenna Type

Step 21

Then, go back to the main page

21.1 – Go to the “point” tab

21.2 -Select point Survey

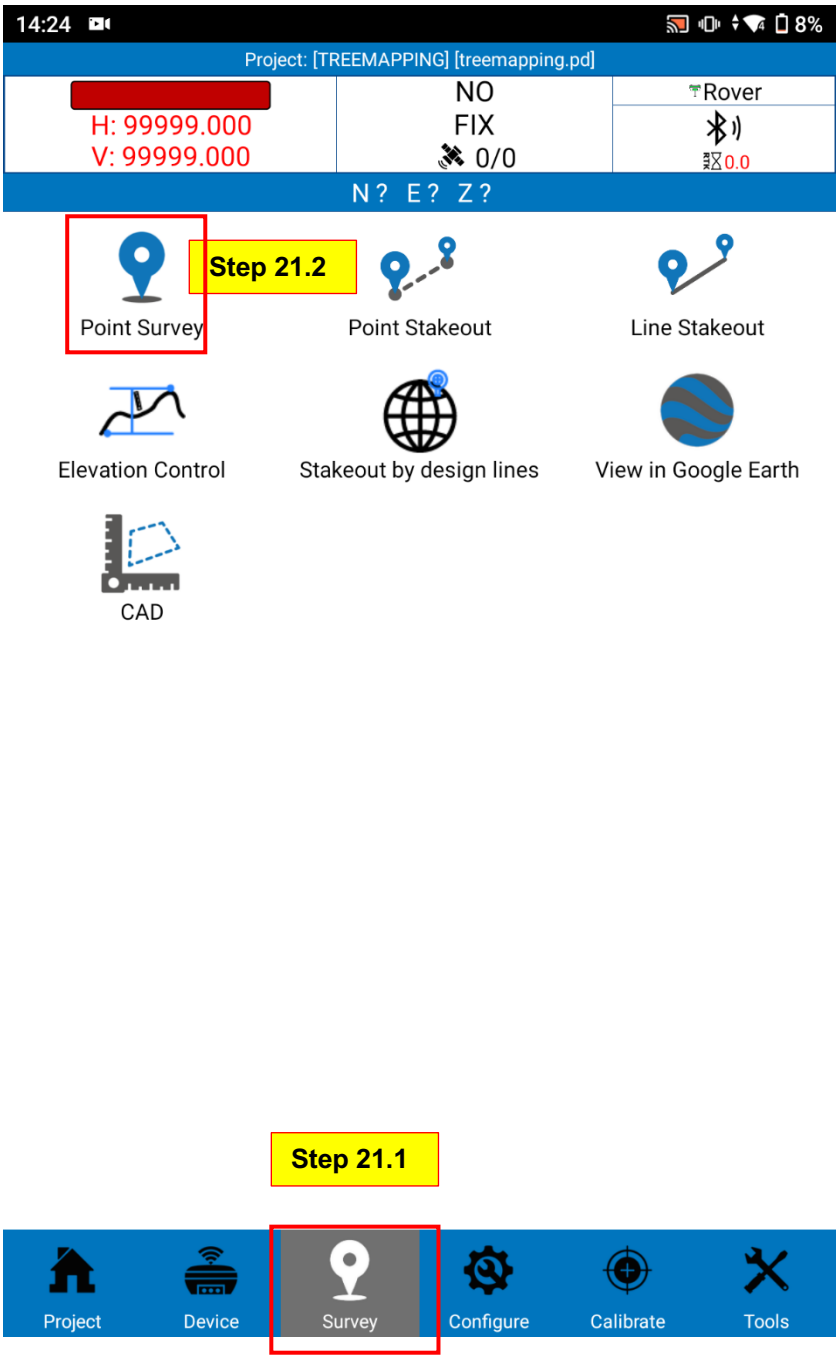


Figure 57 - Point Survey

Step 22

Then this interface will appear. Through the below icon, you can get the open street map

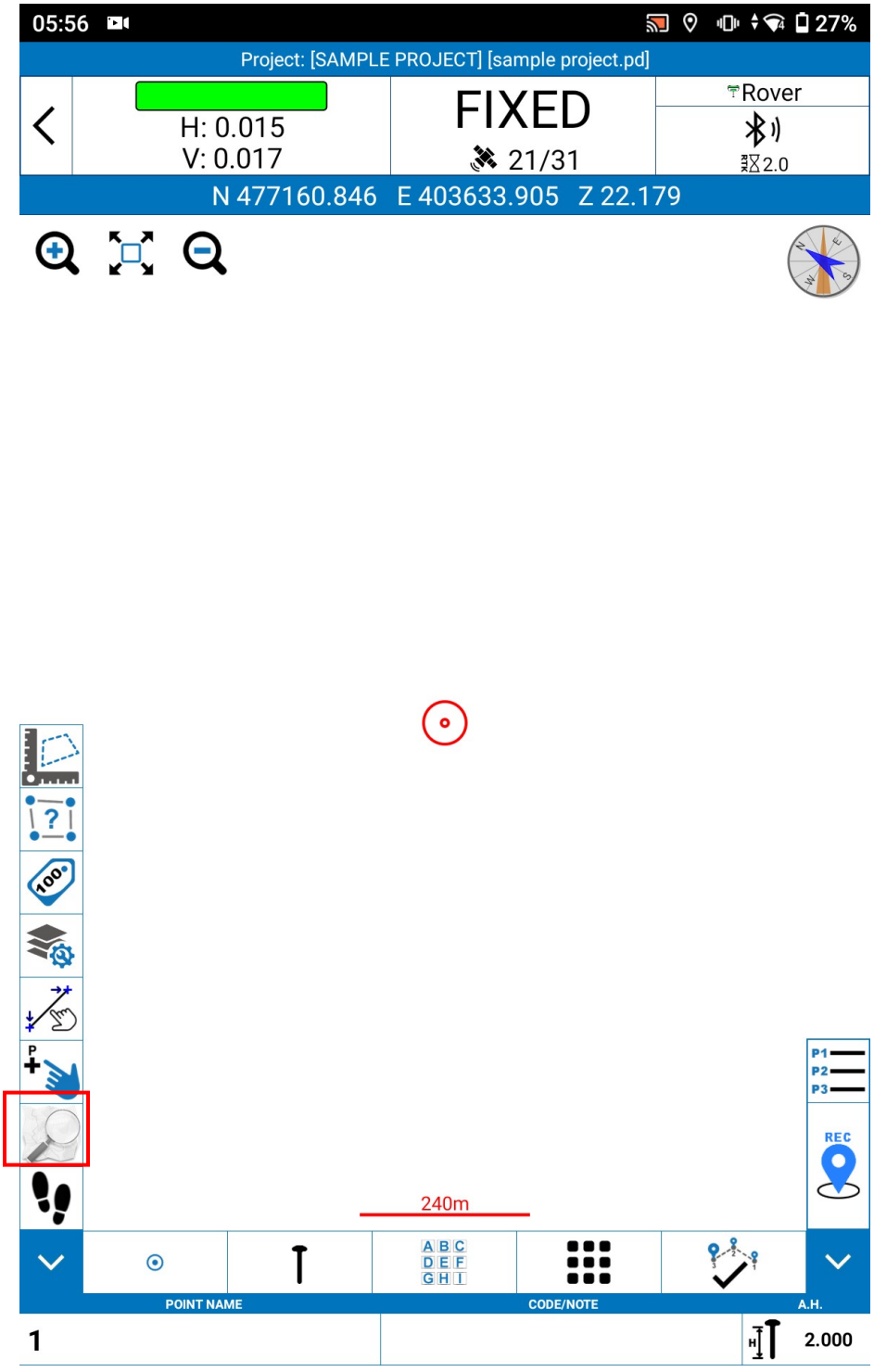


Figure 58 -Survey Map

Step 22

Click “Topo Point”

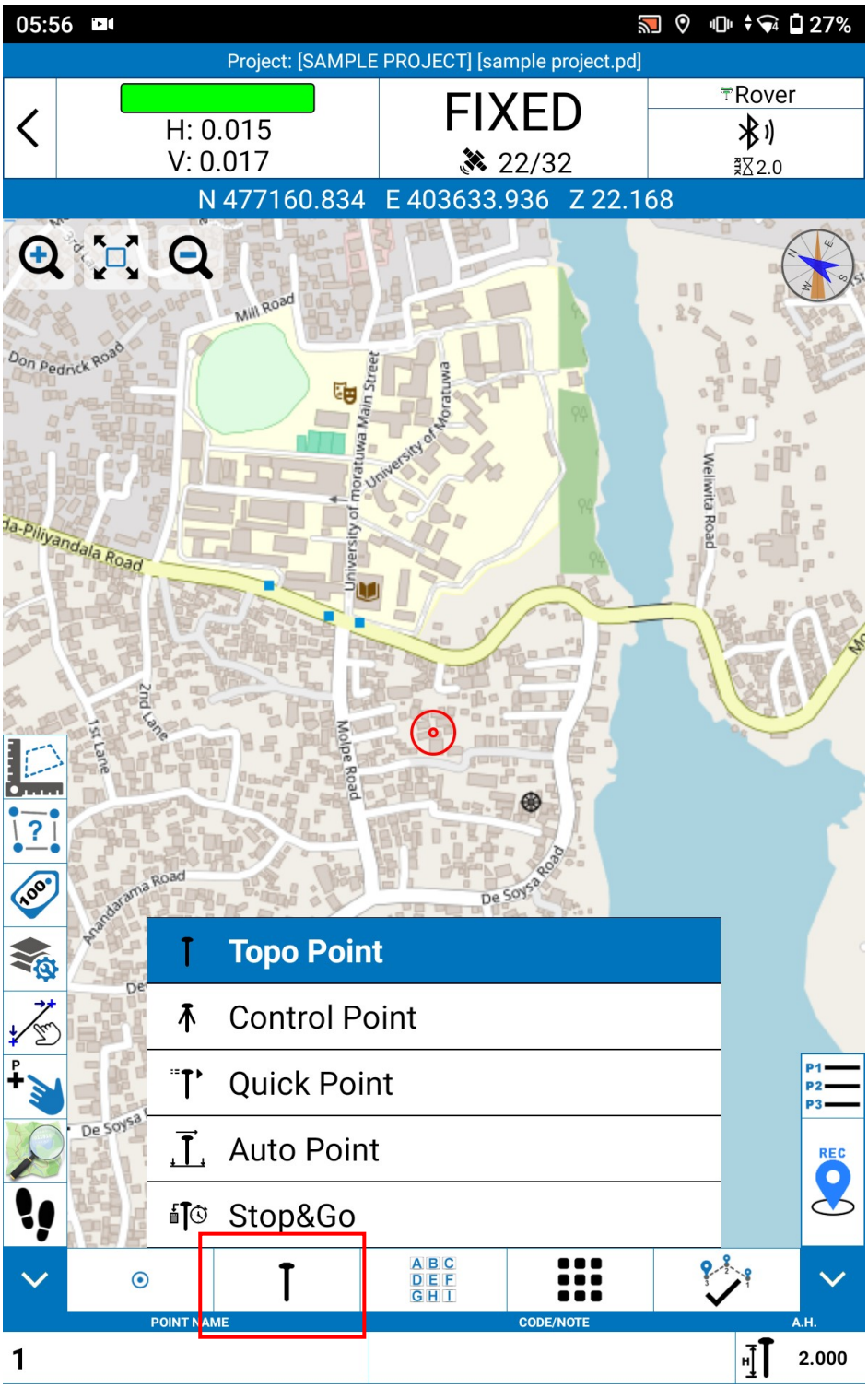


Figure 59 -Topo Point

Step 23:
Then you will be directed to the "Topo Point Settings."

- Solution Limit: Set it to "Fixed."
- HRMS Setting: Set this according to your preference. This setting determines the accuracy level for data collection. Data will only be collected if it meets the specified accuracy level.
- If you do not need high accuracy, you can set the Solution Limit to "Float," or if you do not want to enforce any accuracy requirements, tick the "Ignore this quality check" option.
- Select save

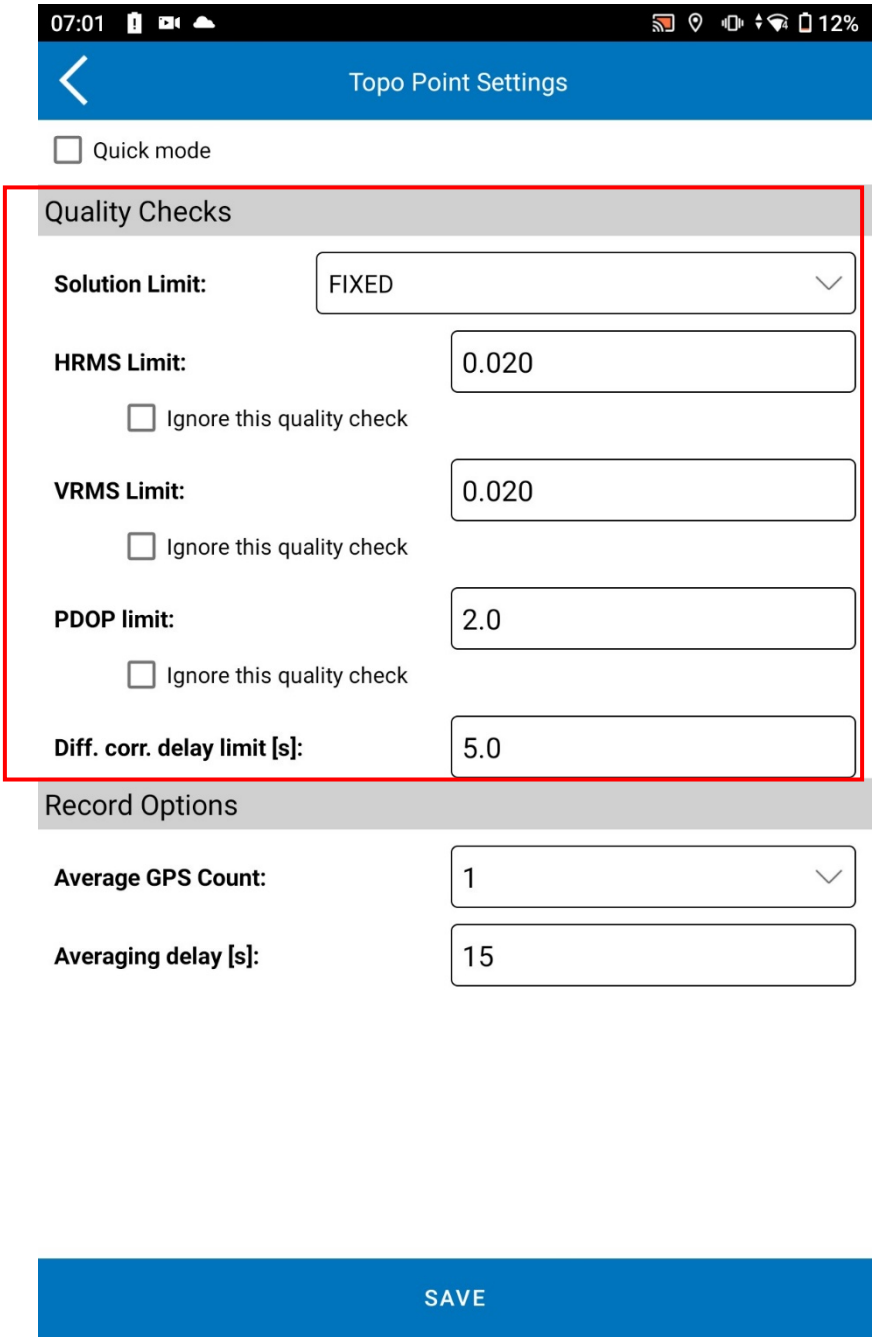


Figure 60 - Quality Check

Step 24

Then you will be directed to this page and select the below icons.

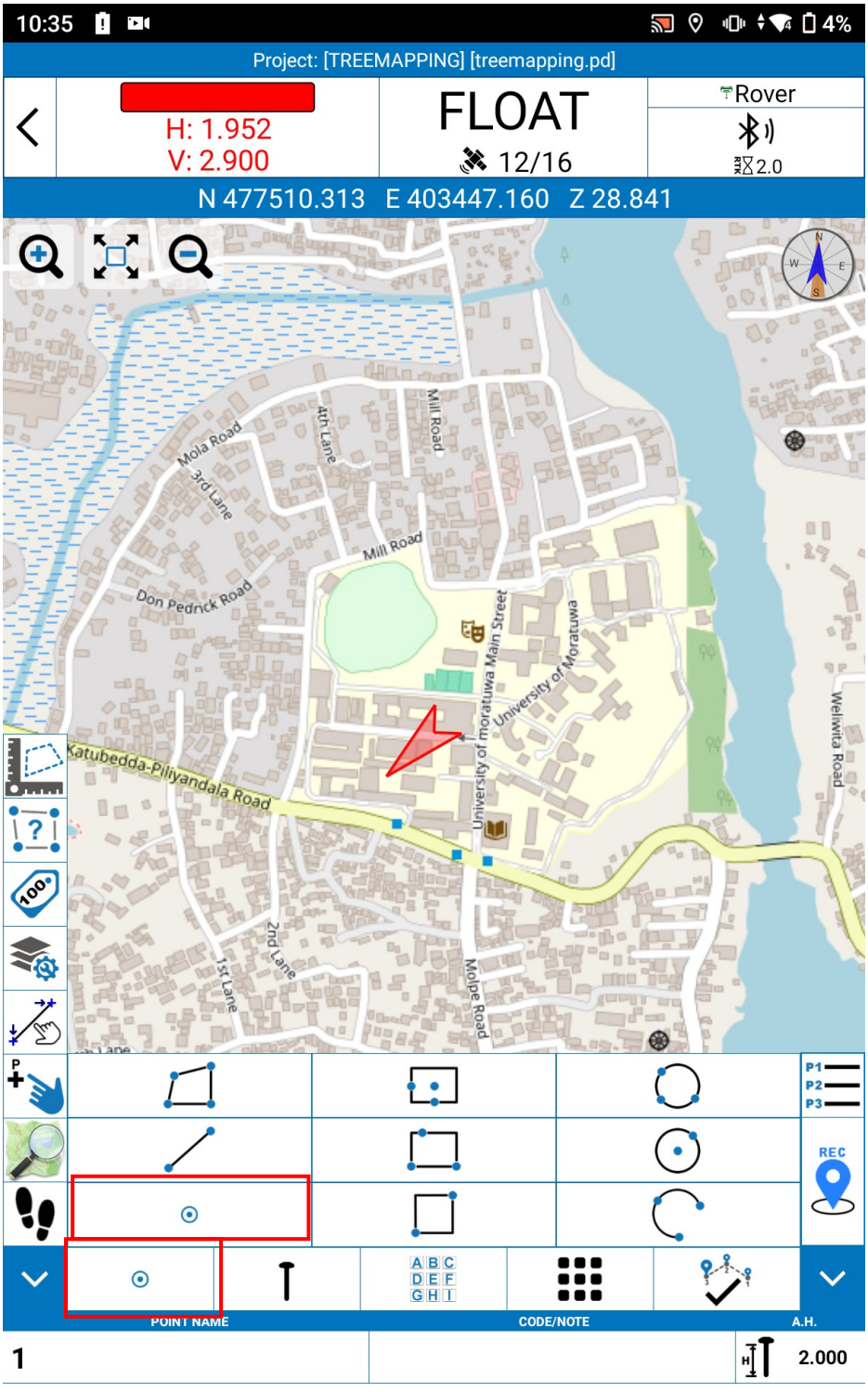


Figure 61 -Map Page

Step 25
Then, click on the icon below to start collecting data. While collecting data, ensure that the "H & V" indicators are green, indicating high accuracy.

Figure 62 -Get the point

Step 26:

Then select ok

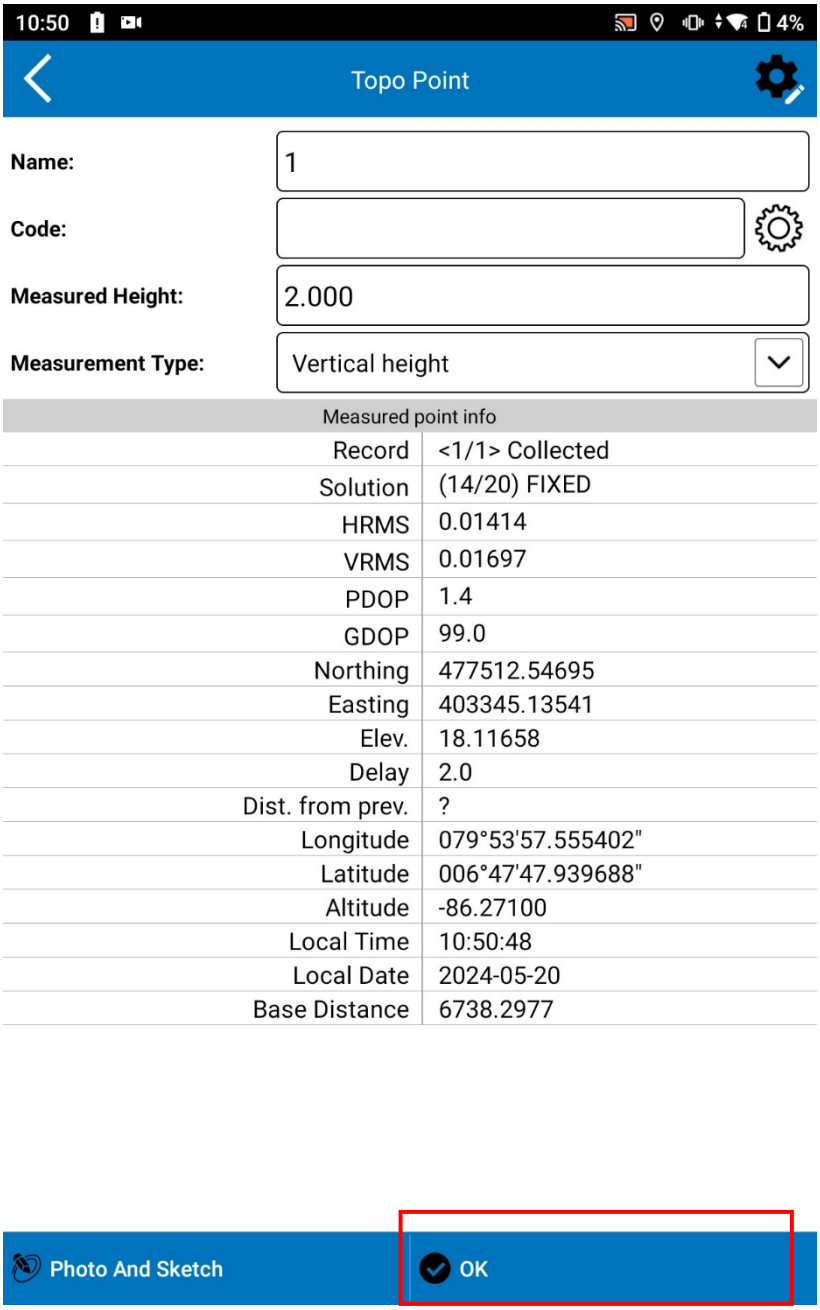


Figure 63 - Save the Point

Step 27
Similarly, you can collect the data. For this project, we conducted a survey on trees at the University of Moratuwa.
Click on the below icon to see the collected data.

Figure 64- Collected Point

This is the point Library

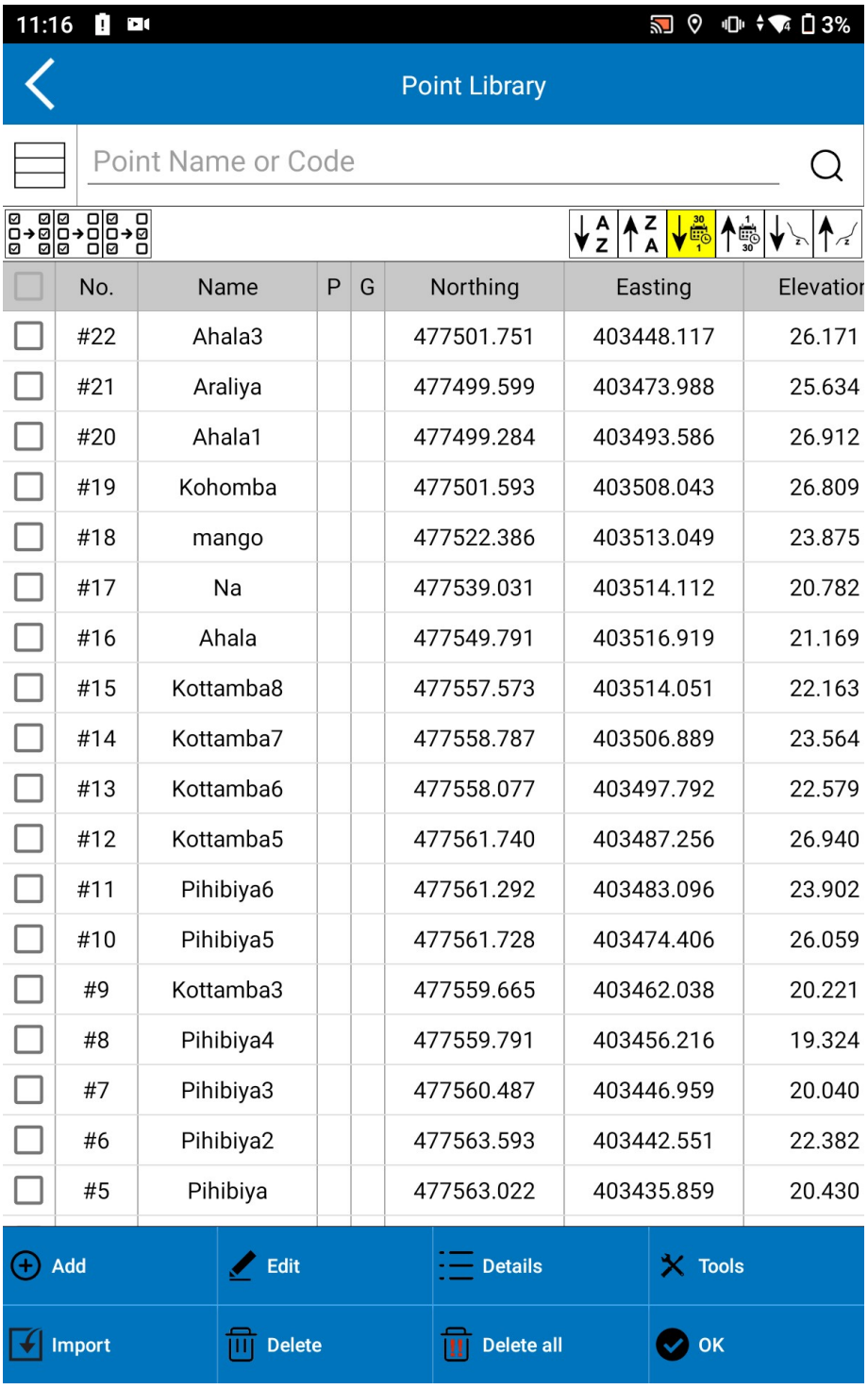


Figure 65 - Point Library

Step 28

Again, go to the main Project tab and click on the export icon to export the data.

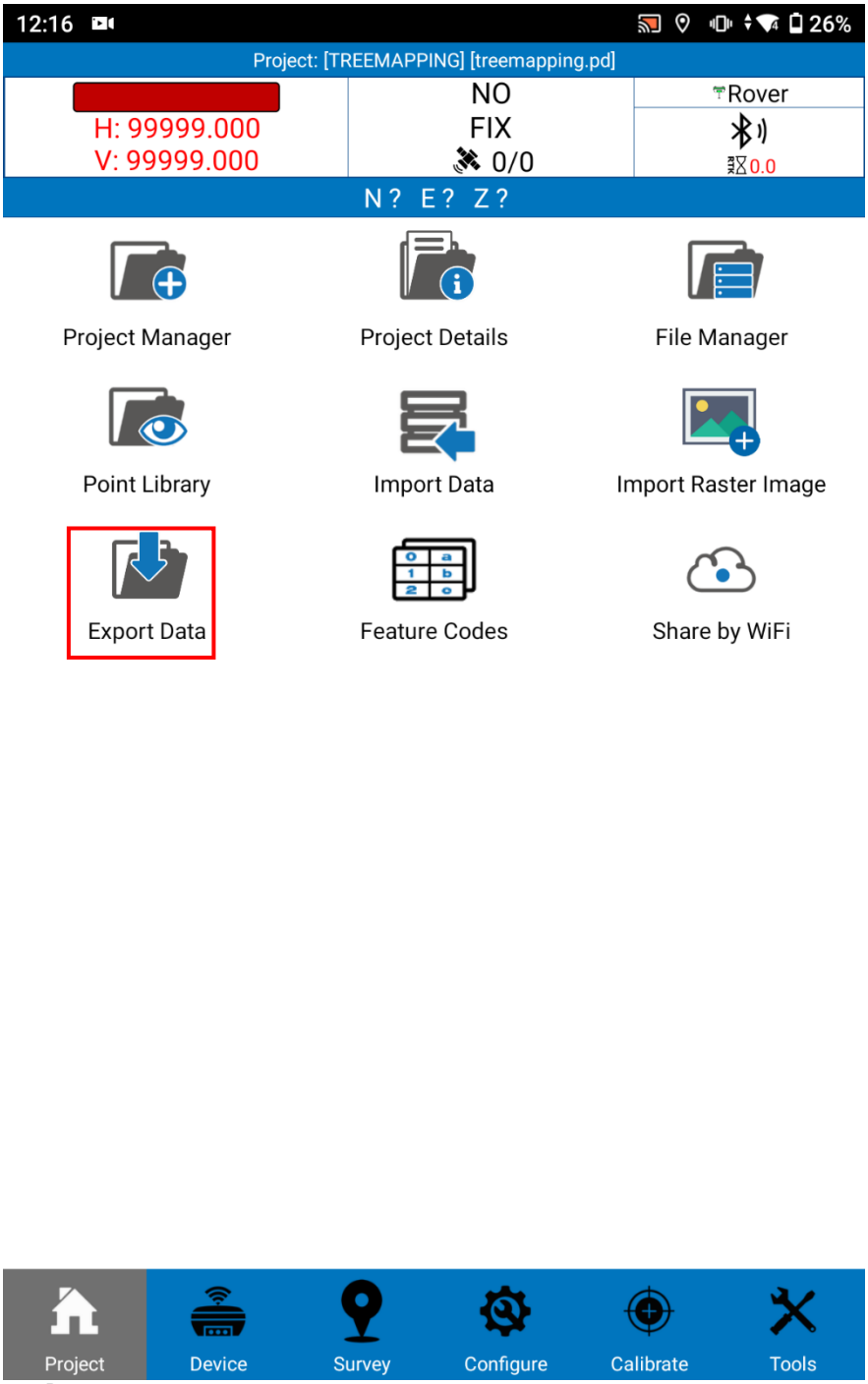


Figure 66 - Export Data

Step 28

28.1 **-**Tick the "Share after exporting" option, which will allow you to share the data through different platforms. If not, the file will only be saved to the device.
28.2 -Then, select "Export.

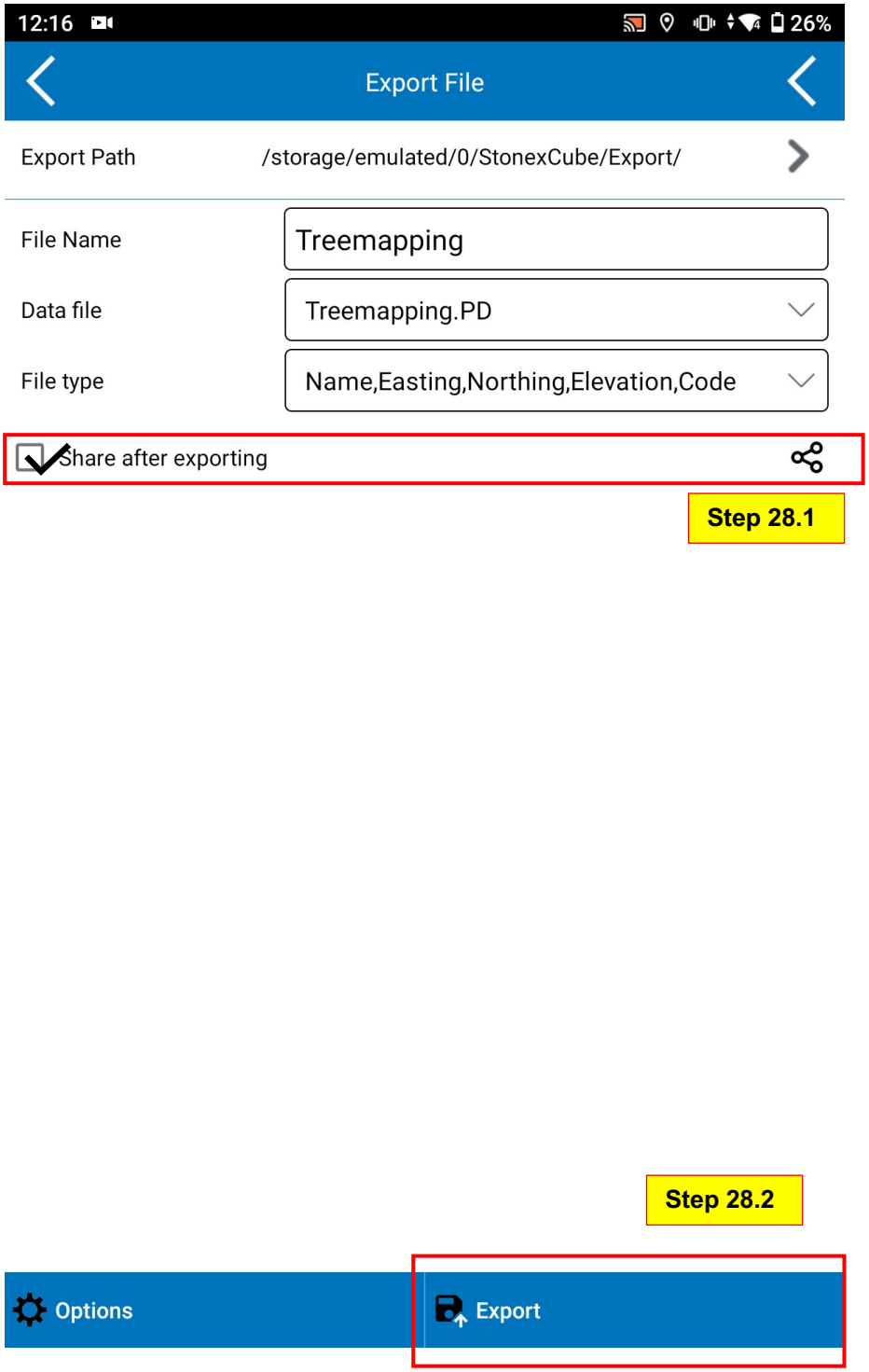


Figure 67 -Click Export

Step 29

Select the Export Type

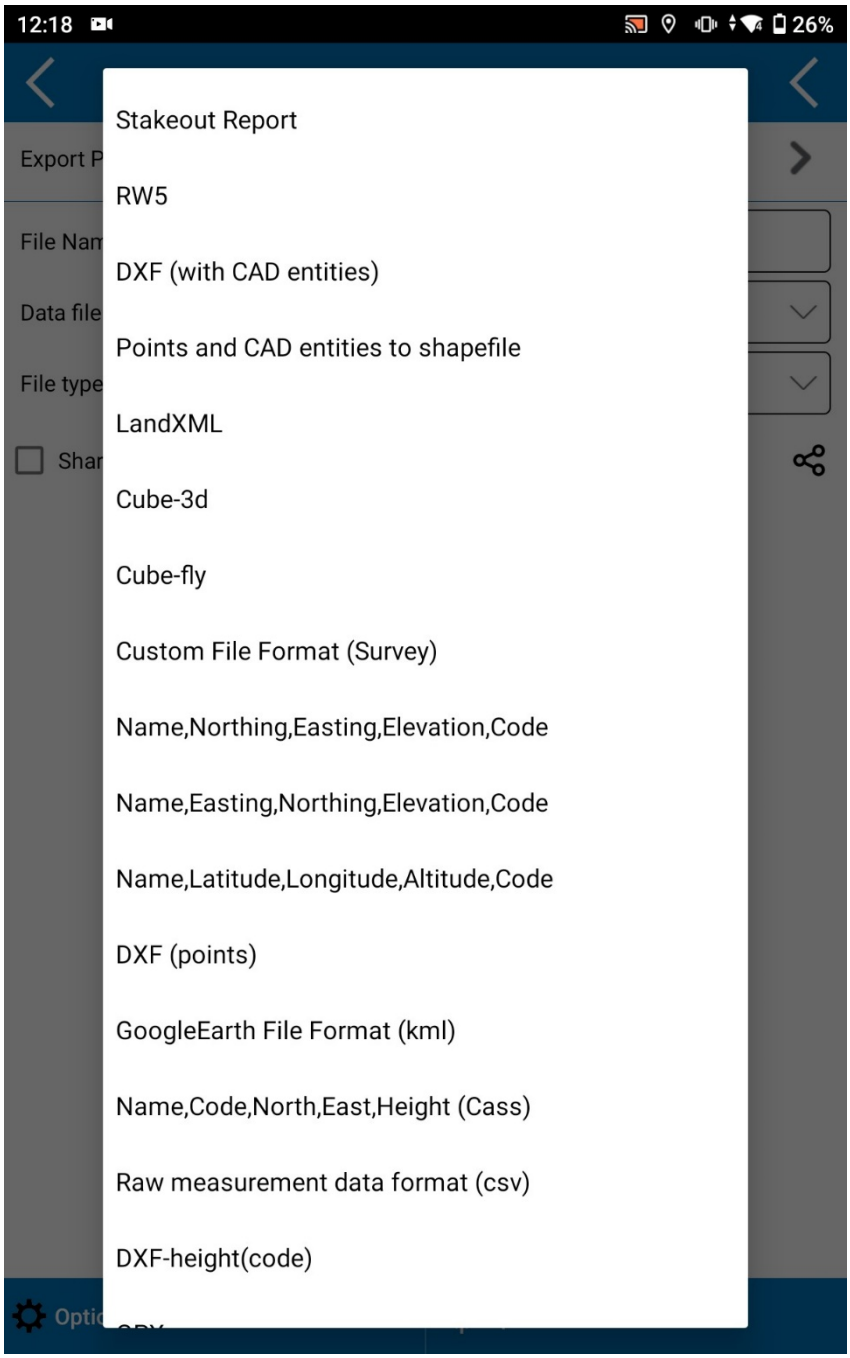


Figure 68 - Export Formats

Step 30
Click Ok

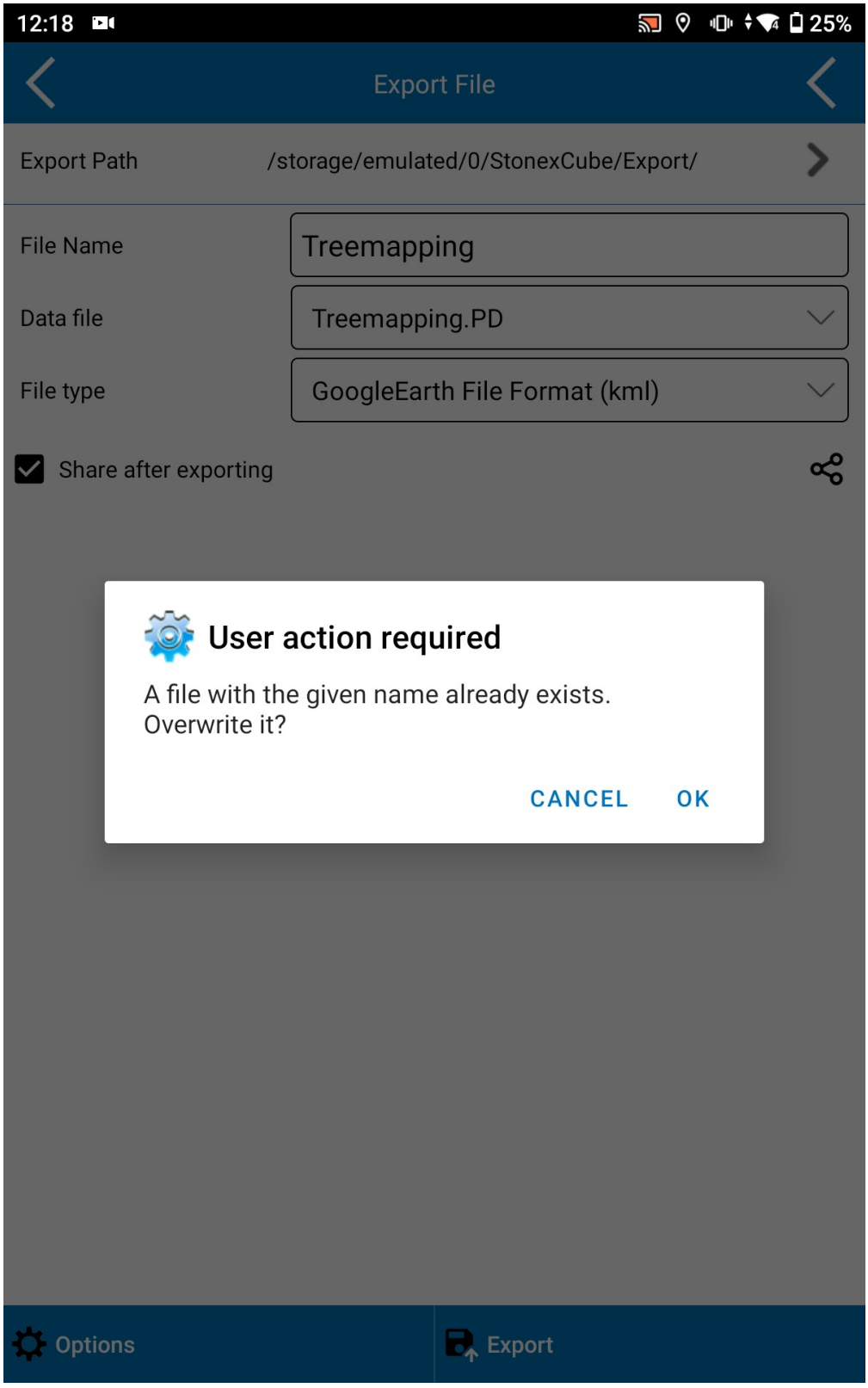


Figure 69 -User Action

Step 31
Share through any platform

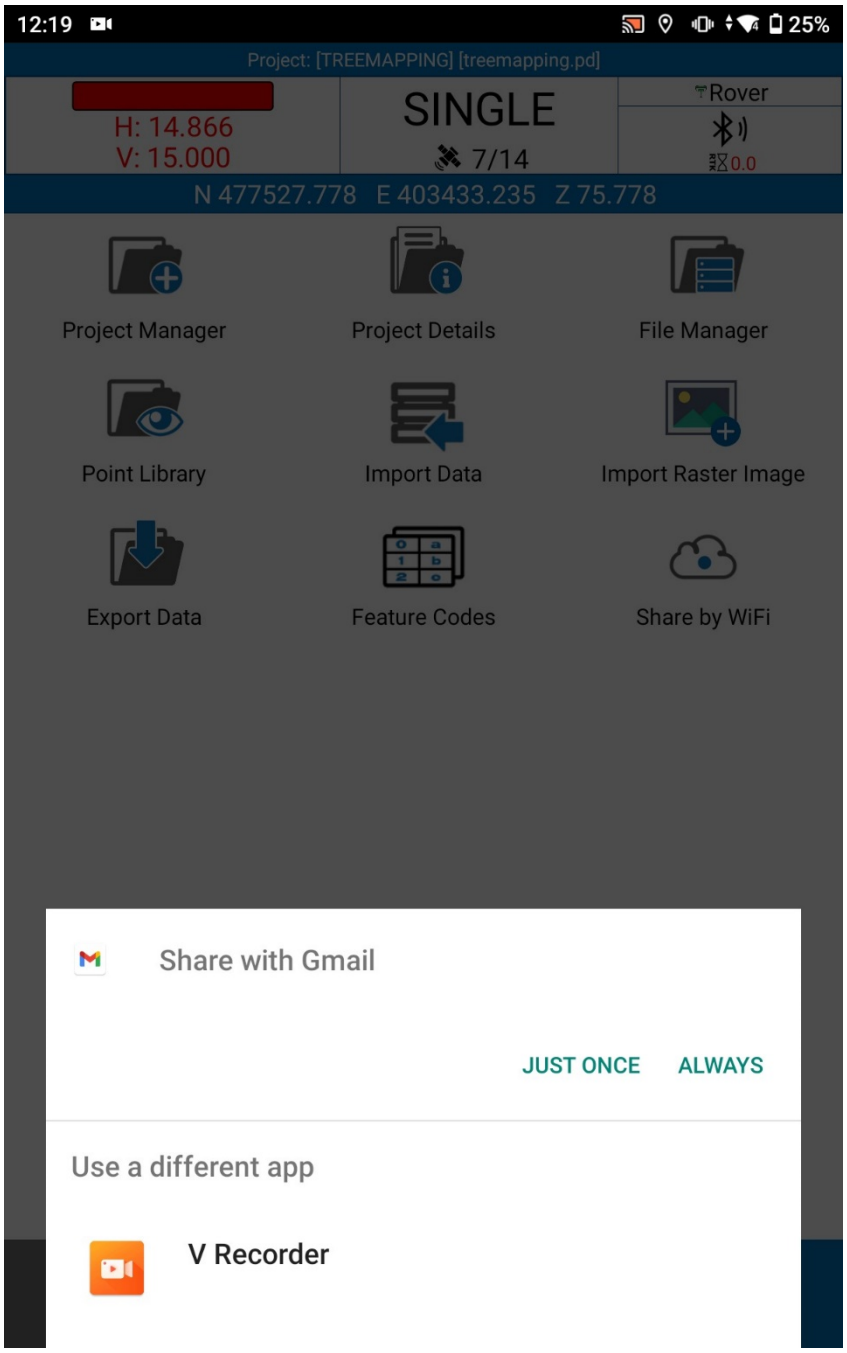


Figure 70 -Share

4.4.3.S70 Data Collection

Step 01

Click on the below icon (Cube a v6) to start.

Figure 71 -Cube a v6

Step 02
2.1 - Go to the Project tab.

2.2- Click on Project Manager to create a new file

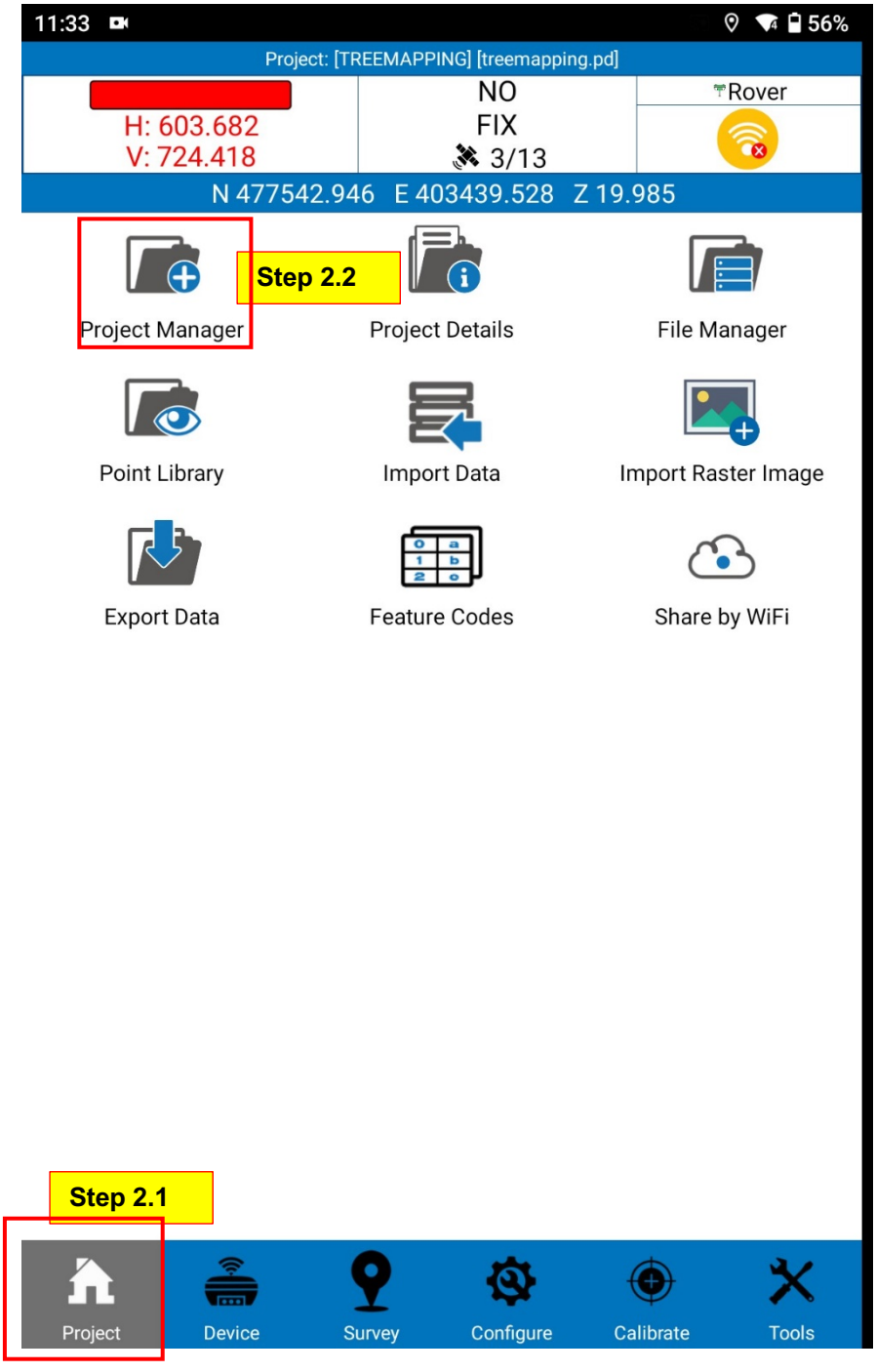


Figure 72 -Project Manager

Step 03

Then you will get the below interface and then go to the “New”

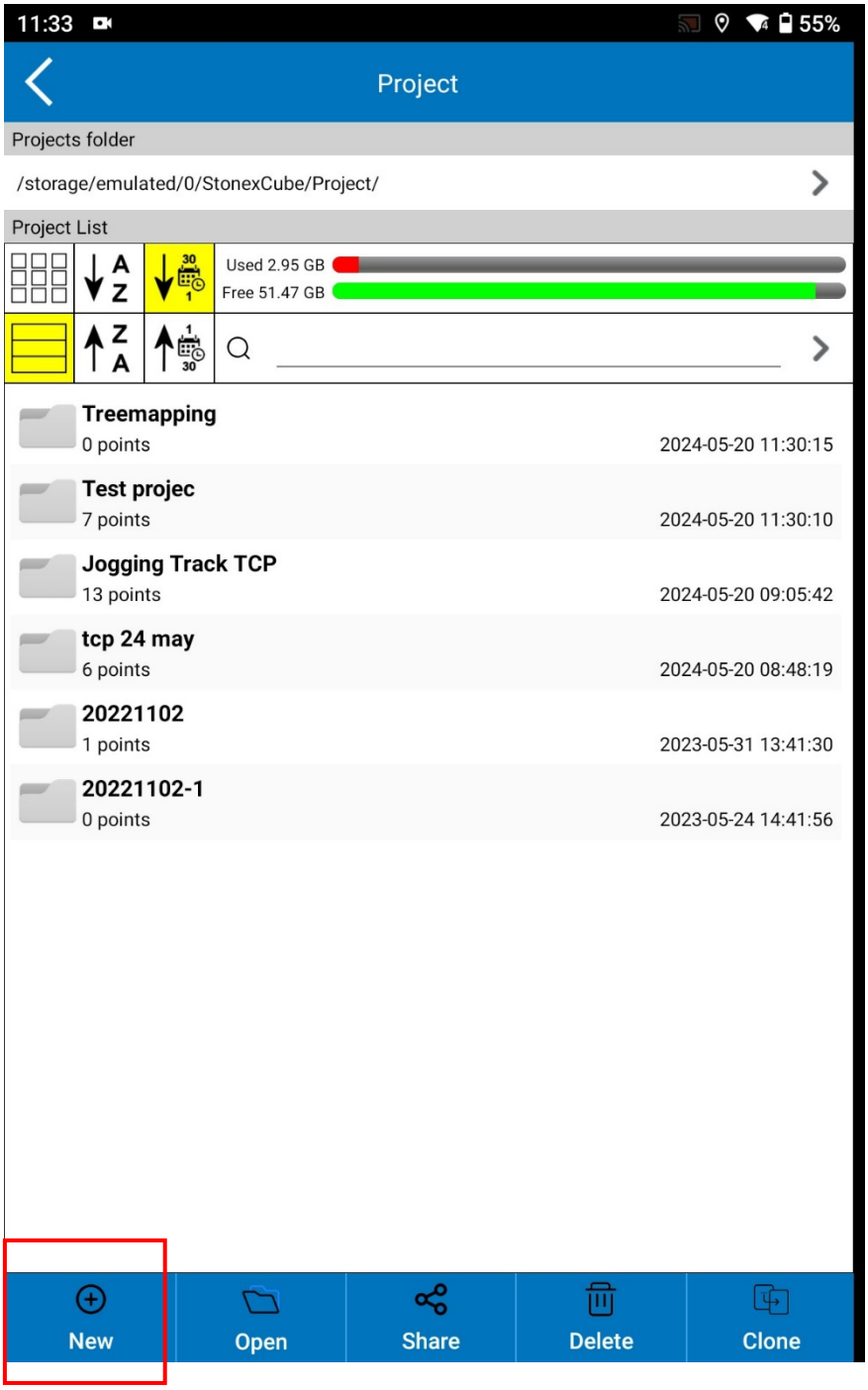


Figure 73 -Create New File

Step 04

Then give the project name as per the study.

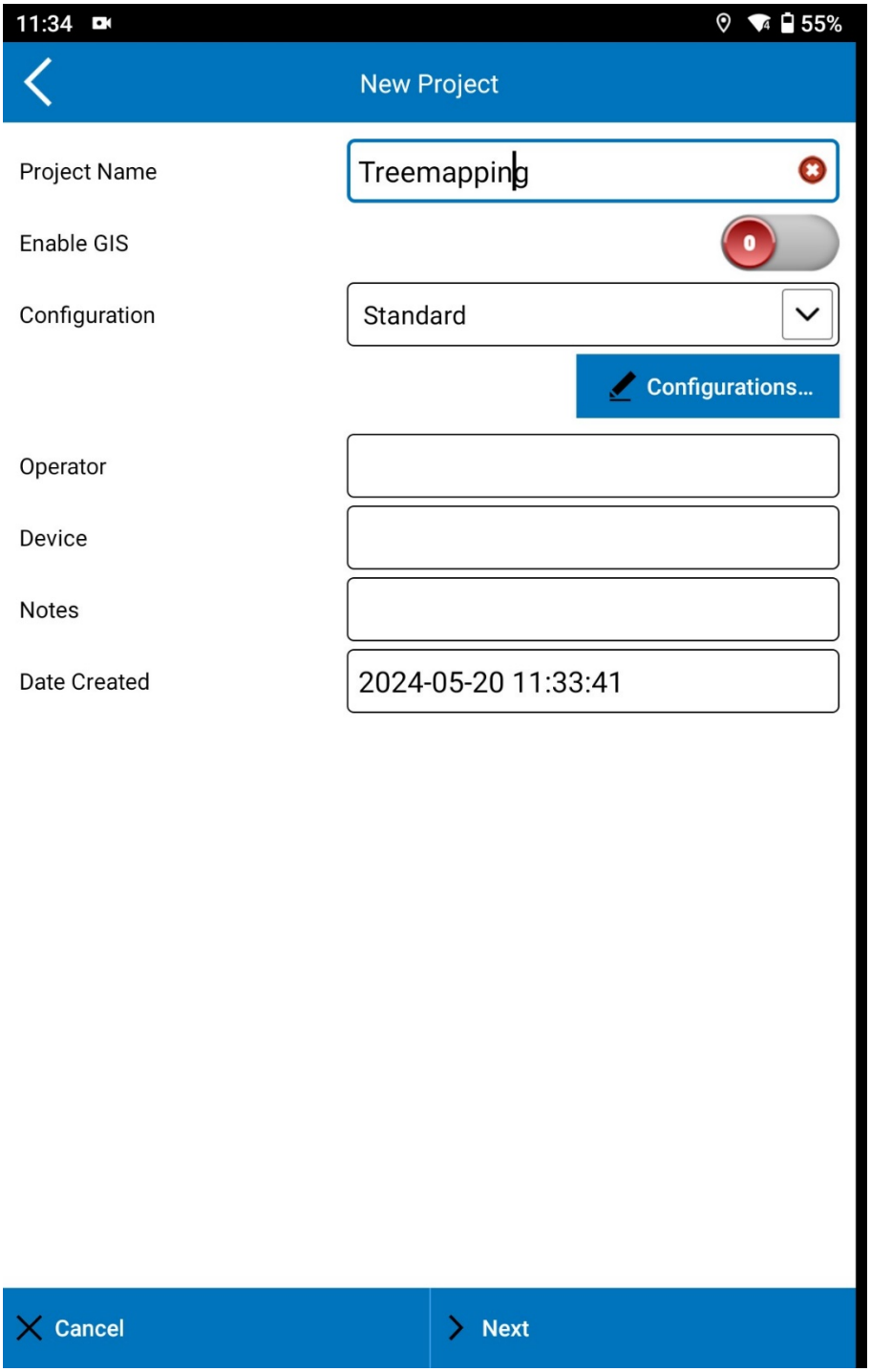


Figure 74 --Create Project

Step 05

Here, compared to S70G, for S70, you need to enable the GIS option.

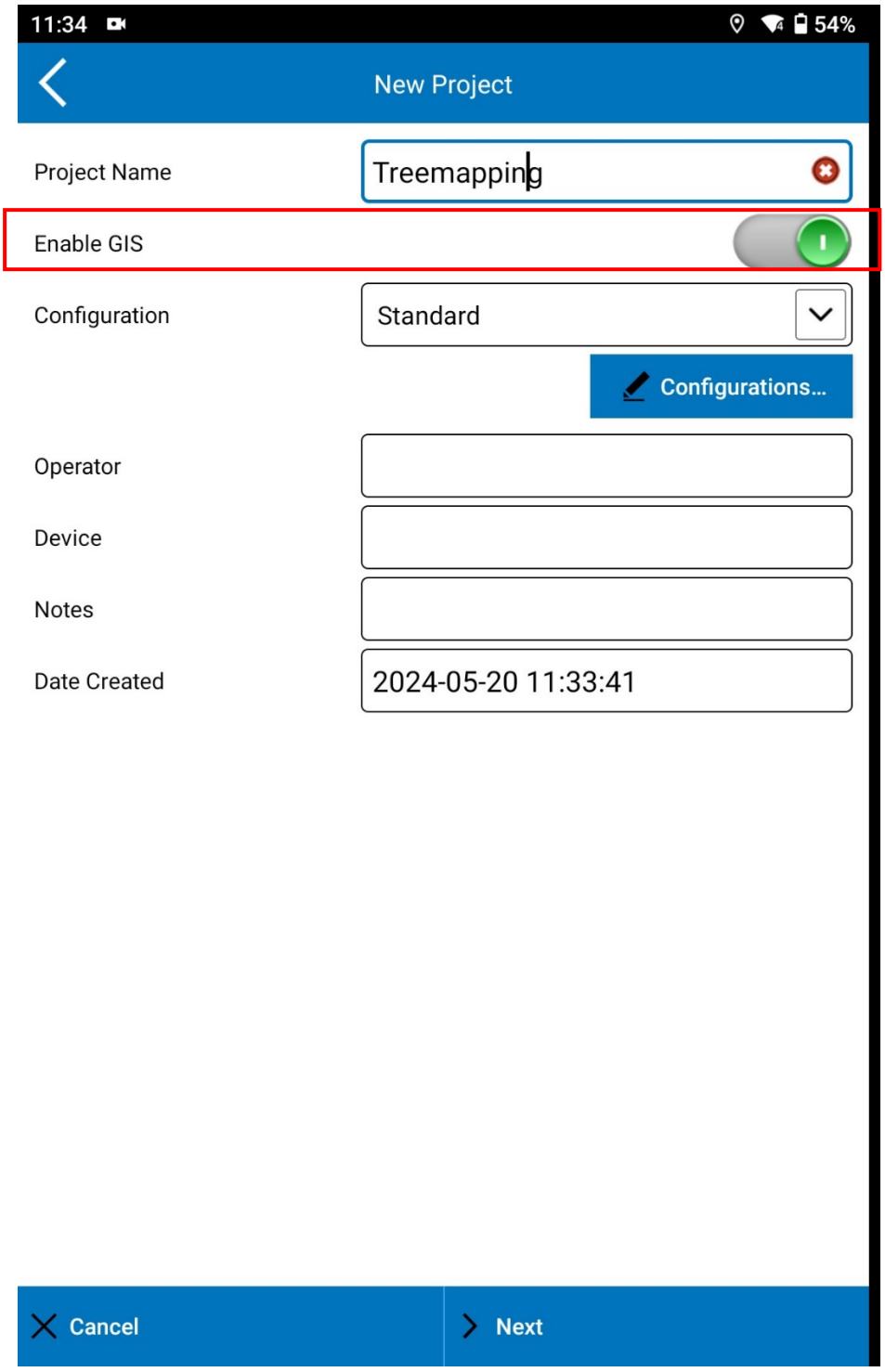


Figure 75 -Enable GIS

Step 06

Then you will get this interface and click on “ file”.

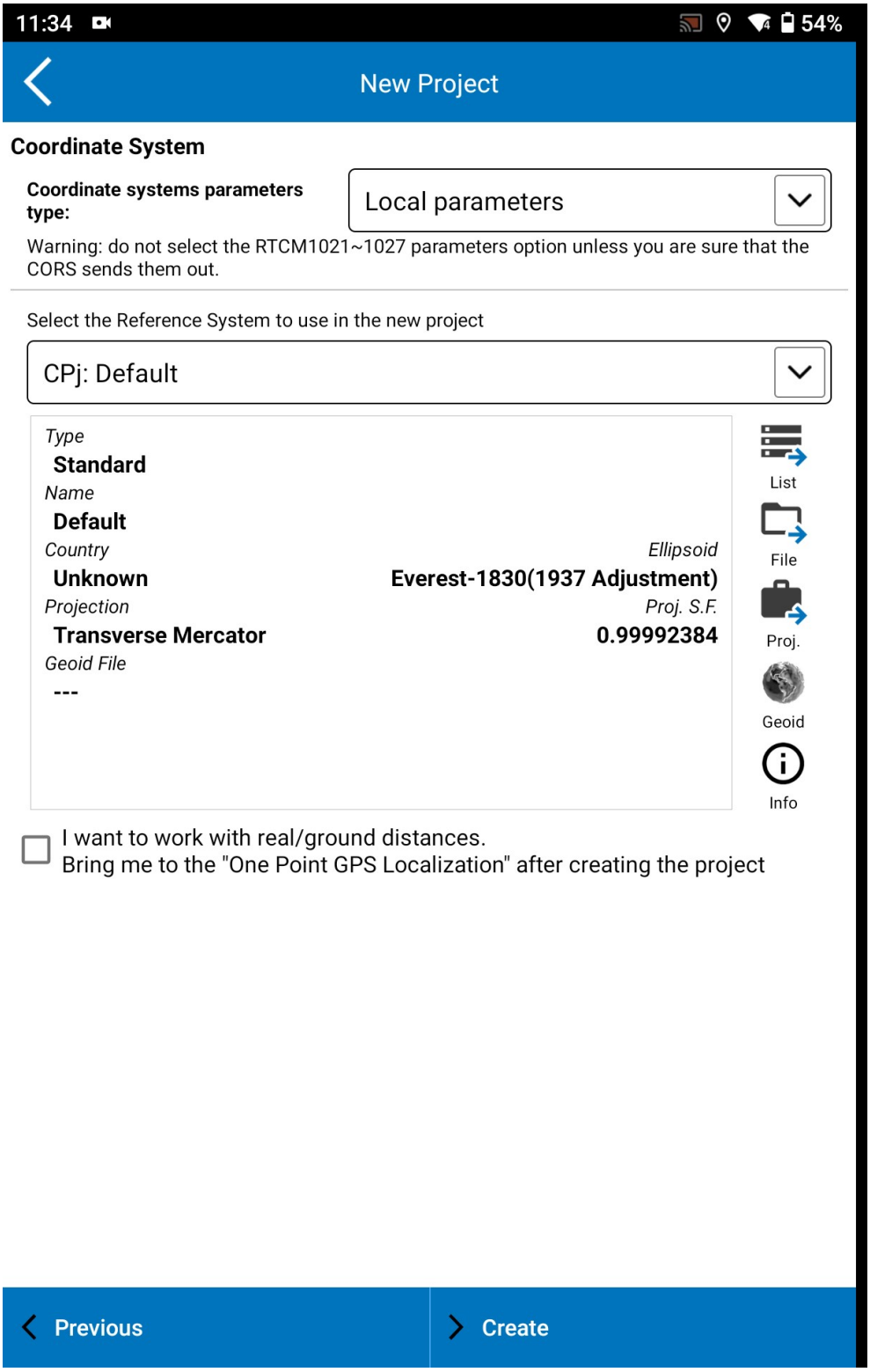


Figure 76 -Set Coordinates

Step 07

Then you will get this interface and in there click on "**Stonex cube**

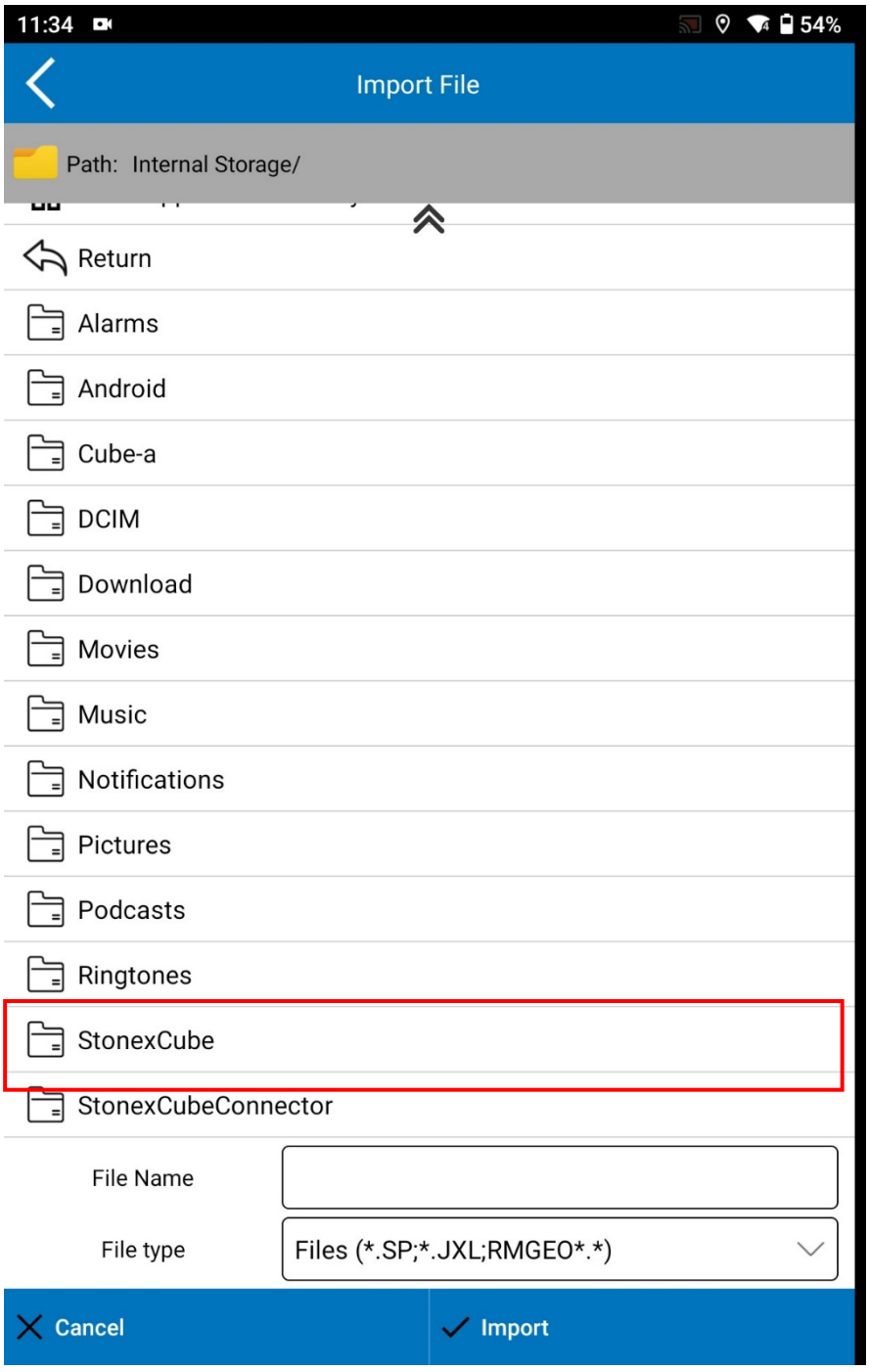


Figure 77 -Stonex Cube

Step 08

Click on the “Coordinate” to set the coordinate system

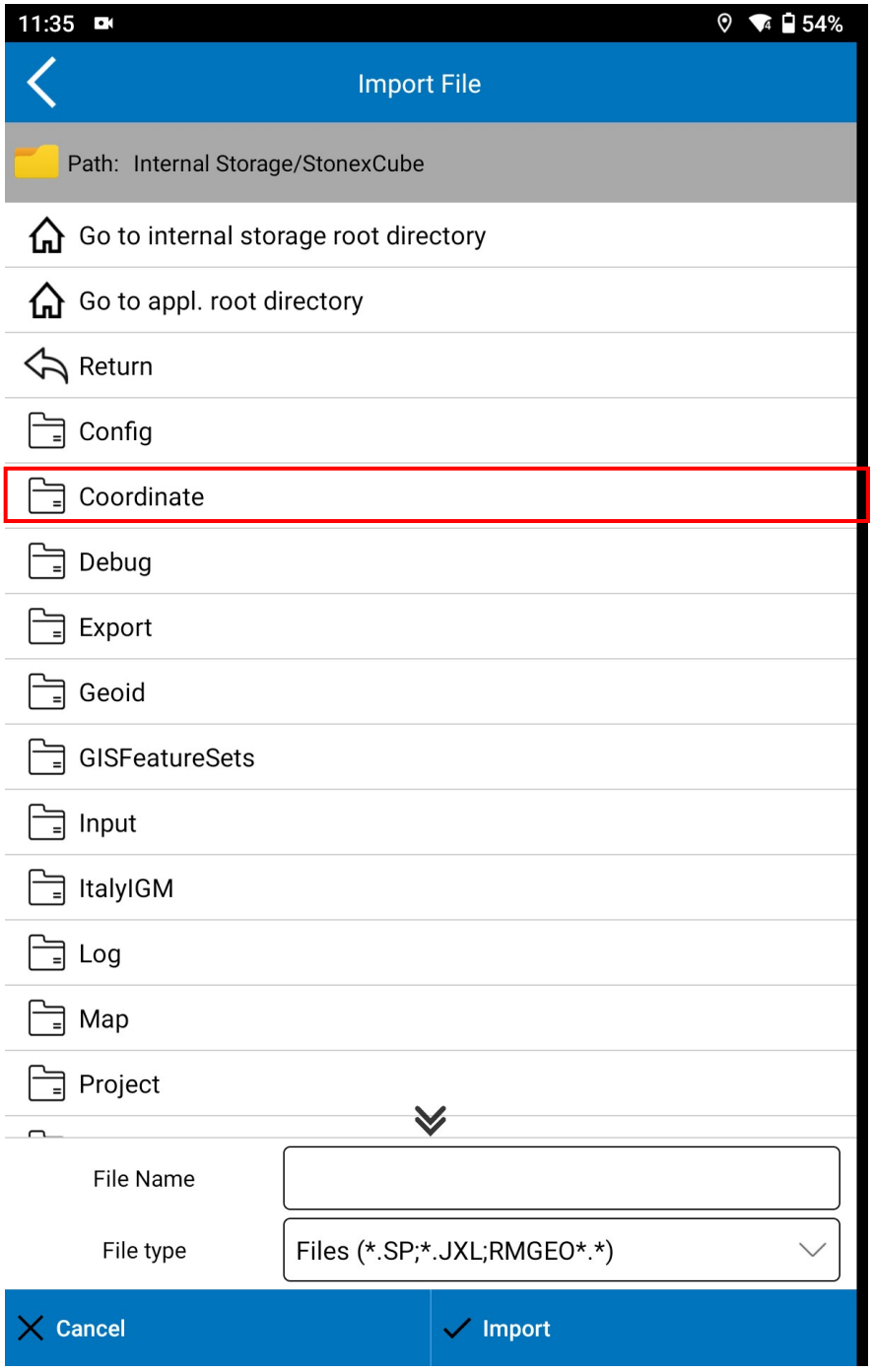


Figure 78 - Coordinate Systems

Step 09
Click on the Coordinate System and select the import

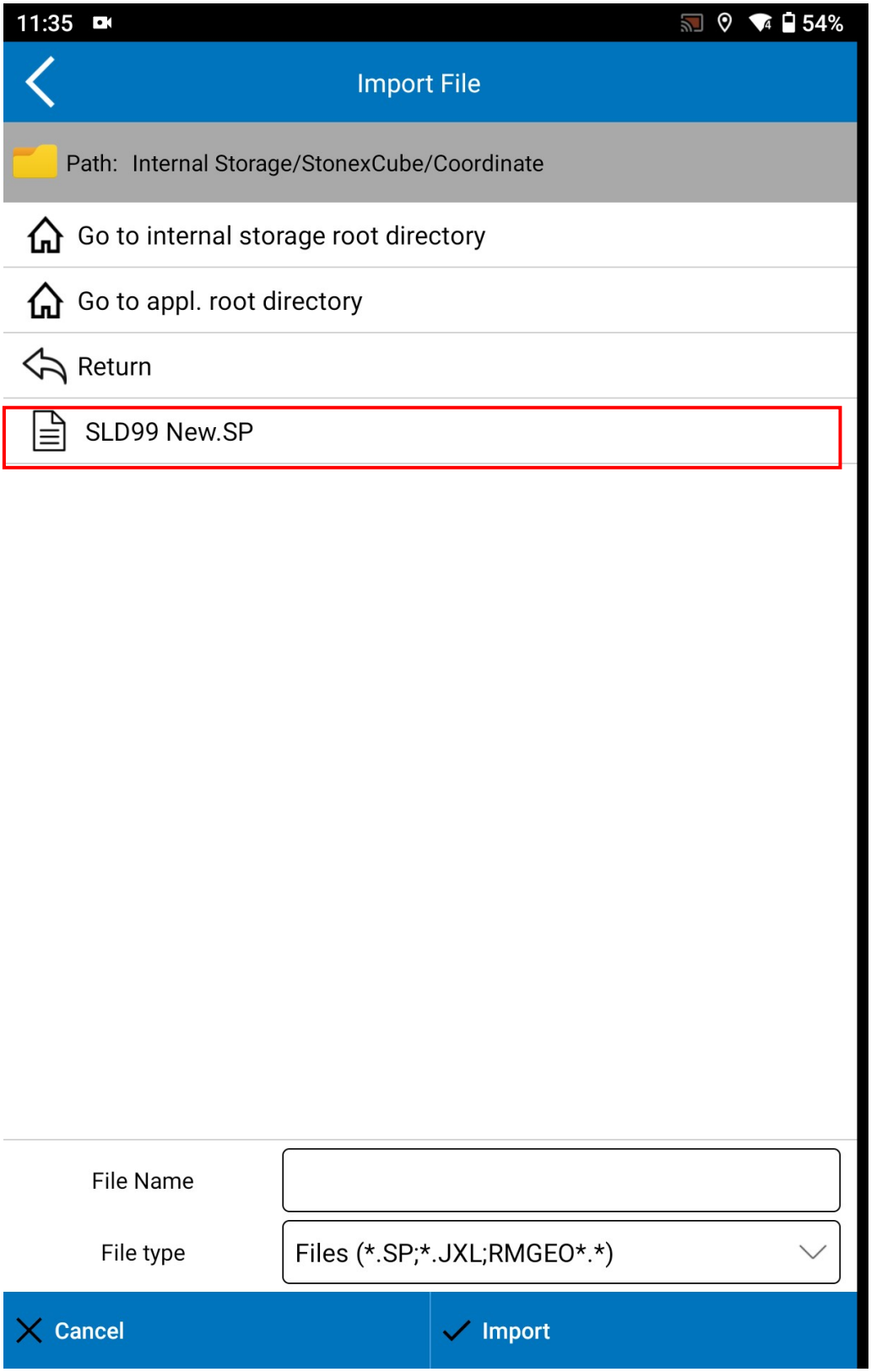


Figure 79 -Set the Coordinates

Step 10

Click on "Edit" and give a name for your study. Under "Tree Mapping," we are going to do Ahala tree mapping at the University of Moratuwa.

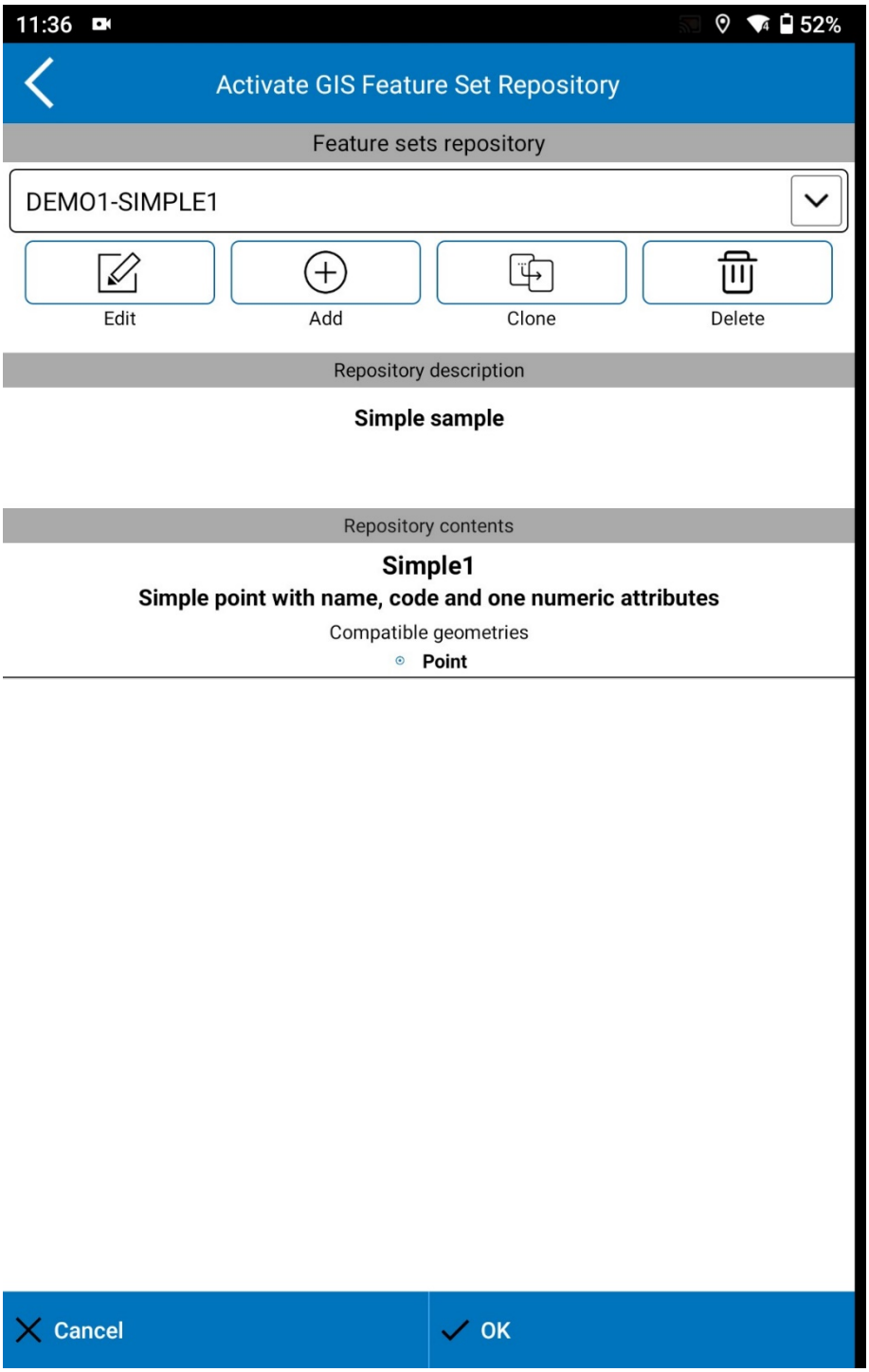


Figure 80 - Tree Mapping Sub-Category

Step 11

Give the name

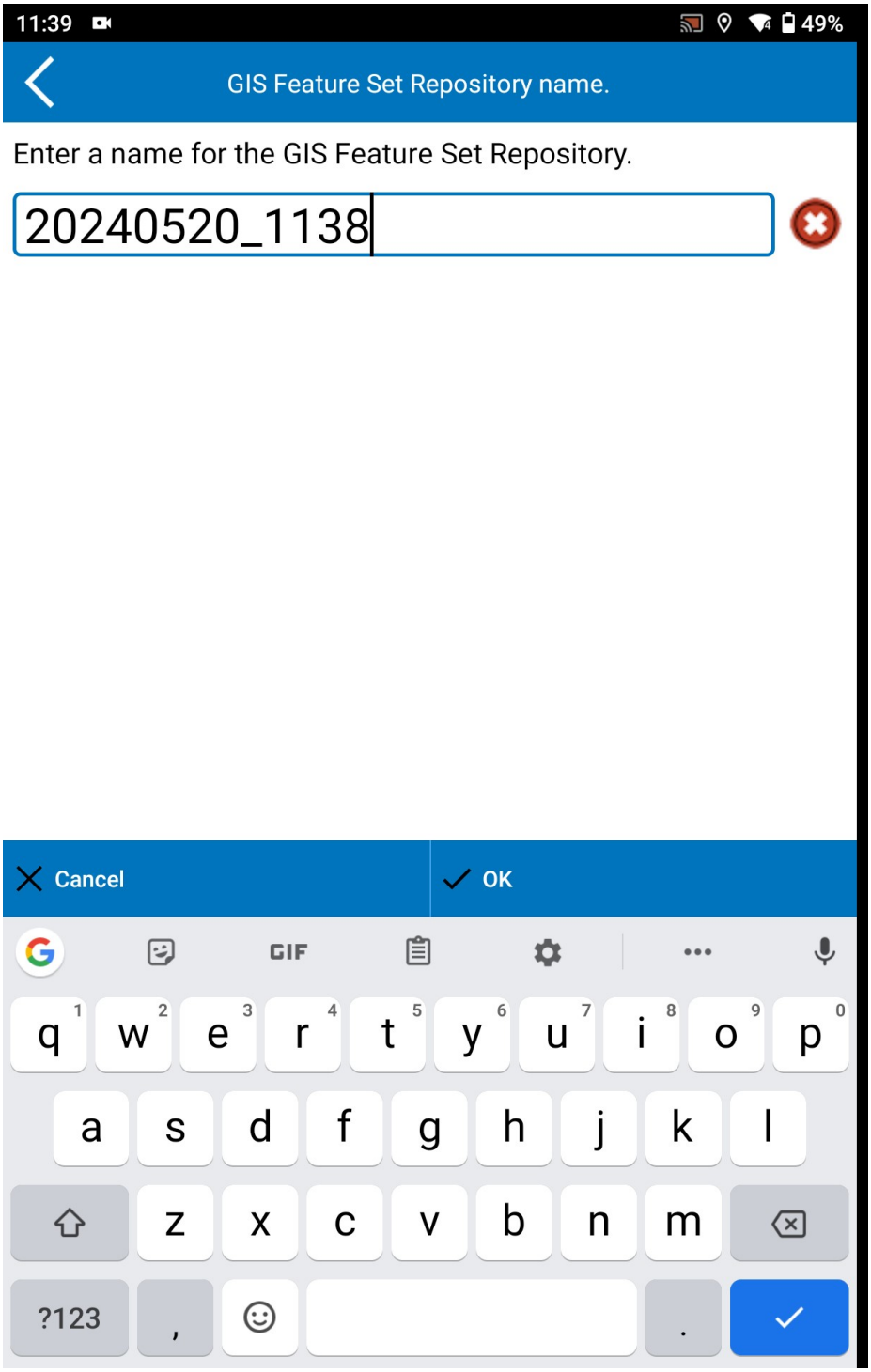


Figure 81 -Naming

Then it will appear as below figures:

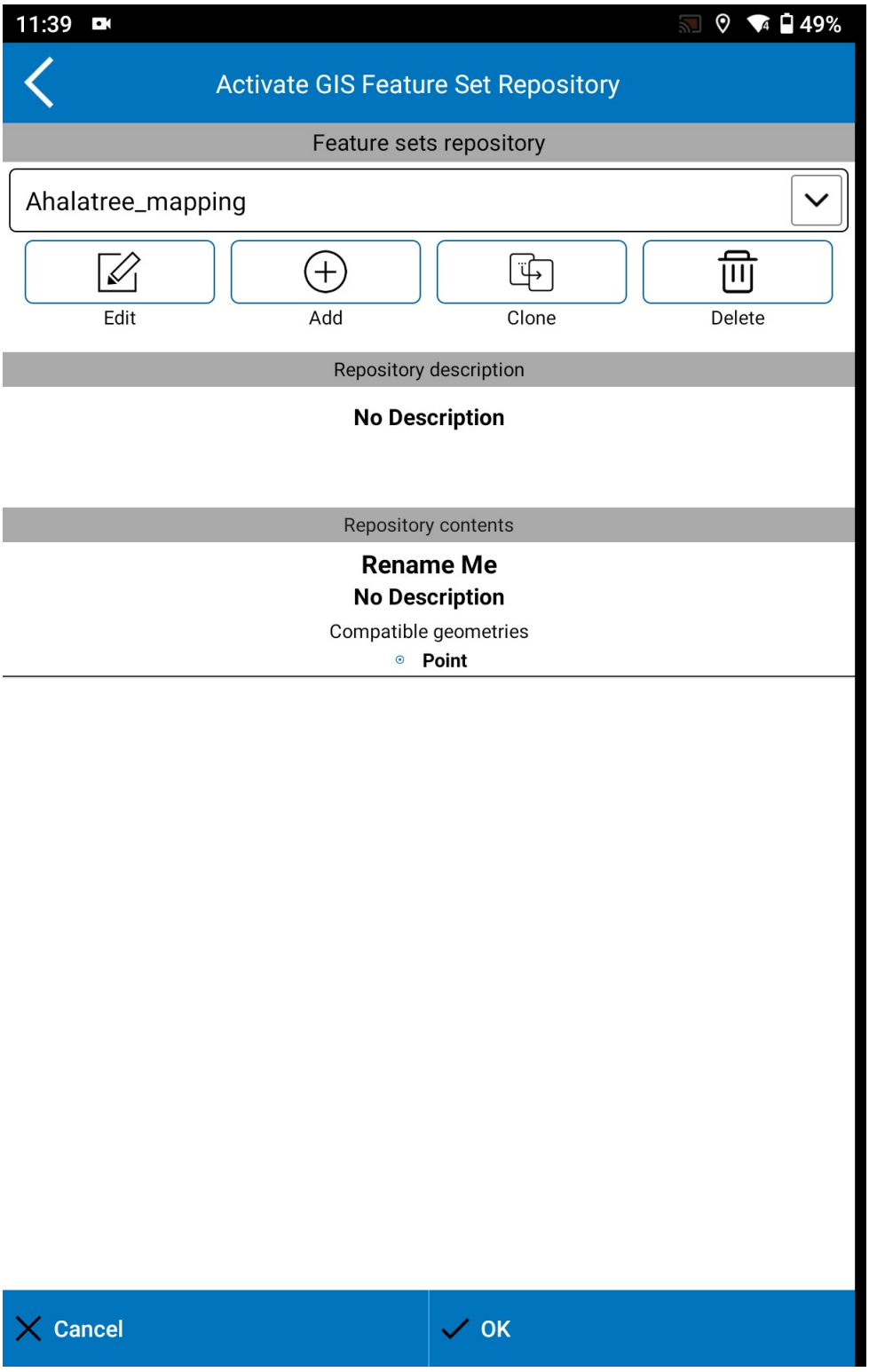


Figure 82 -Activate GIS Features

Step 12

Click on **"Edit"**

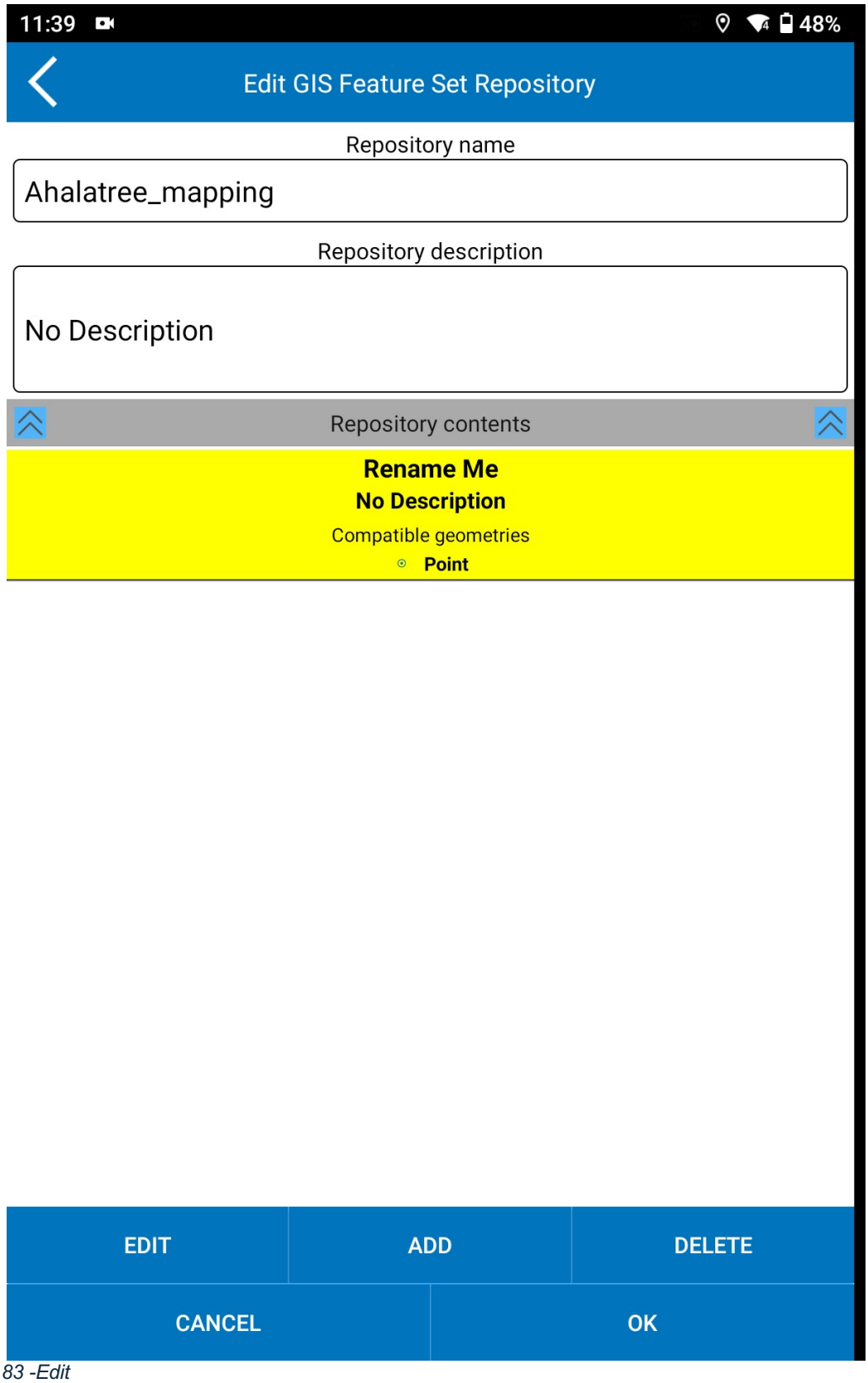


Figure 83 -Edit

Step 12

Then, give a name for the details you want to include in the survey. As shown in the figures (84,85,86,87), by clicking on **"Add,"** you can include additional details.

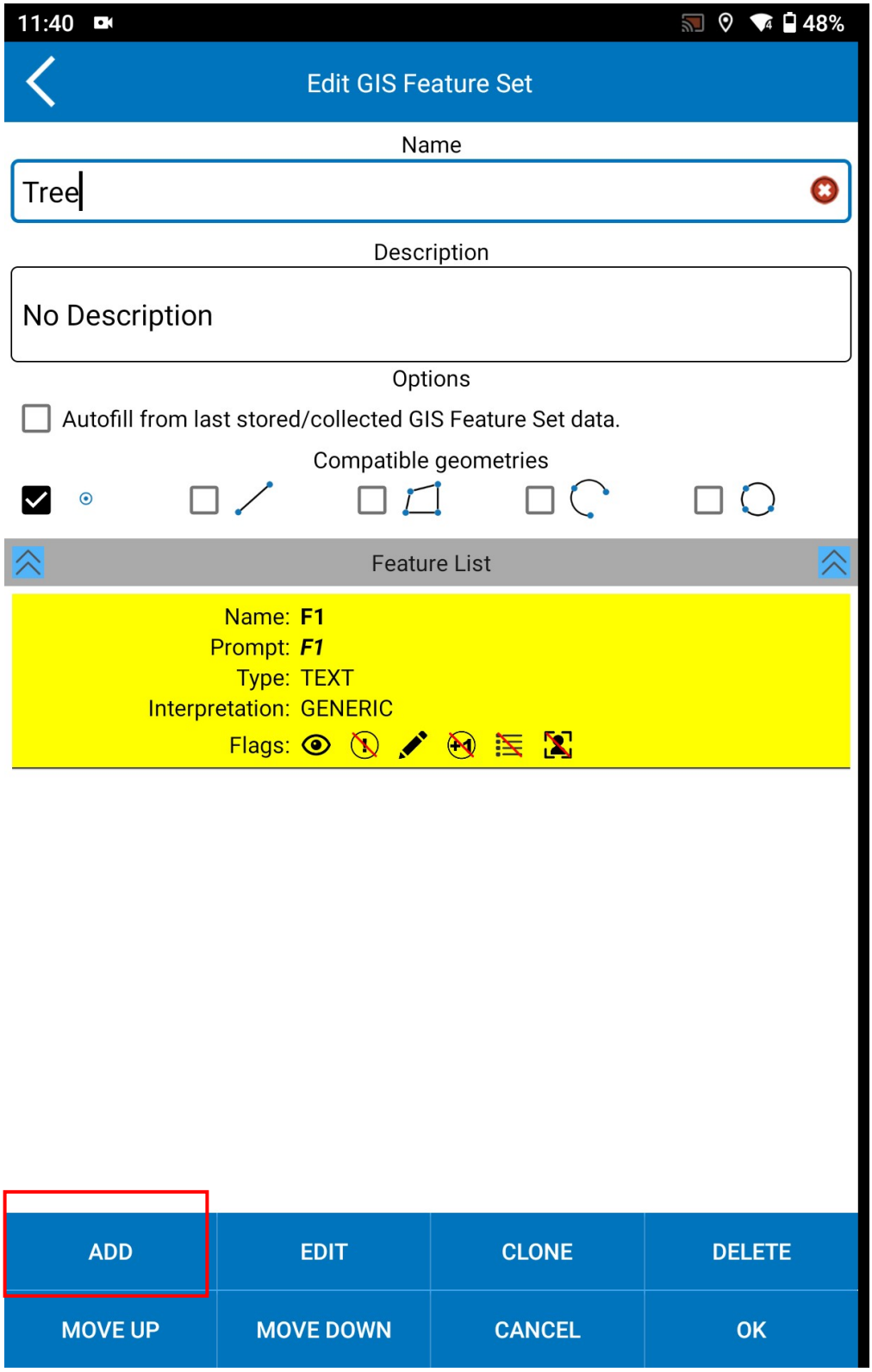


Figure 84 -ADD

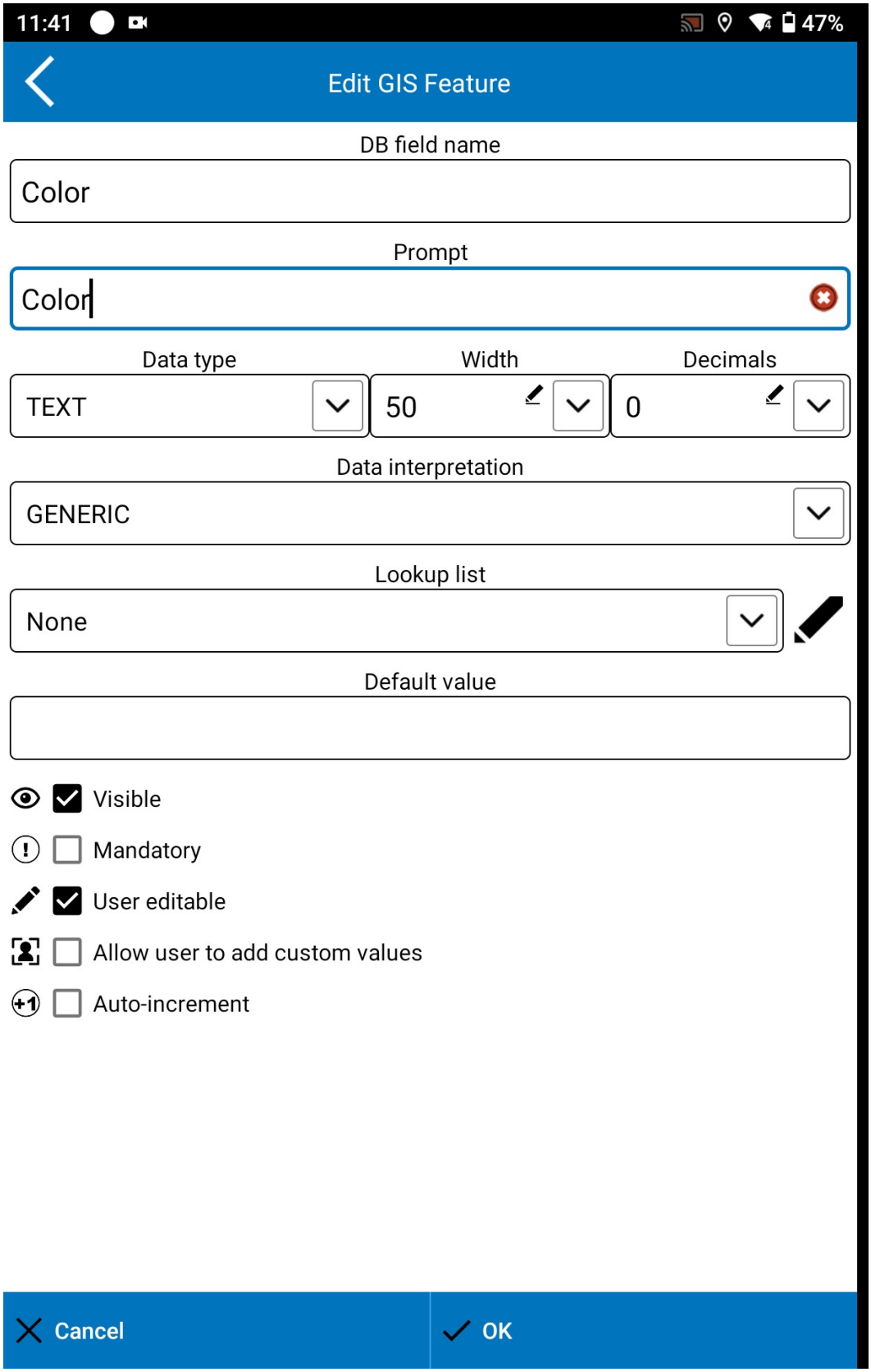


Figure 85 -Edit GIS Features

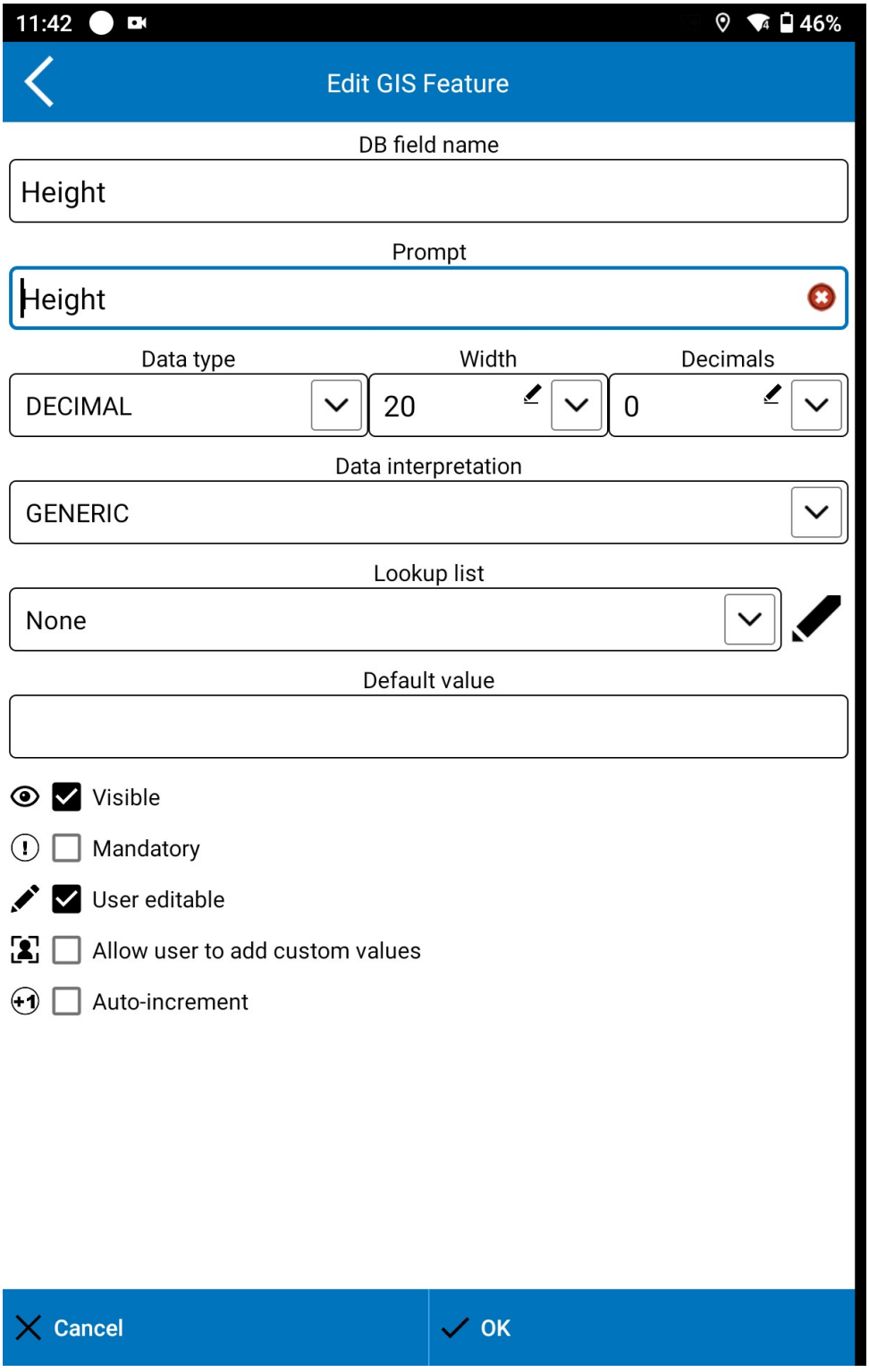


Figure 86 - Edit GIS Features

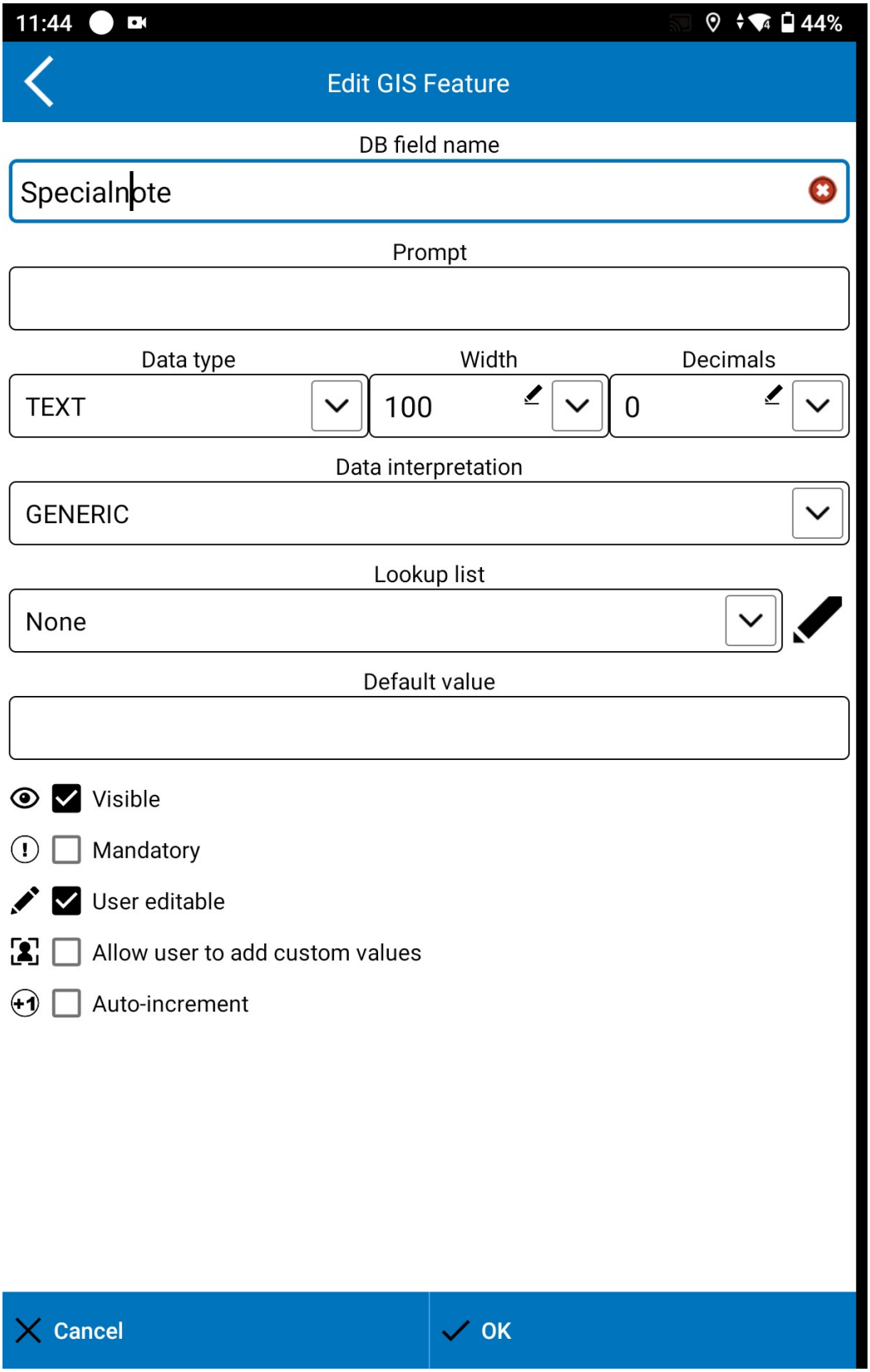


Figure 87 - Edit GIS Features

Step 13

Click Ok

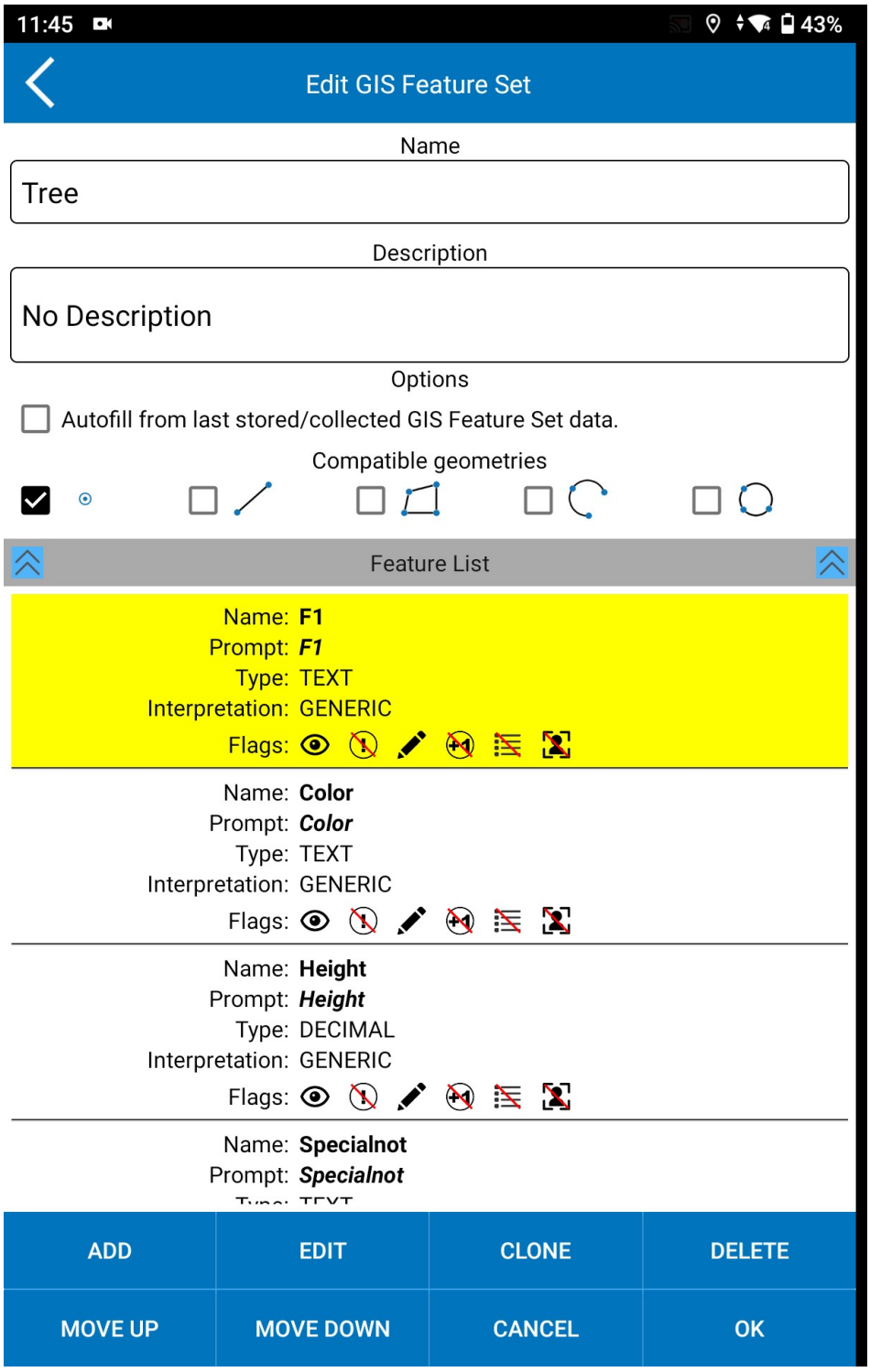


Figure 88 -Set GIS Features

Step 14

Click Yes

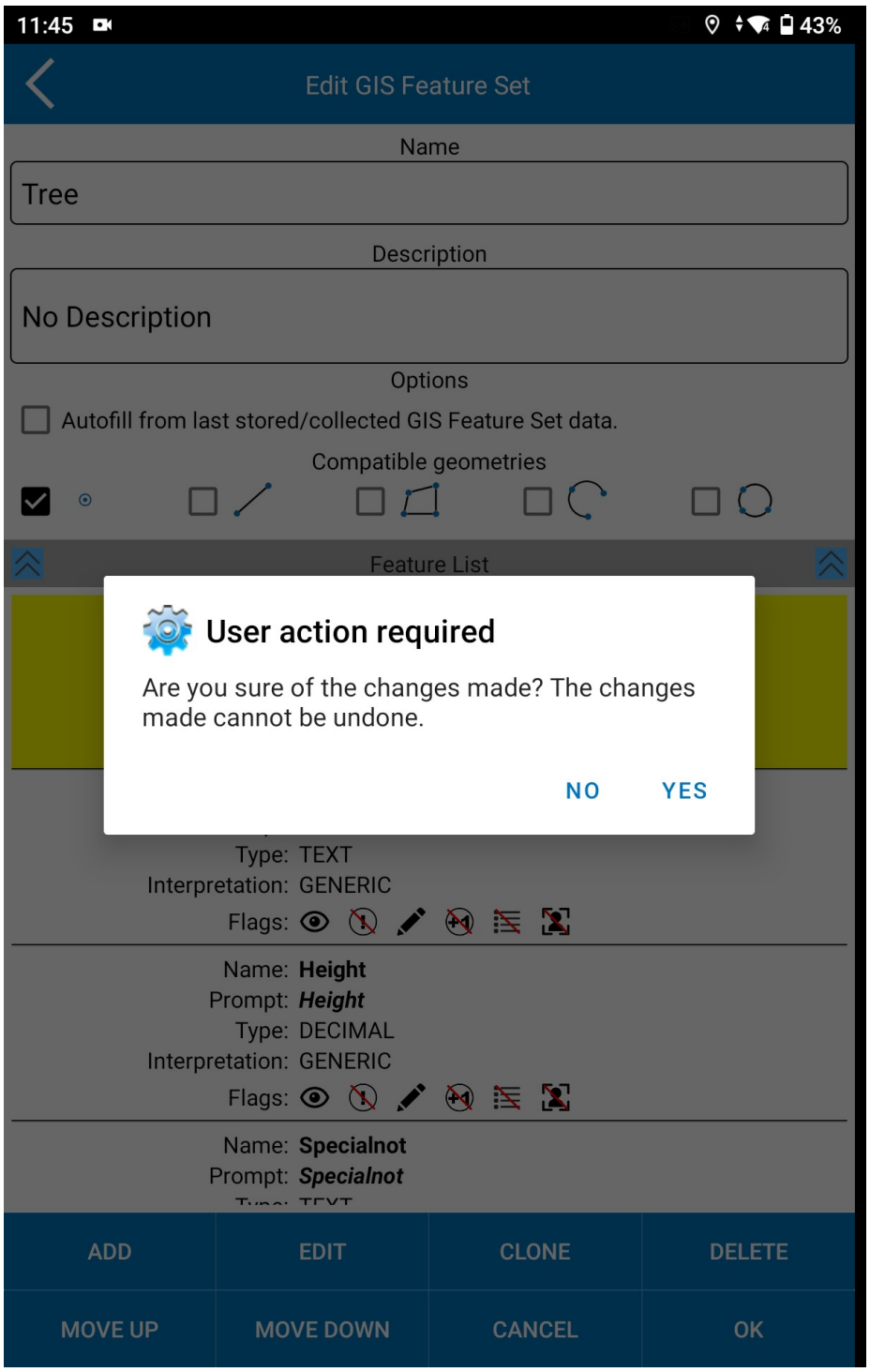


Figure 89 – User Action Required

Step 15

Click Ok

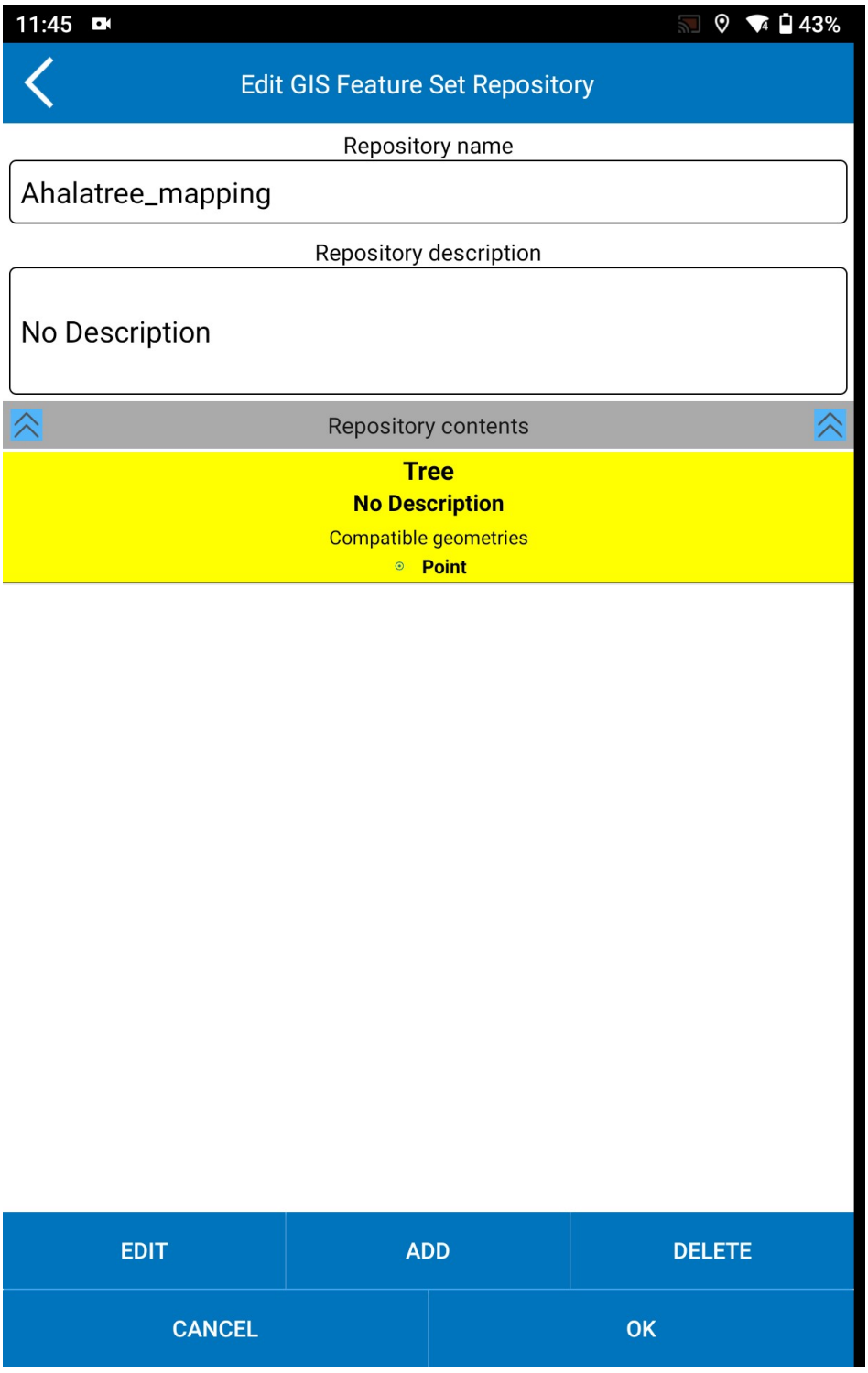


Figure 90 -Set Repository

Step 16

Click Yes

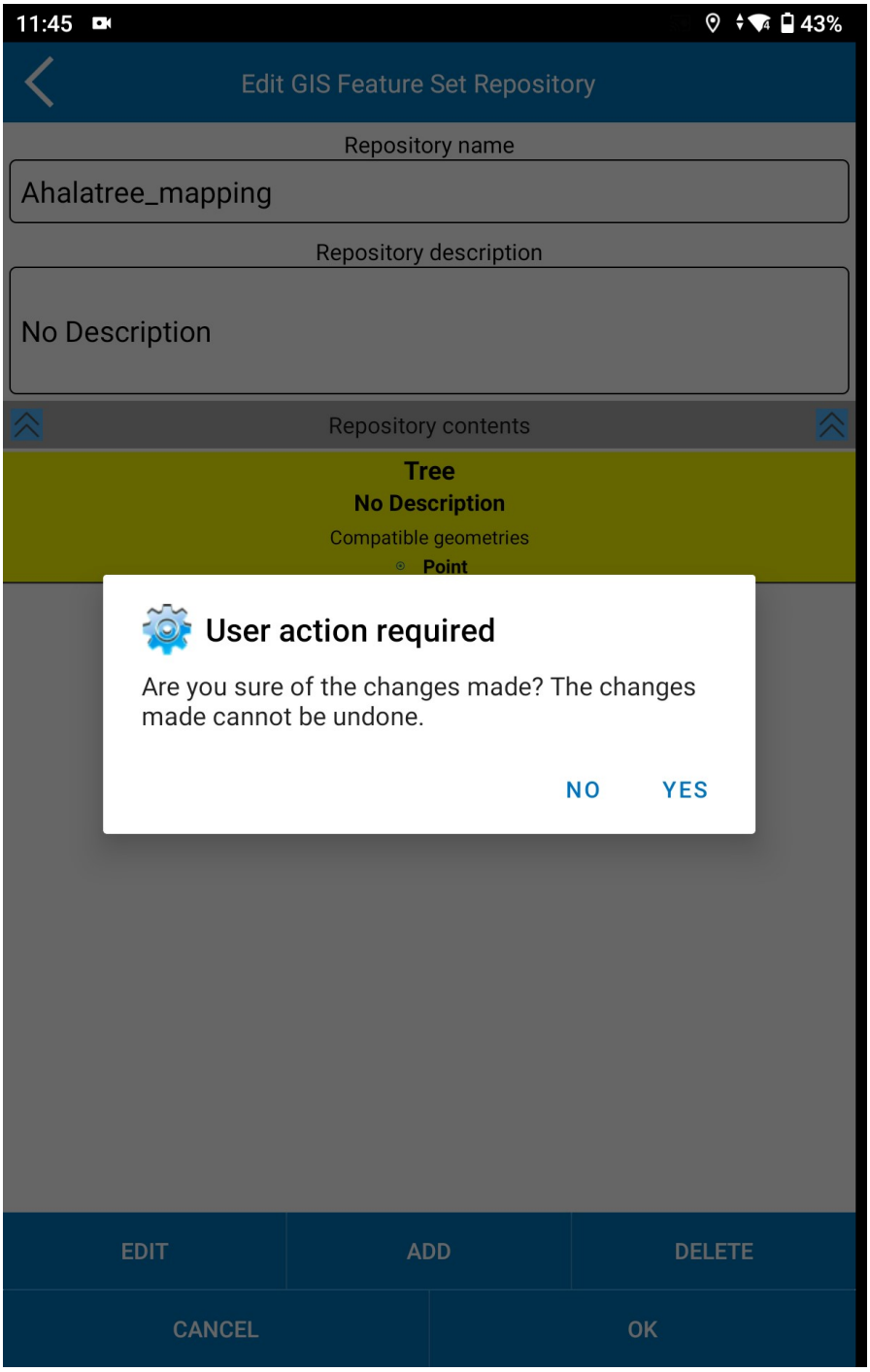


Figure 91 -User Action

Step 17

Click Ok

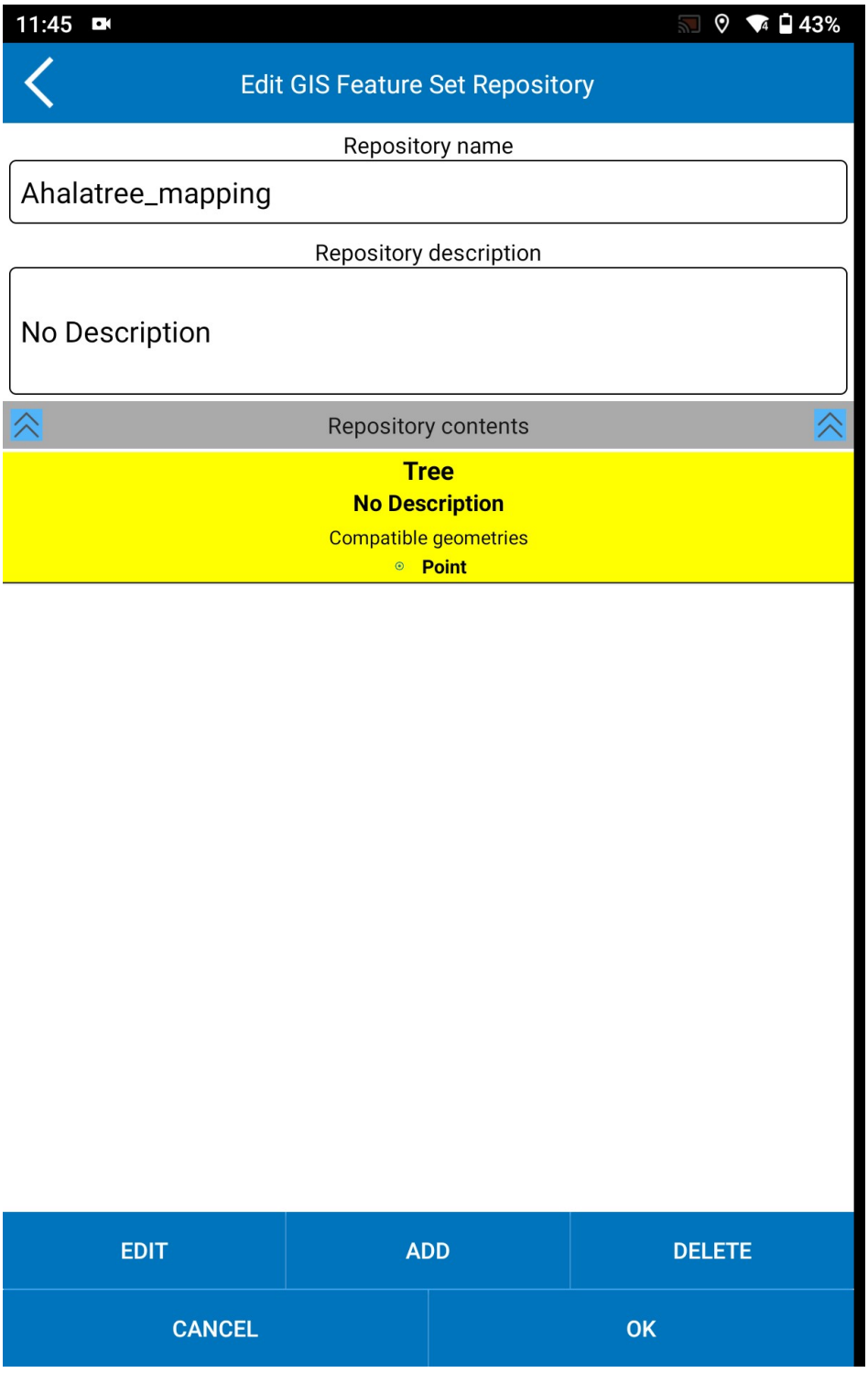


Figure 92 -Set Gis and Repository

Step 18

18.1 – Then go to the main page and click on the “Device Tab”

18.2 – Then select on Communication

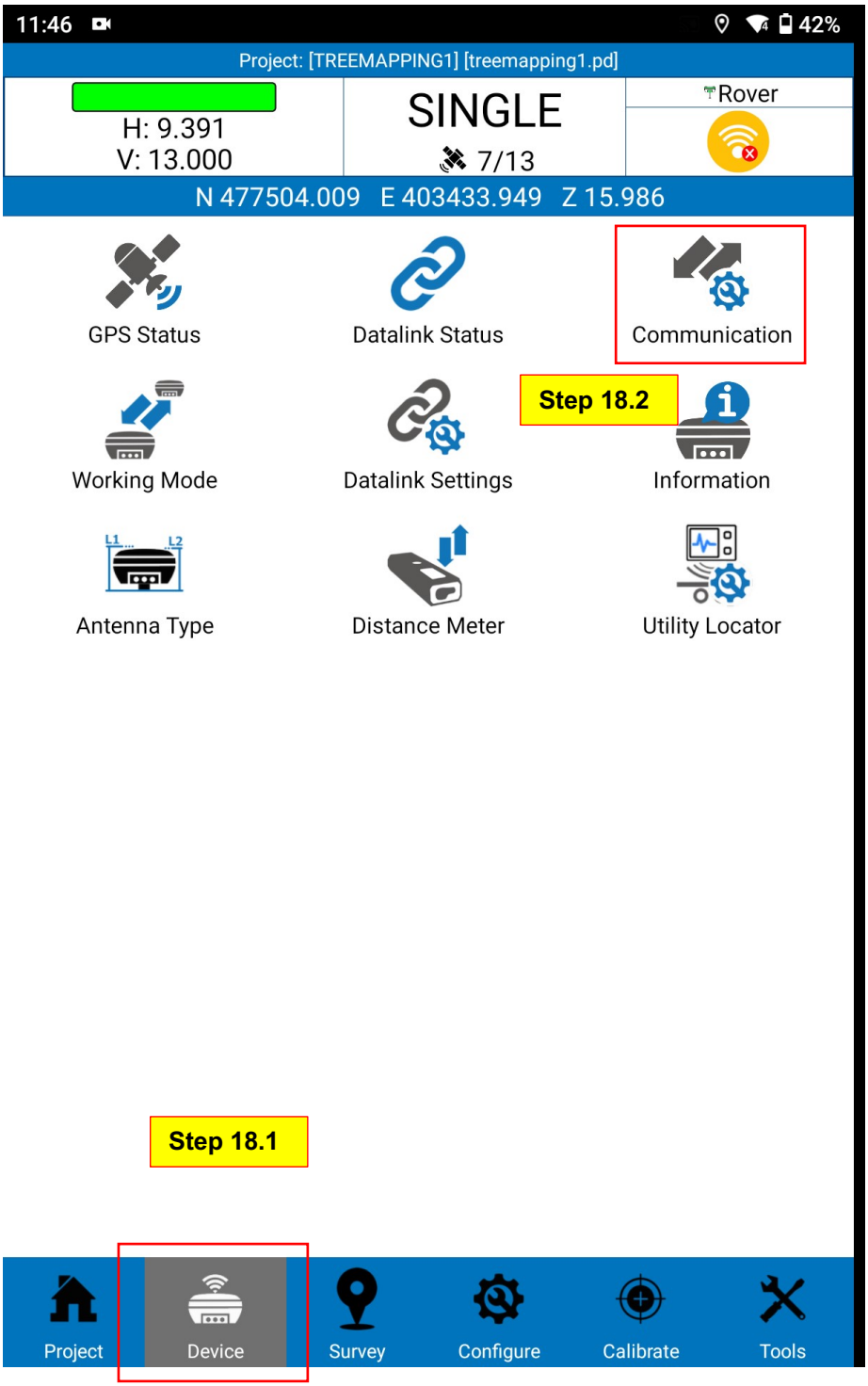


Figure 93 -Set up the Device

Step 19

Then you will see the interface below. Click on the Disconnect button first, which belongs to the previous task

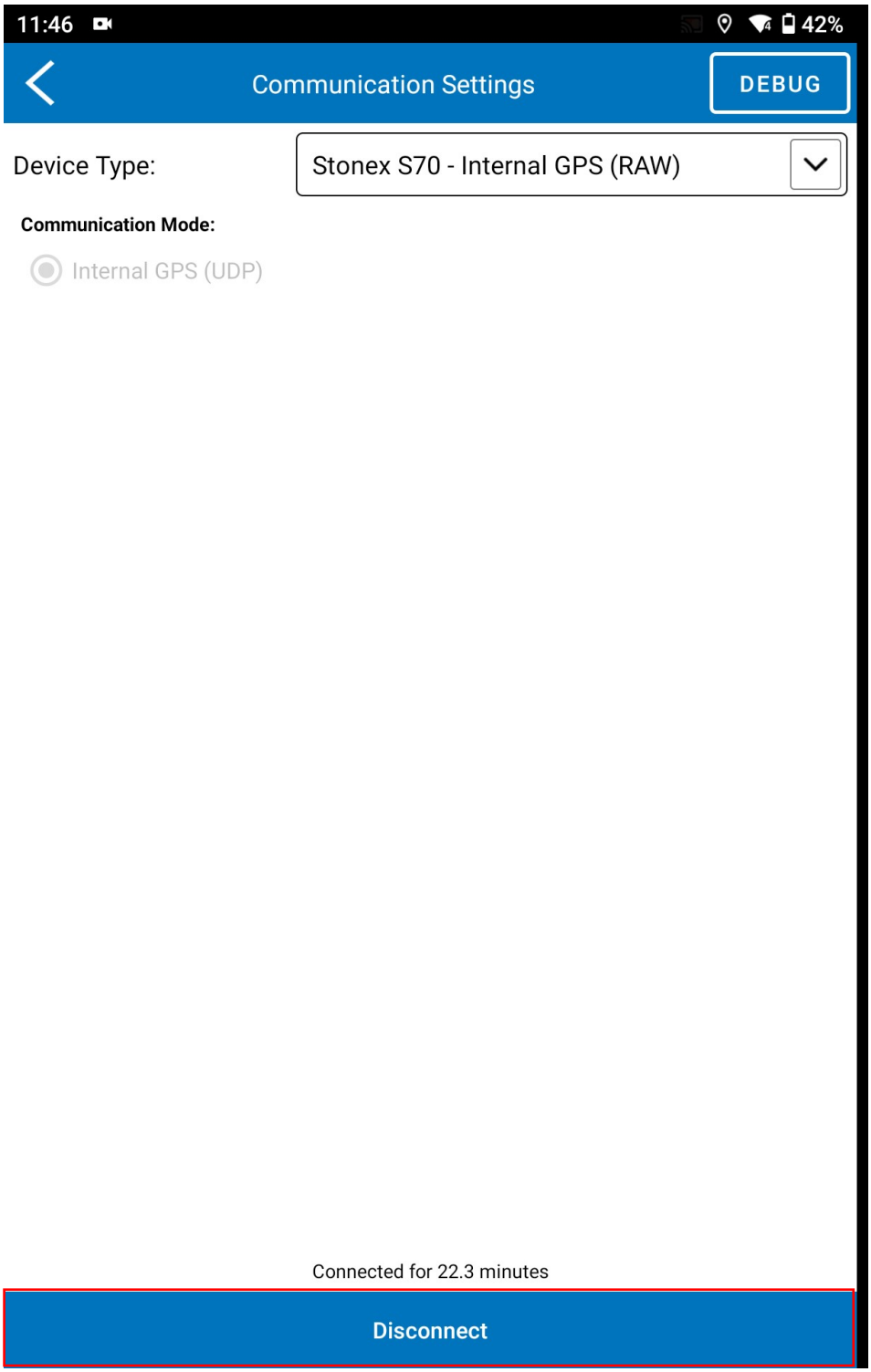


Figure 94 - Disconnecting

Step 20

20.1-Then, click on the drop-down menu, select "Stonex 70G,"

20.2 - Then click on "Connect."

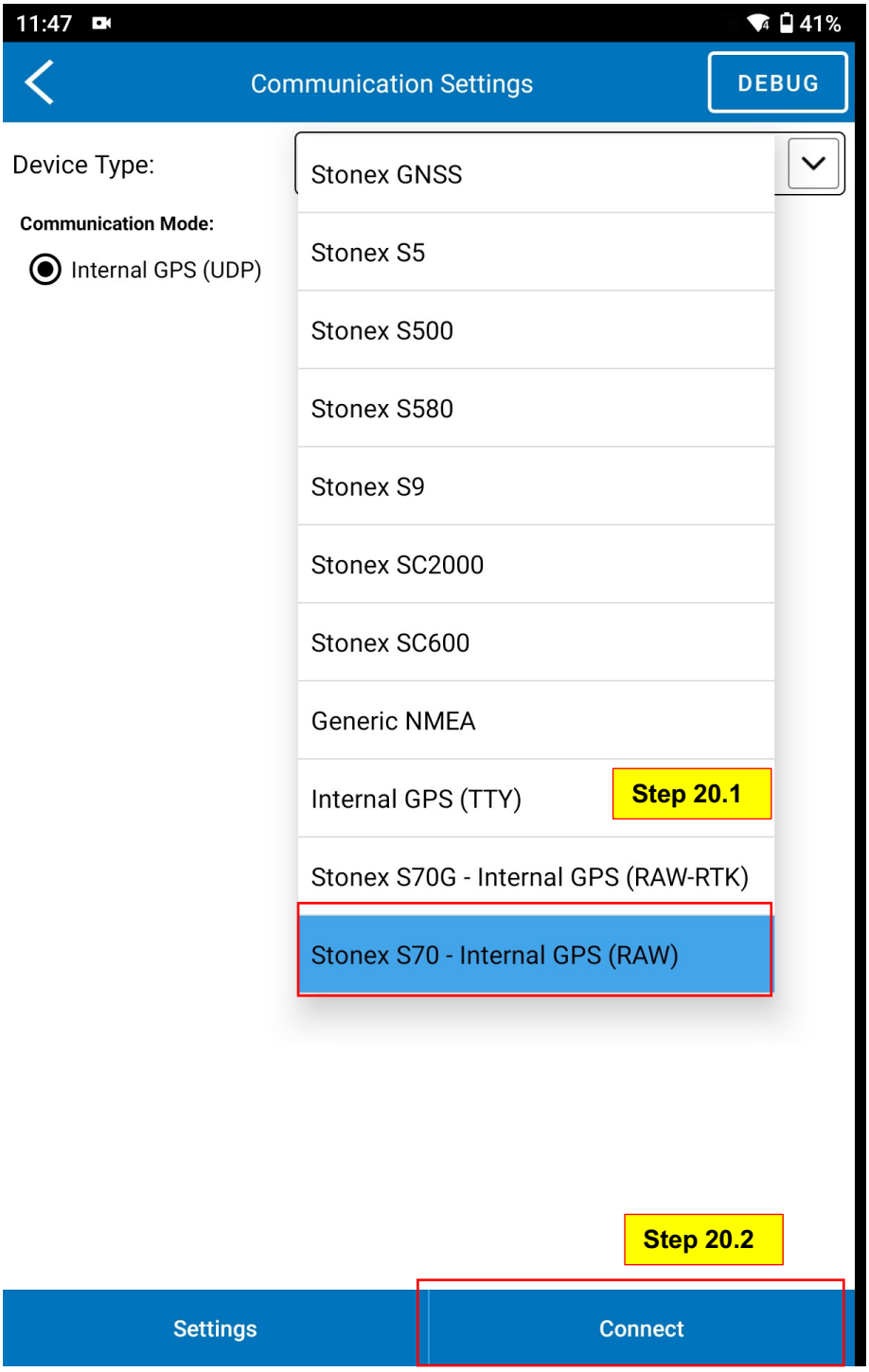


Figure 95 -Connect the Device

Step 21

Then go back and select the “Working mode” under the device tab

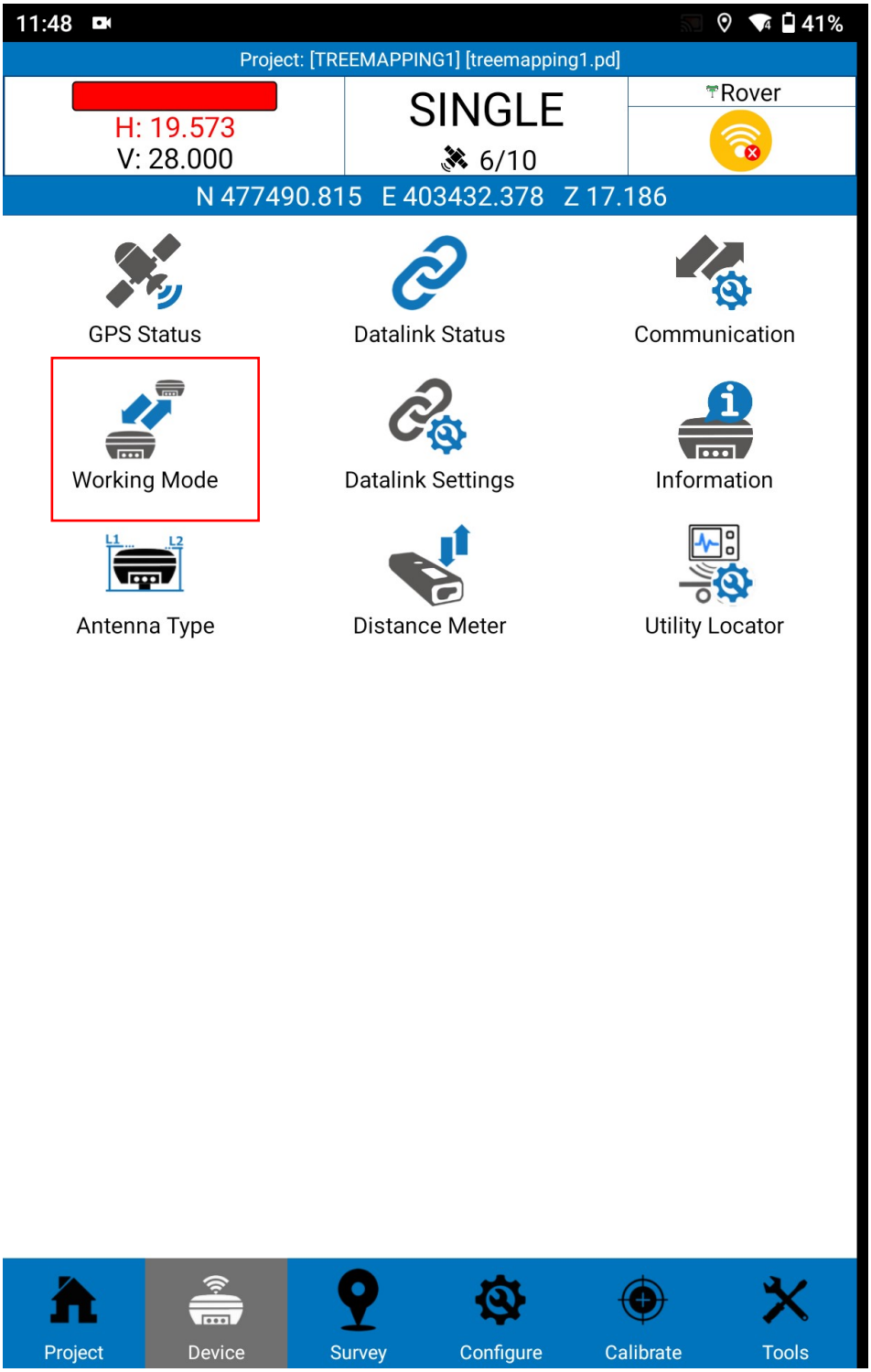


Figure 96 -Working Mode

Step 22

Select **"Rover"**

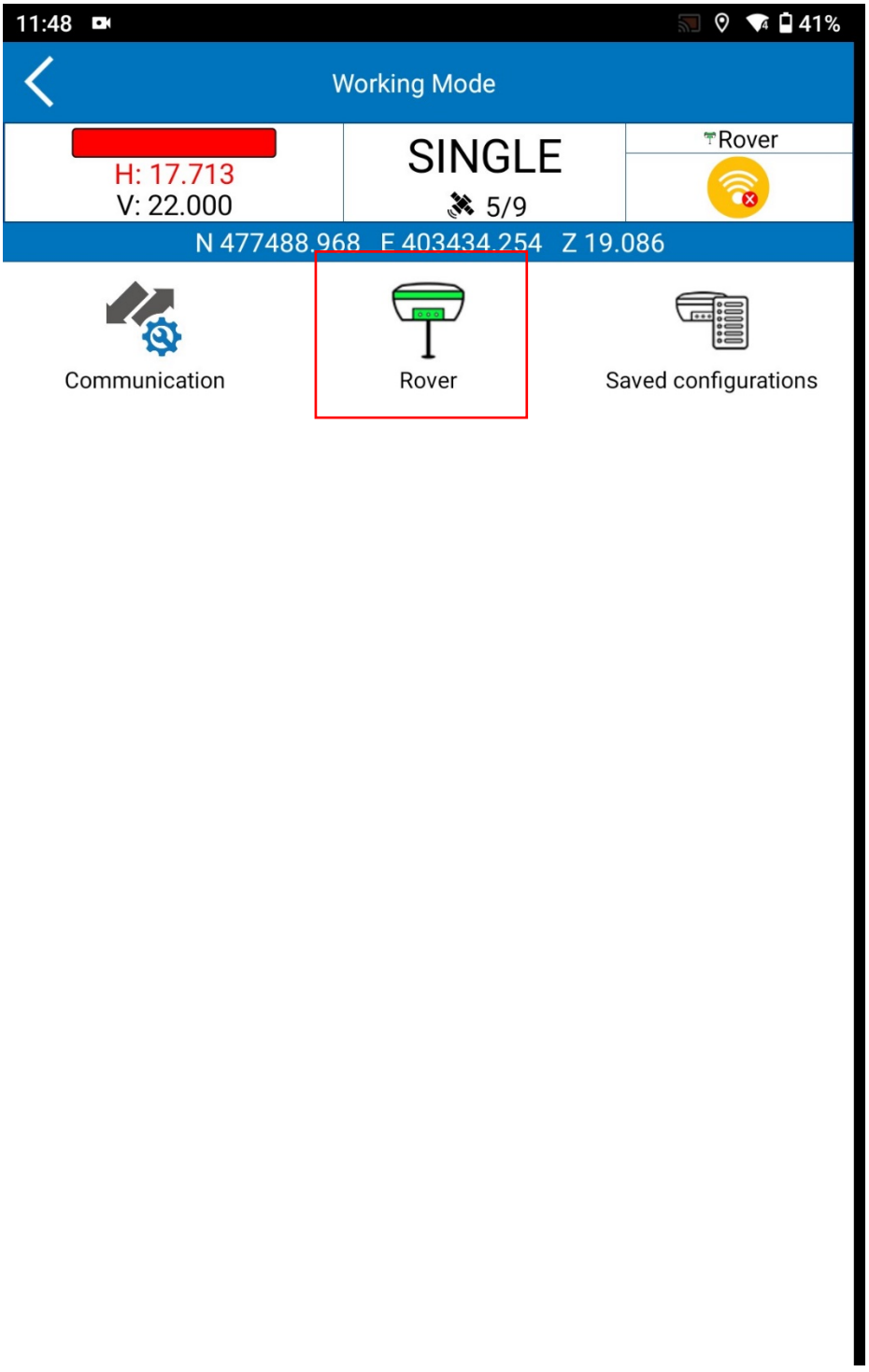


Figure 97 -Rover

Step 23
Set the following parameters: Elev. mask: Set it between 10 and 15.

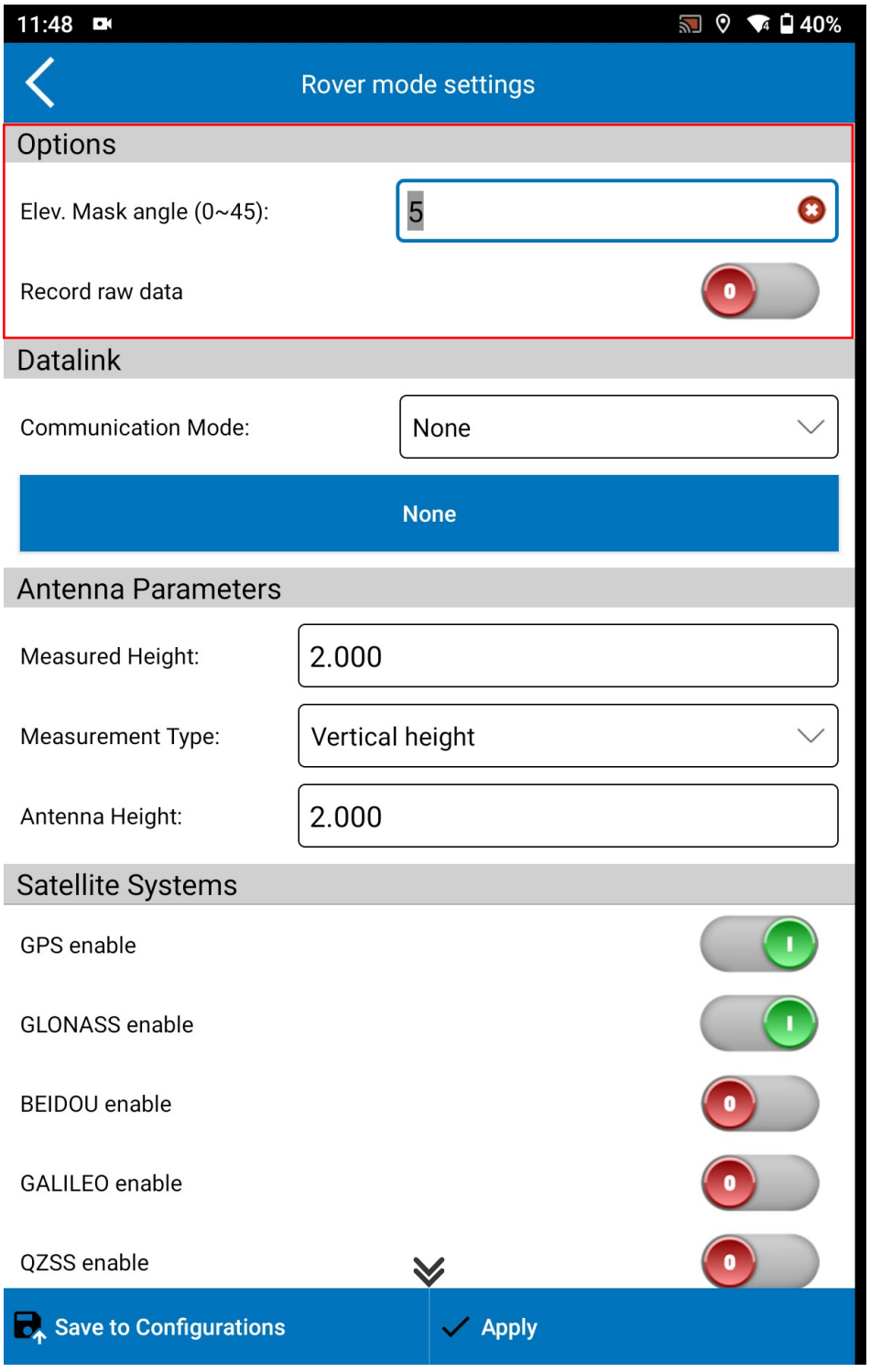


Figure 98- Set the parameters

Step 24

Enable the following “satellite system” options and select apply

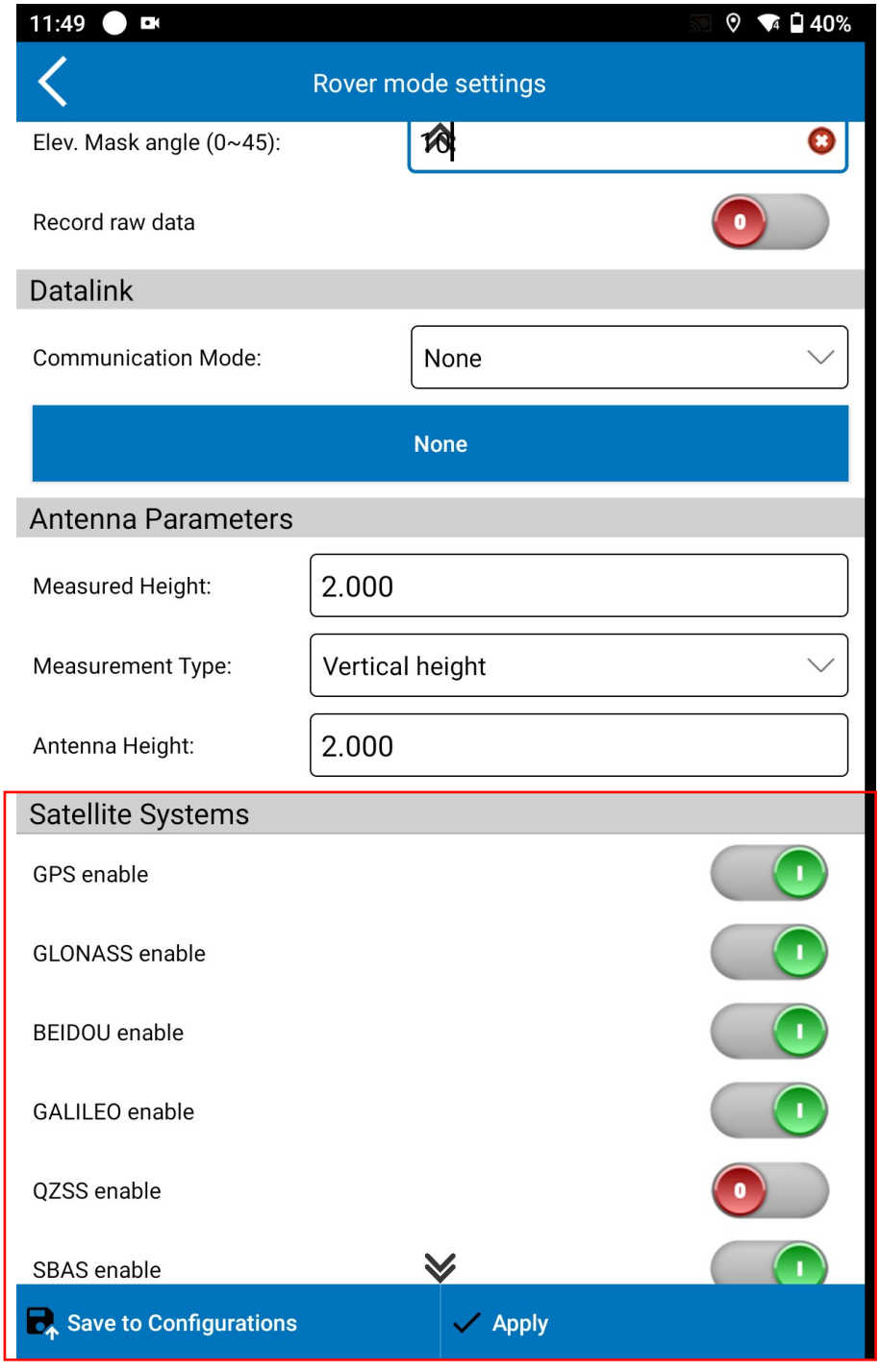


Figure 99- Enable the following satellite system

Step 25

Then, go back to the main page
25.1 – Go to the “point” tab
25.2 -Select point Survey

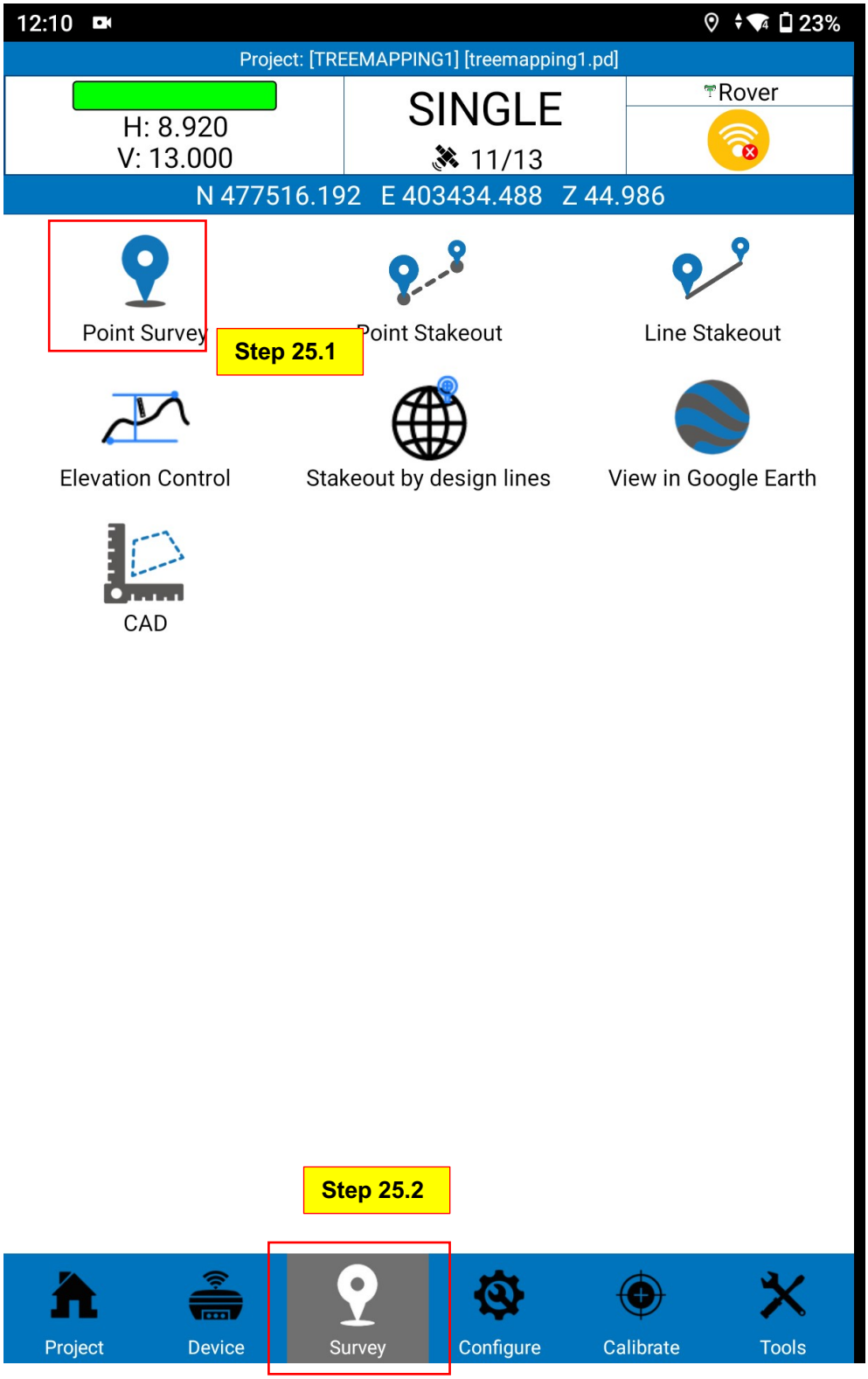


Figure 100-Point Survey

Step 26

Then you will be directed to this page and select the below icons.

Figure 101 -Map page

Step 27
Then, click on the icon below to start collecting data. While collecting data, ensure that the "H & V" indicators are green, indicating high accuracy.

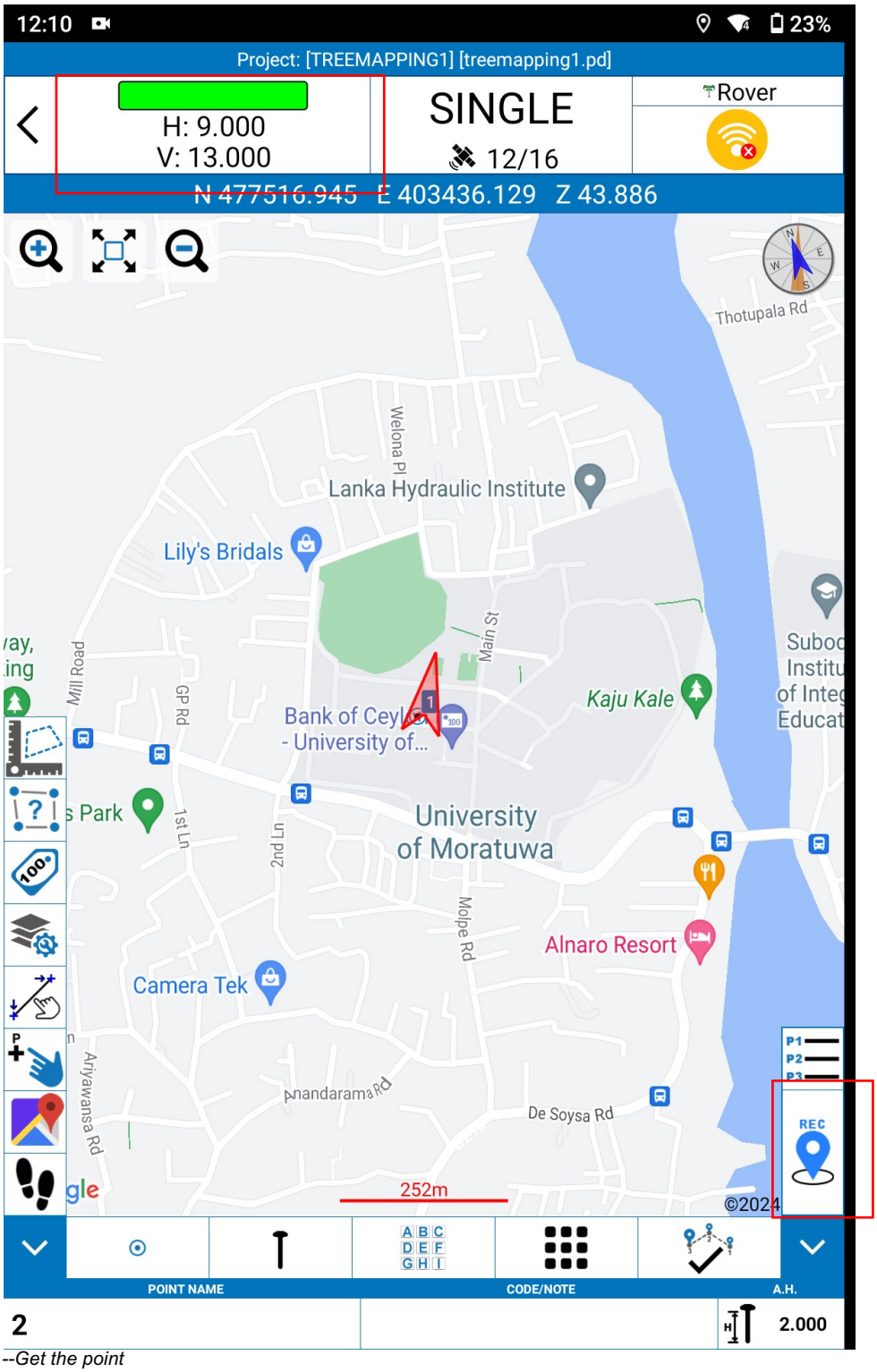


Figure 102 --Get the point

Step 28
Then select ok

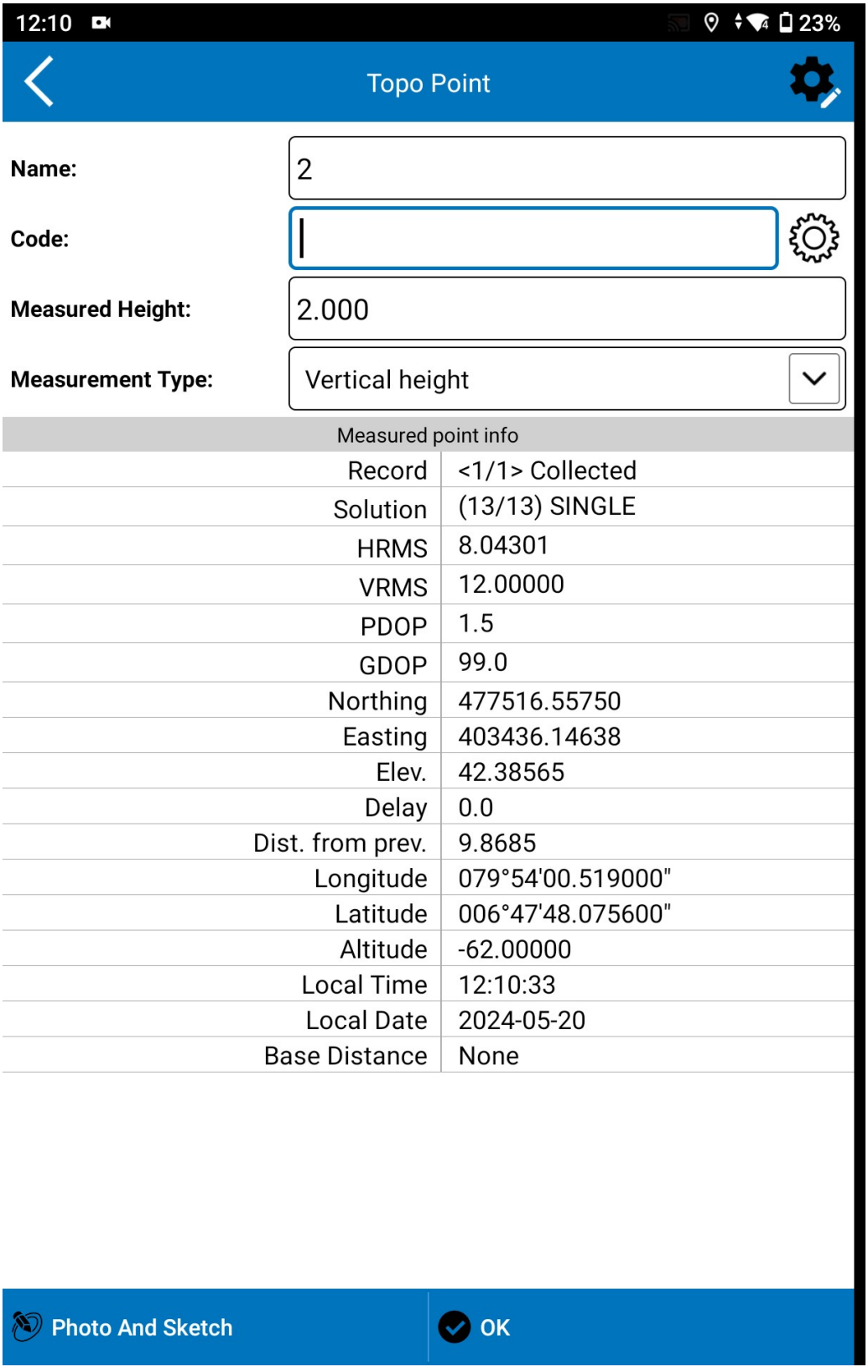


Figure 103-Topo point

Step 29
Add descriptions

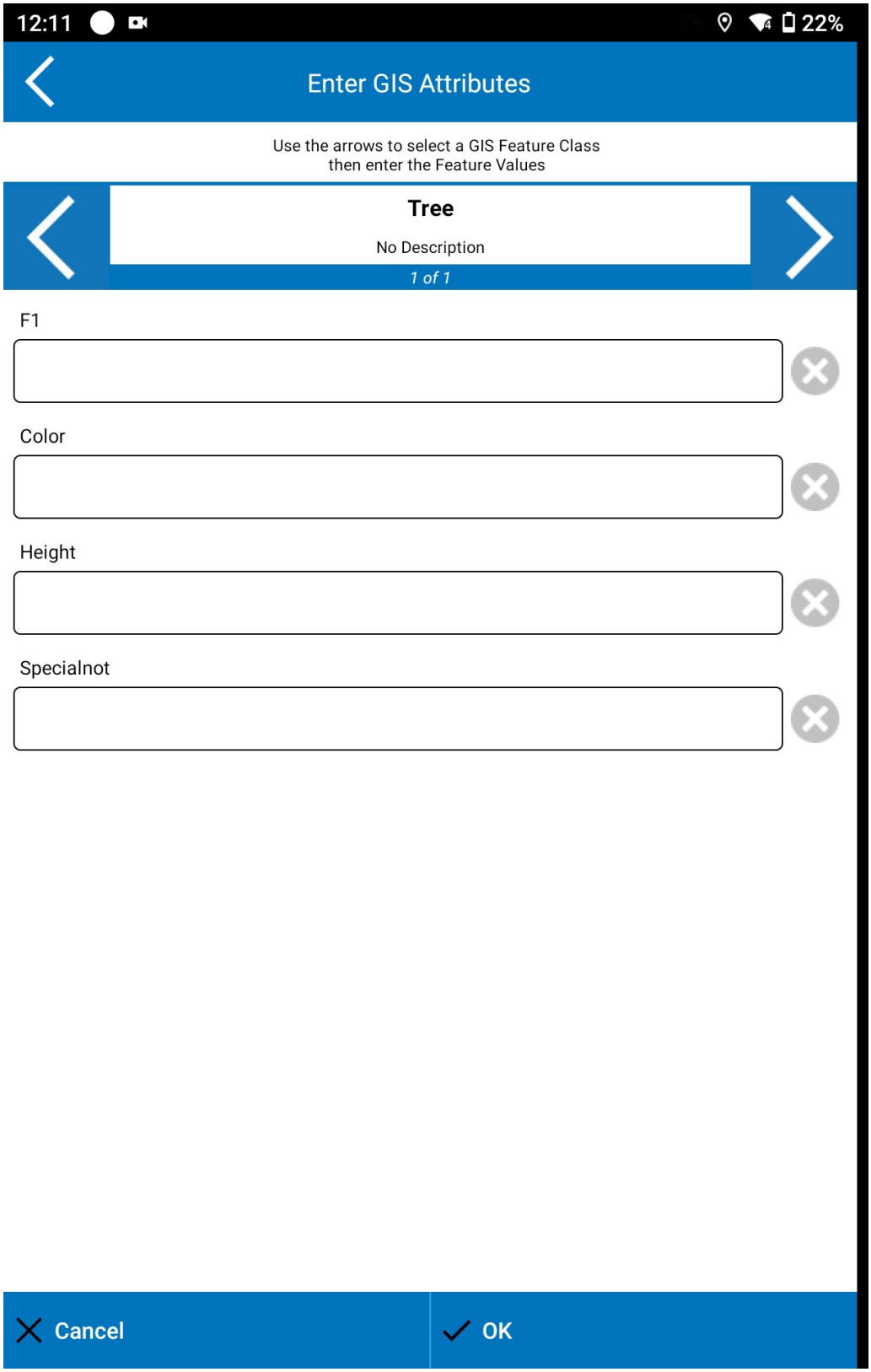


Figure 104- Add description

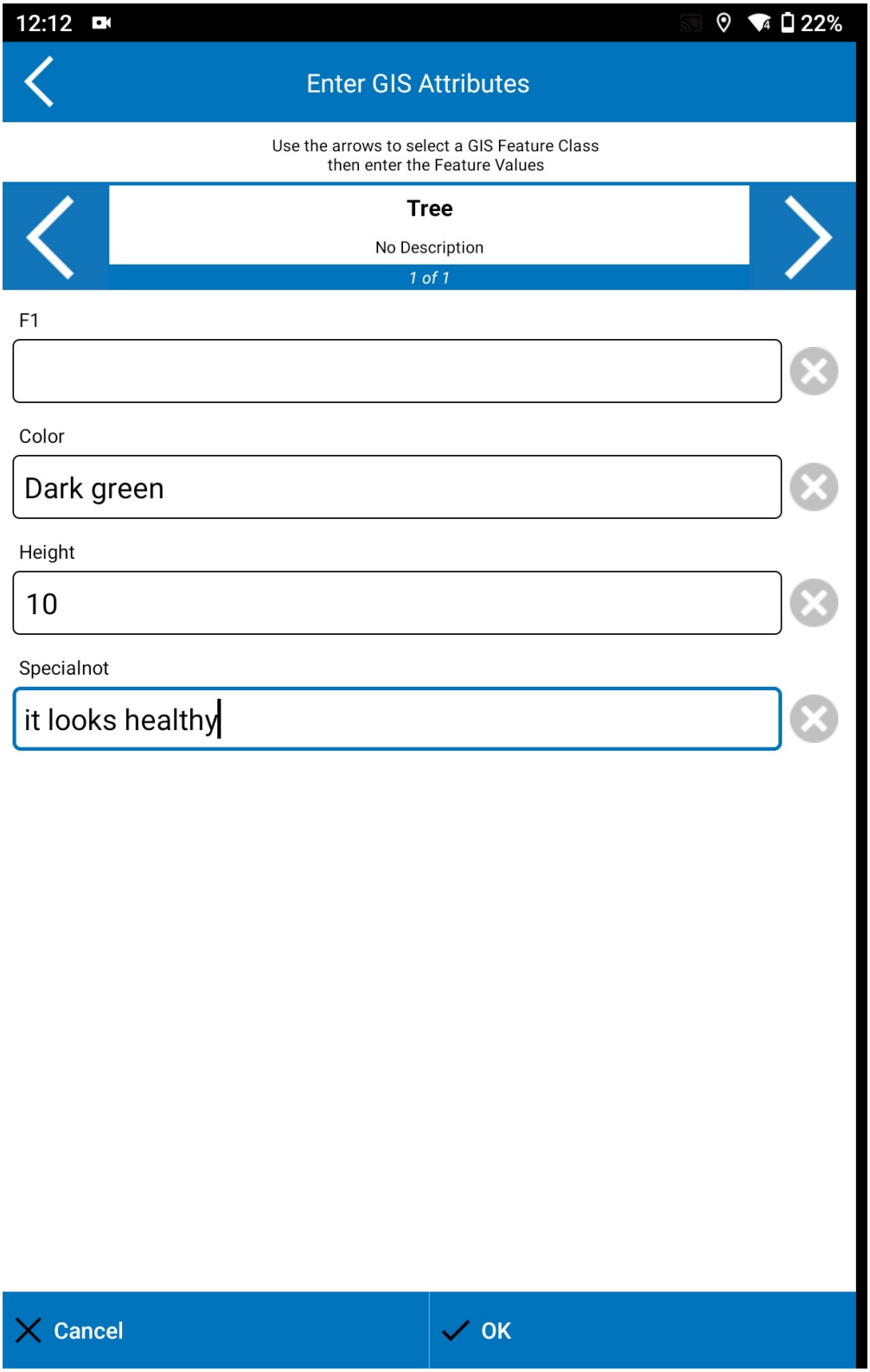


Figure 105-Enter GIS attributes

Step 30
Similarly, you can collect the data. For this project, we conducted a survey on trees at the University of Moratuwa.

Click on the below icon to see the collected data.

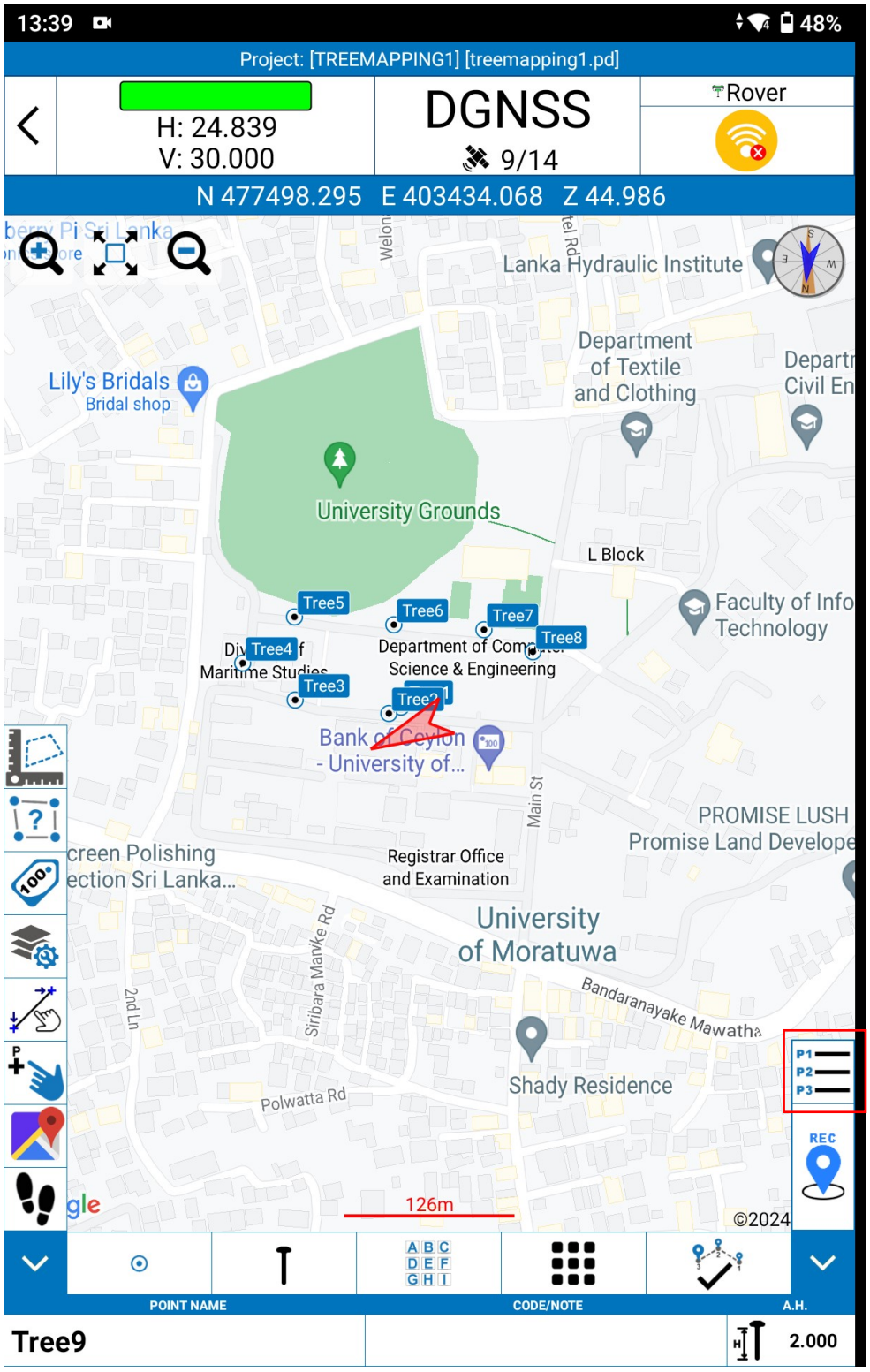


Figure 106 - Collect the data

This is the point Library

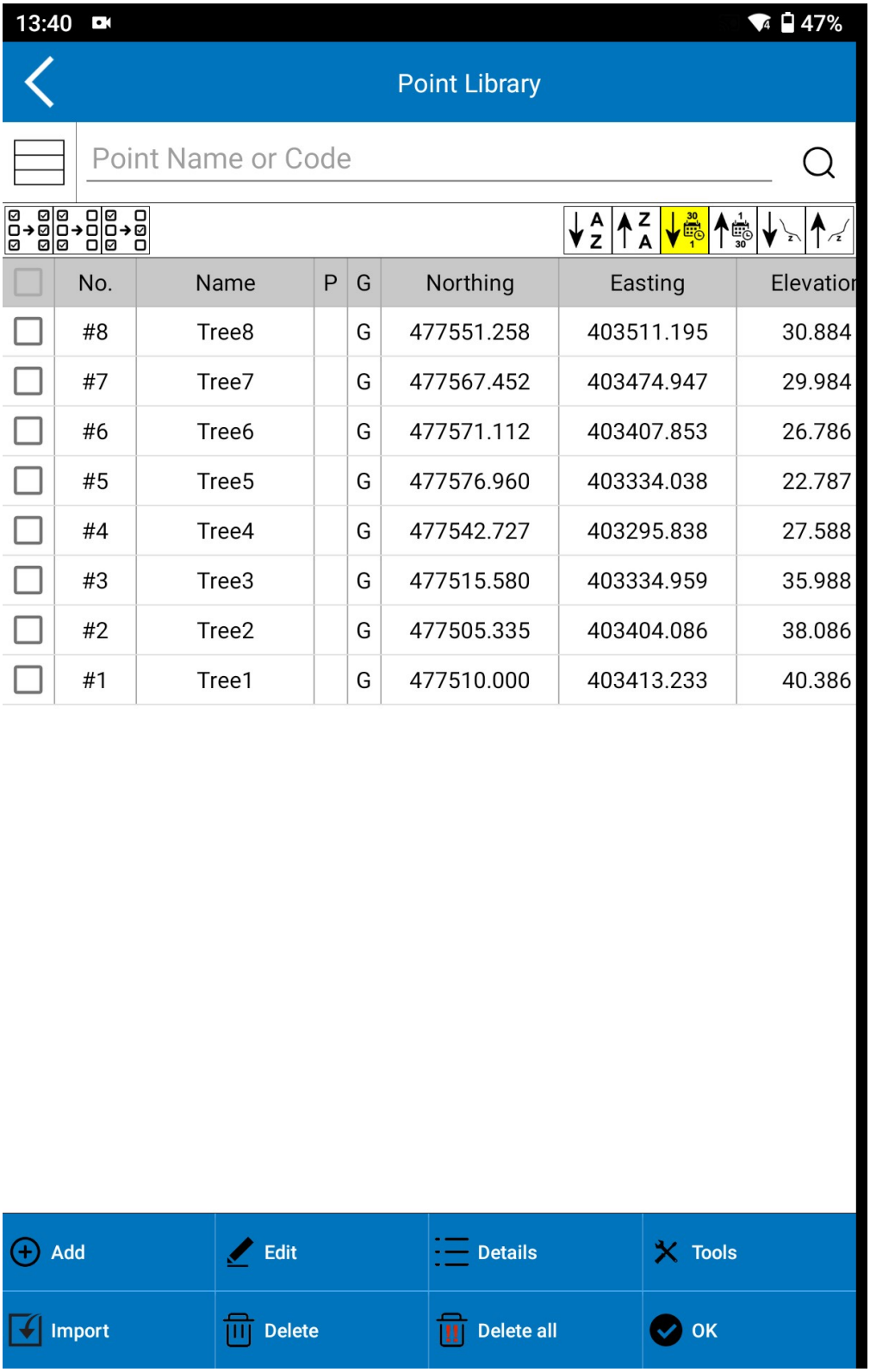


Figure 107- Point Library

Step 31

Again, go to the main Project tab and click on the export icon to export the data.

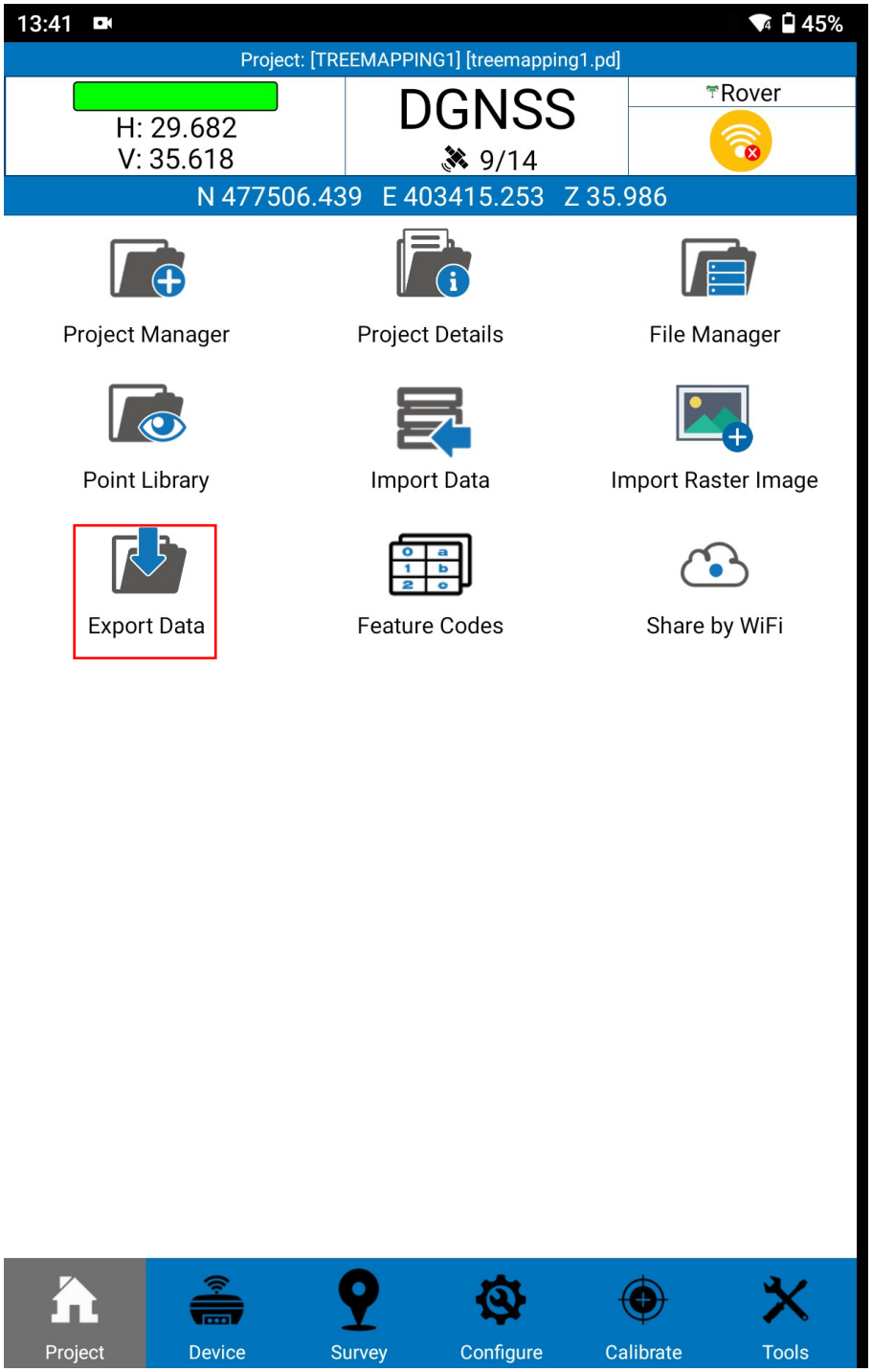


Figure 108 -Export Data

Step 32
32.1 **-**Tick the "Share after exporting" option, which will allow you to share the data through different
platforms. If not, the file will only be saved to the device.

32.2 -Then, select "Export.

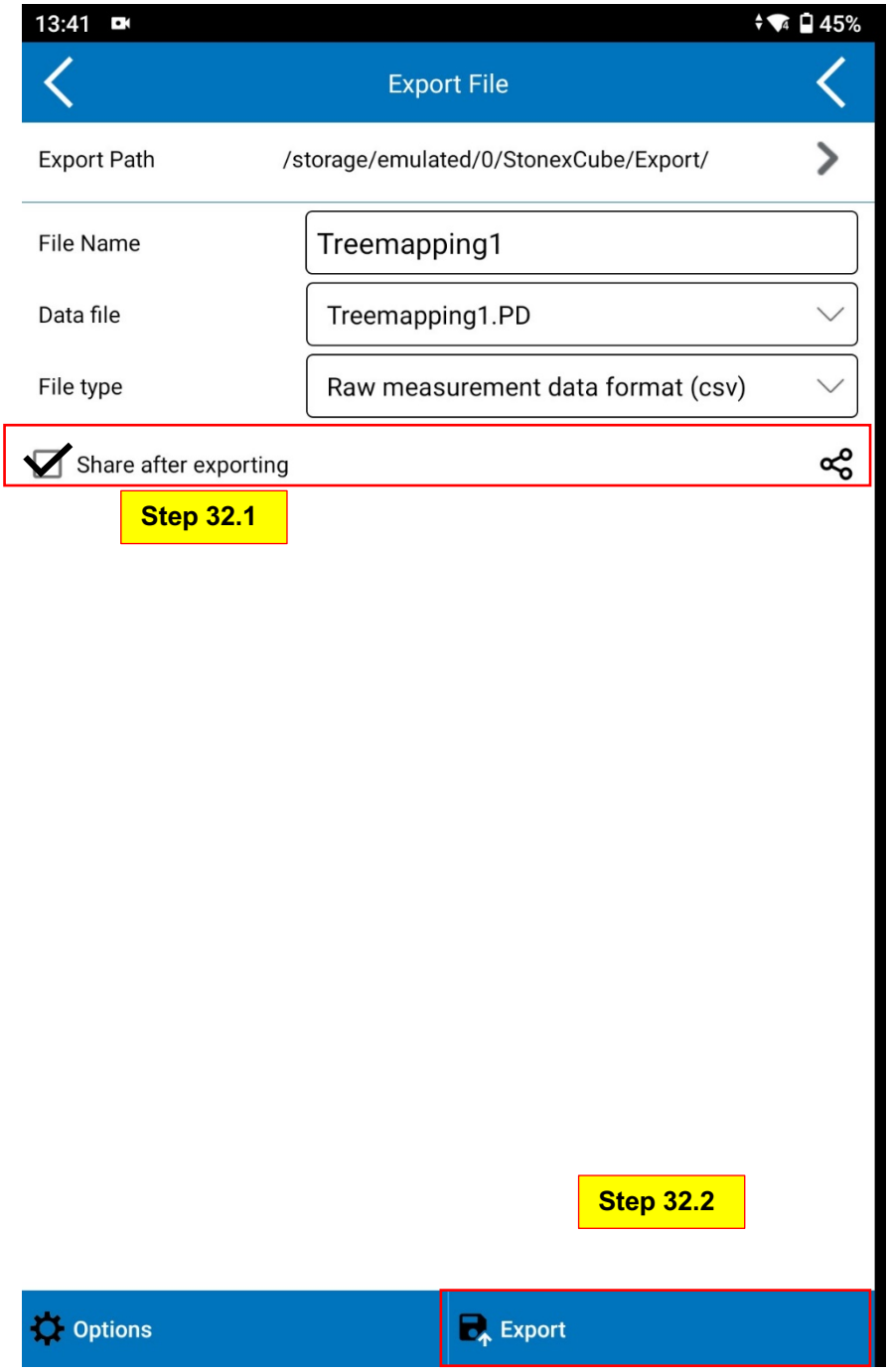


Figure 109 -Exporting

Step 33:

Select the Export Type (Here you can export the shapefiles)

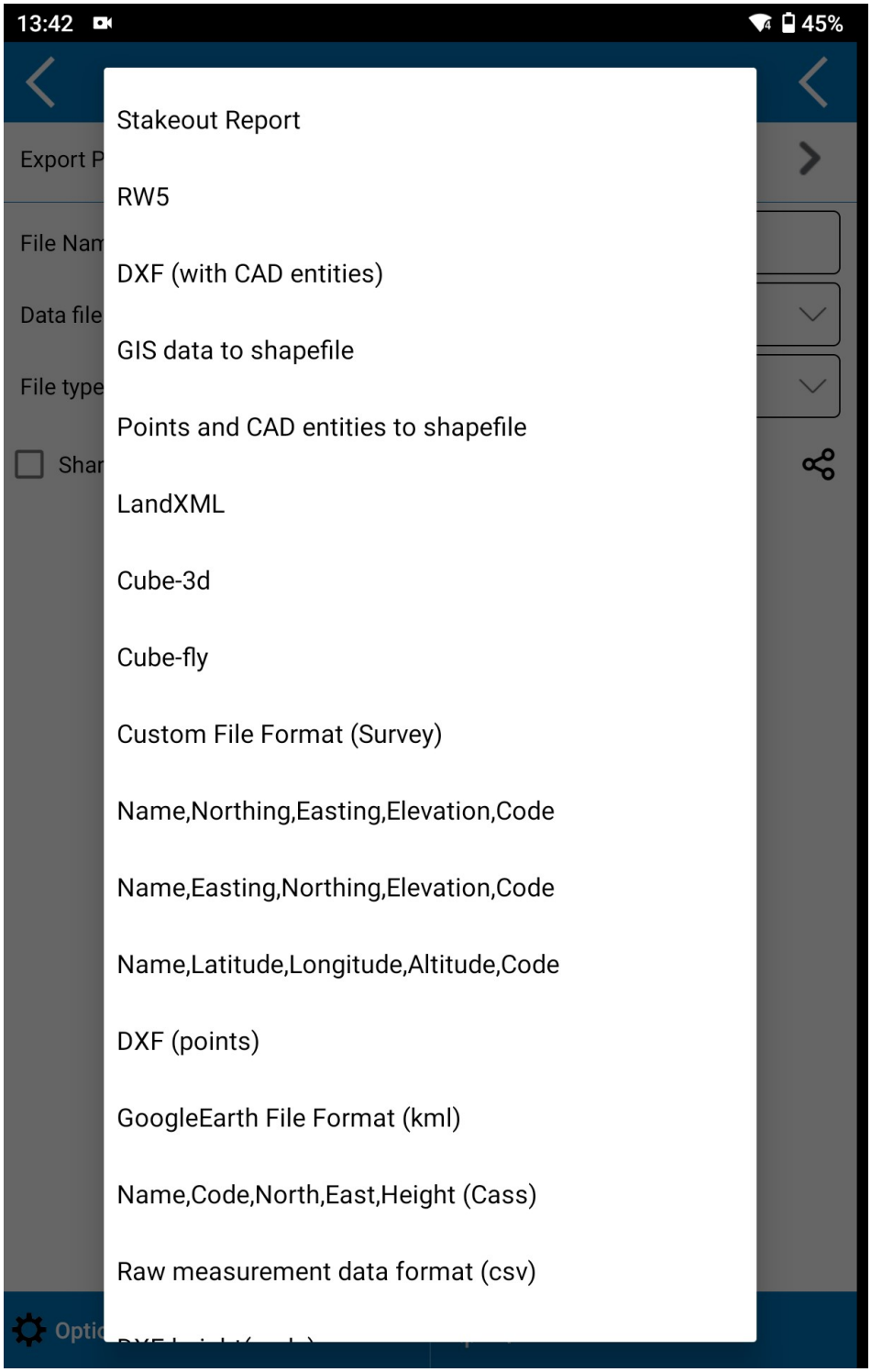


Figure 110 -Export Format

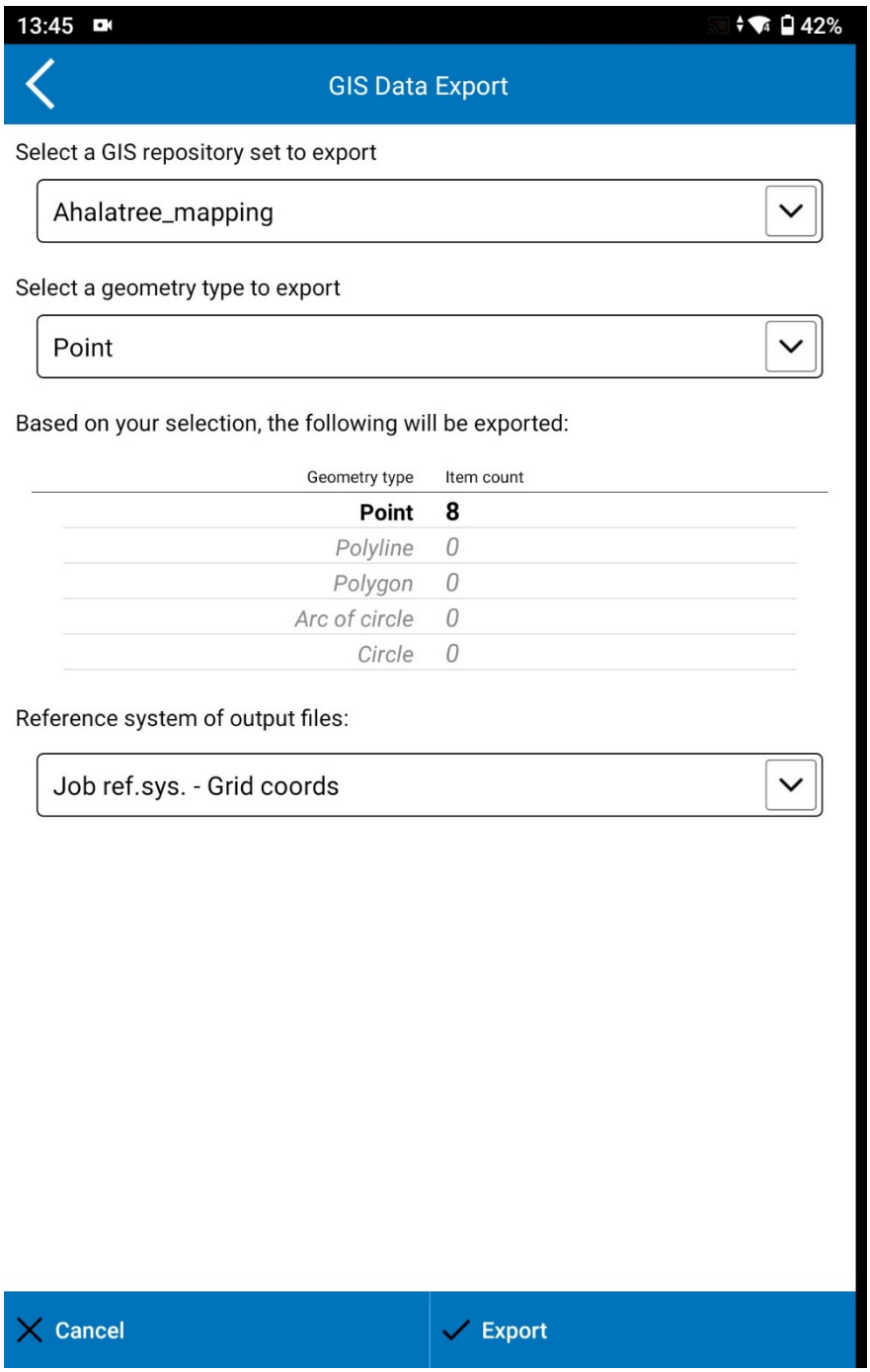


Figure 111 -Export

5. MEASURE AND MAP NOISE POLLUTION WITH MOBILE PHONE

5.1 Introduction

Noise pollution, which is frequently ignored, has a major impact on human health and the environment. Urbanization, industrial activity, and transportation are major contributors to growing noise levels, which can cause stress, hearing loss, and other health problems. Addressing noise pollution is critical to building healthier, more livable communities.

With the advancement of technology, the general population may now measure and map noise pollution using their mobile devices. Modern smartphones are equipped with sensitive microphones and strong processors, allowing them to serve as portable noise meters. Various applications use these characteristics to assist users monitor noise levels in their surroundings, allowing them to make educated decisions.

This section of the manual will walk you through the process of measuring and mapping noise pollution using your mobile device. It will go over how to choose the right apps, how to take precise measurements, how to interpret data, and how to create noise maps. By the end of this manual, you will have the knowledge and skills you need to help raise awareness and reduce noise pollution in your community.

Monitoring noise levels is important. Monitoring noise pollution is critical for a variety of reasons.

- Health Protection: By evaluating noise levels, people and communities may decrease exposure and safeguard their health.
- Understanding noise patterns is useful in urban planning and environmental management.
- Regulation and Policy: Accurate noise data facilitates the development and implementation of noise rules and policies.
- Public Awareness: Educating the public about noise pollution and its effects can lead to more community-led noise-reduction measures.

5.2 Overview of Mobile Apps for Noise Measurement

Mobile apps have made it easier to measure noise pollution accurately and conveniently. These apps leverage the microphone of your smartphone to capture sound levels in decibels (dB) and provide valuable data for noise monitoring and analysis. One such app is NoiseCapture, which is popular for its comprehensive features and ease of use.

Noise Capture is an open-source mobile application designed to measure environmental noise levels. It is available on the Google Play Store and is widely used for its accuracy and user-friendly interface

Figure 112 -Noise Capture App

5.2.1 Features of Noise Capture App:

- Accurate Noise Measurement: The app measures sound levels in real time using your phone's microphone.
- Data Logging: It allows you to log noise data over time, providing a detailed record of noise levels.
- GPS Integration: Noise Capture integrates with GPS to tag noise measurements with geographic coordinates, enabling the creation of noise maps.
- User-Friendly Interface: The app is easy to navigate, making it accessible for both beginners and experienced users.
- Data Sharing: You can share your noise measurements.
- Graphical Analysis: The app provides graphical representations of noise data, helping users visualize noise patterns.

5.2.3 Architecture Diagram and Workflow

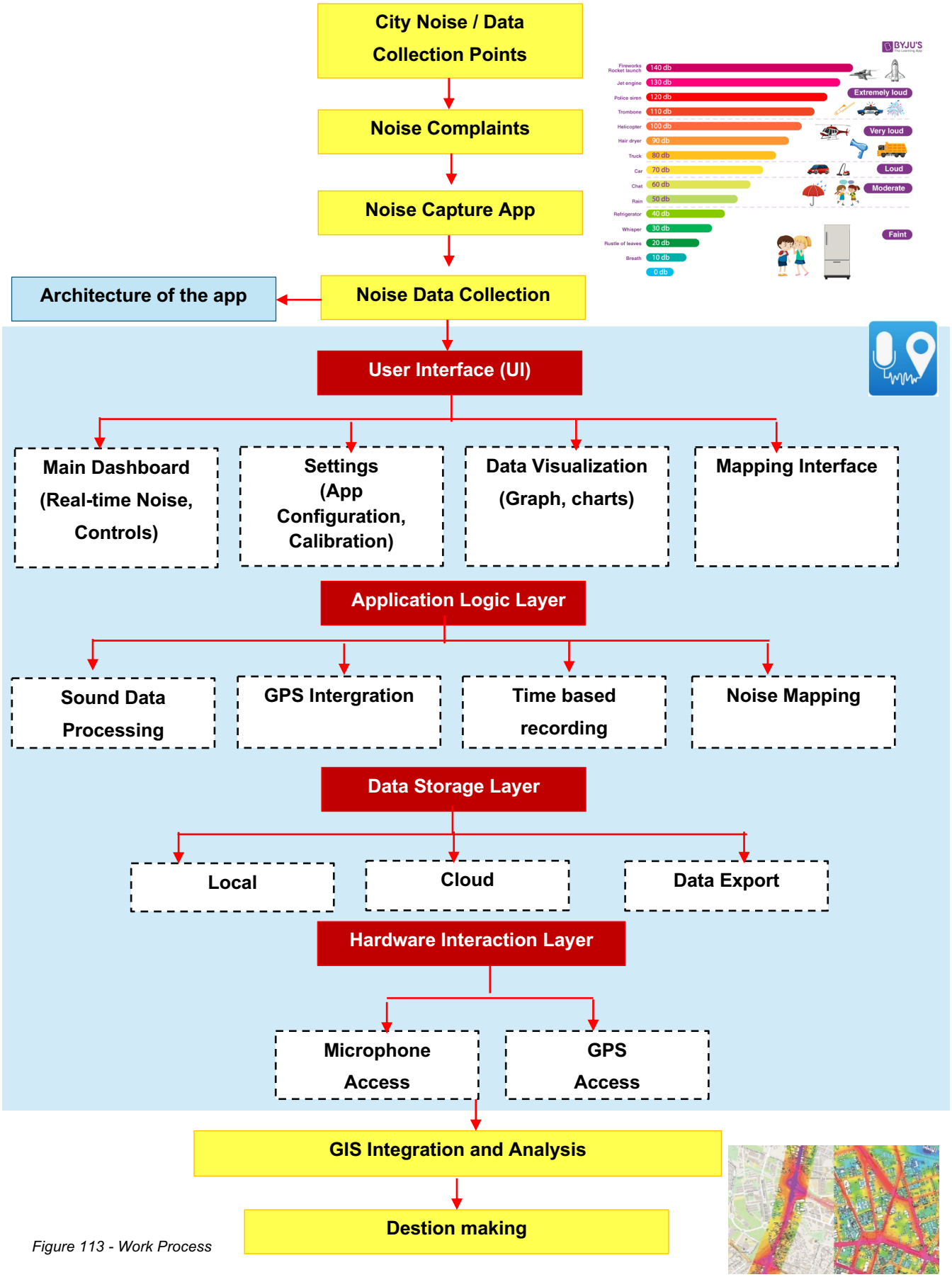


Figure 113 - Work Process

Overview of Other Mobile Apps for Measuring Noise Pollution

App	Android	IOS	Key features
Sound Meter	✓		Real-time noise measurement, sound level charts, calibration.
Decibel X	✓	✓	Real-time noise measurement, spectrum analyzer, data logging, calibration, exporting data, and sharing options.
NIOSH Sound Level Meter		✓	Accurate noise measurement, occupational noise exposure assessment, real-time data, and reporting features.

Selecting the Right App for Your Needs

- Accuracy: Look for apps with good reviews and those that offer calibration features.
- Ease of Use: Select an app with an intuitive interface and clear instructions.
- Additional Features: Depending on your needs, you may require features like data logging, GPS integration, or data sharing.
- Platform Compatibility: Ensure the app is available for your mobile operating system (Android or iOS).

5.3 Steps

Step 1: Download and Install the Noise Capture Application

Figure 116 provides a detailed methodology that outlines the step-by-step process for downloading and installing the application.

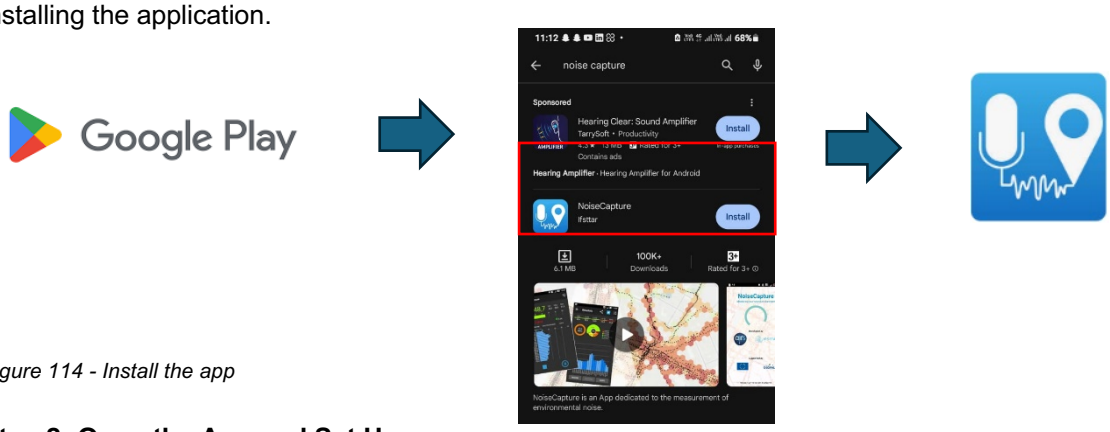
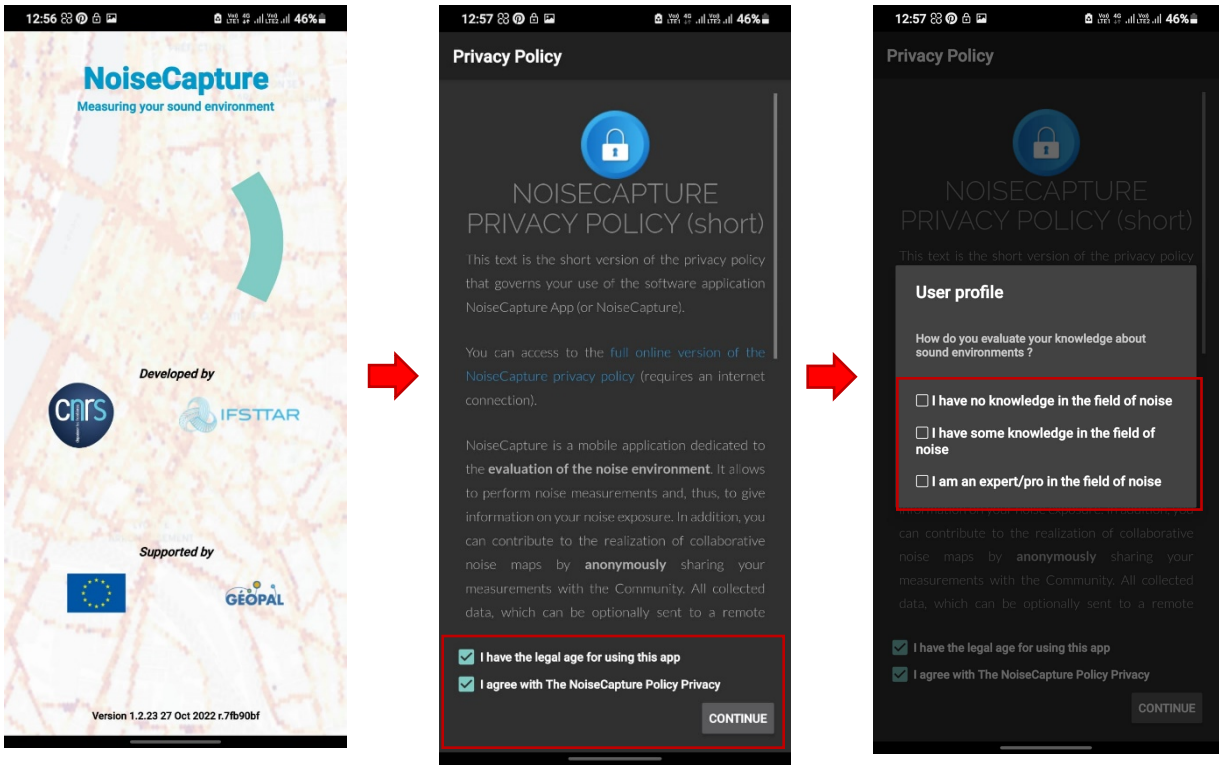


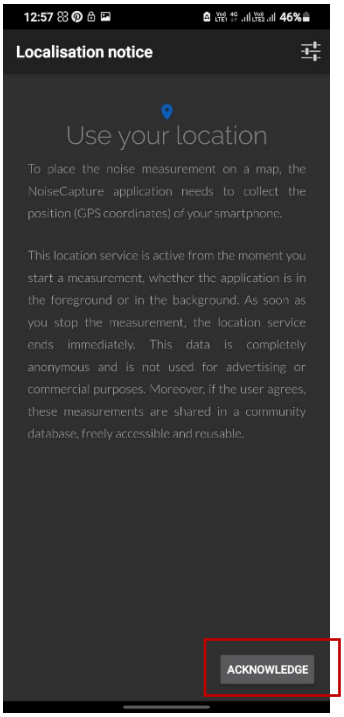
Figure 114 - Install the app

Step 2: Open the App and Set Up

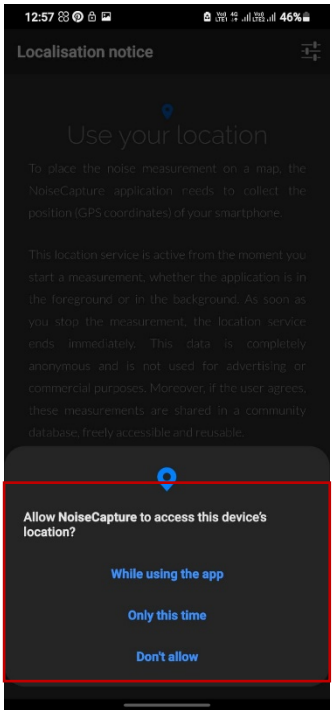
Once you have downloaded and installed the NoiseCapture application, follow these steps to set it up. Figure 117 guides this process.



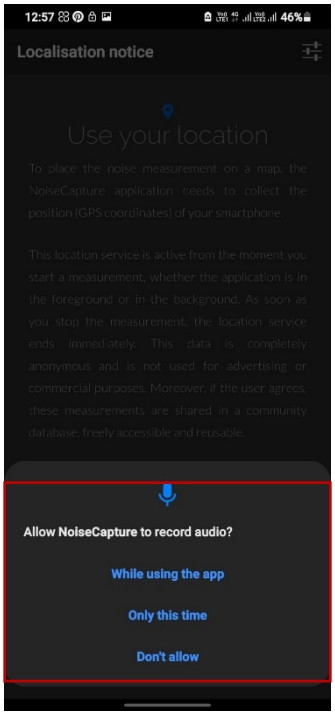
3. Open the app
2. Tick the checkbox
1. Tick the checkbox as per your knowledge



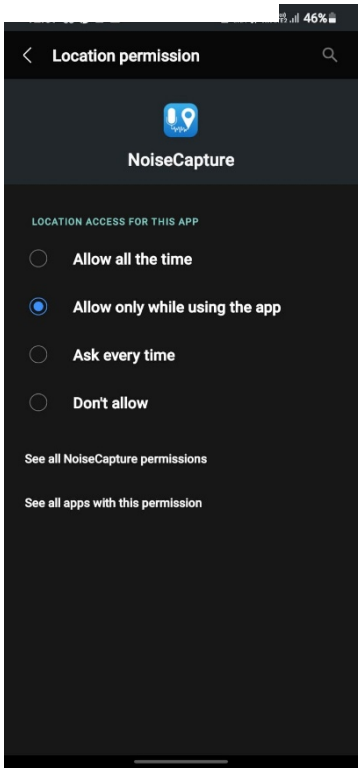
6. Select Acknowldge



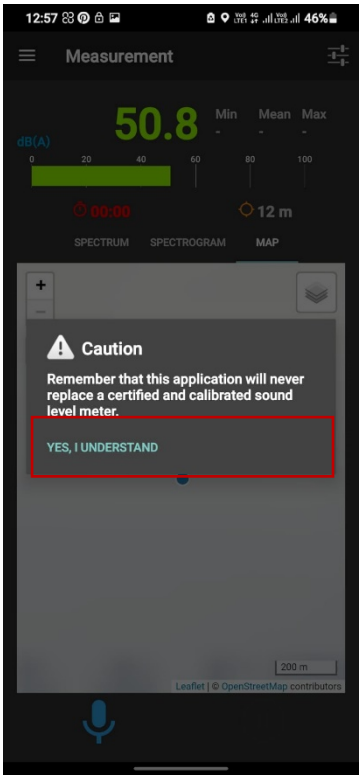
4. Give the location permision



5. Give the microphone permision



8. Set the location Acess



7. Select "Yes I understand"

Figure 115 - Setup the app

Step 3: Start Recording

3.1 – Identify the interface

Once the Noise Capture app is set up, familiarize yourself with the app's interface. The main interface includes three main tabs: Spectrum, Spectrogram, and Map. Each tab provides different functionalities to help you record and analyze noise levels effectively.

- Spectrum: The Spectrum tab displays real-time noise level measurements in decibels (dB). It shows a bar graph indicating the noise levels over time.
- Spectrogram: The Spectrogram tab provides a visual representation of the noise frequency spectrum over time. It shows how the sound frequency components change, with different colors representing different intensity levels. The graph represents two dimensions. The horizontal axis shows the time, while the vertical axis shows the frequency, and the color shows the dB level.
- Map: The Map tab displays your current location and geo-tagged noise levels. It shows where noise measurements are being taken and provides a spatial view of noise pollution.

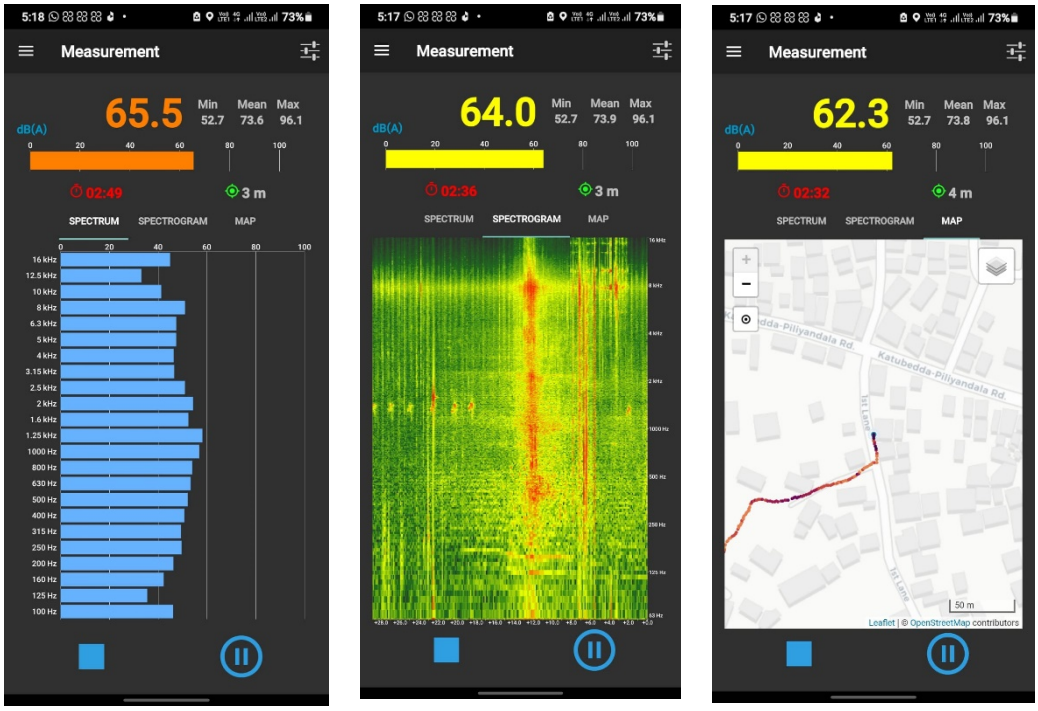


Figure 116 -3 Main Tabs

3.2 – Start Recording

First, start the recording by clicking the recording icon shown below.

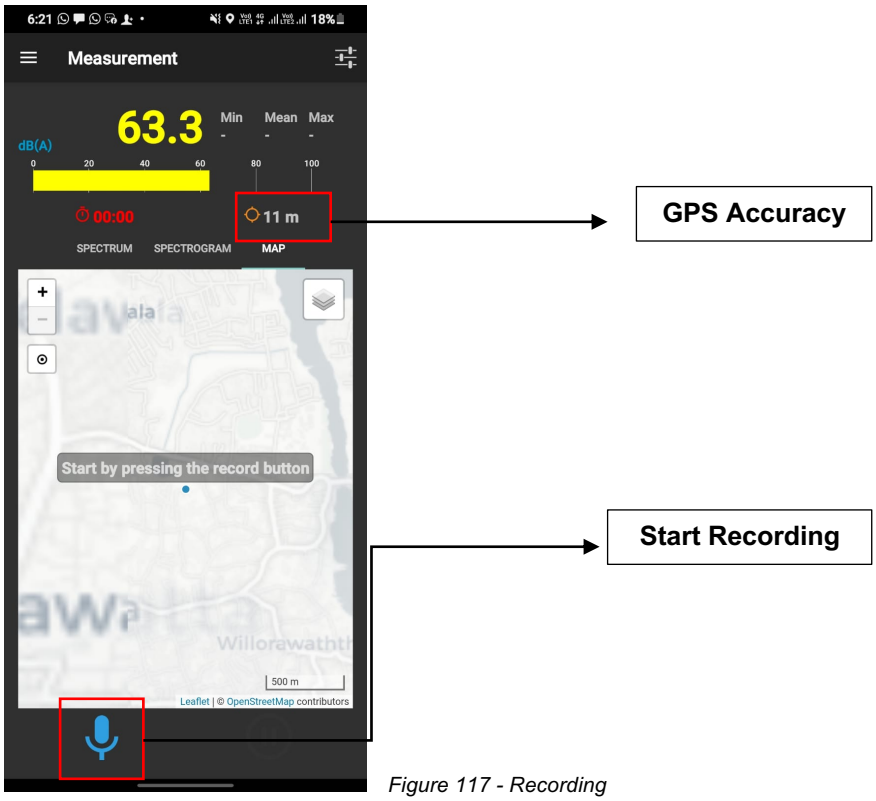


Figure 117 - Recording

Step 4: Once finished with the recording click on the below icon to stop the recording.

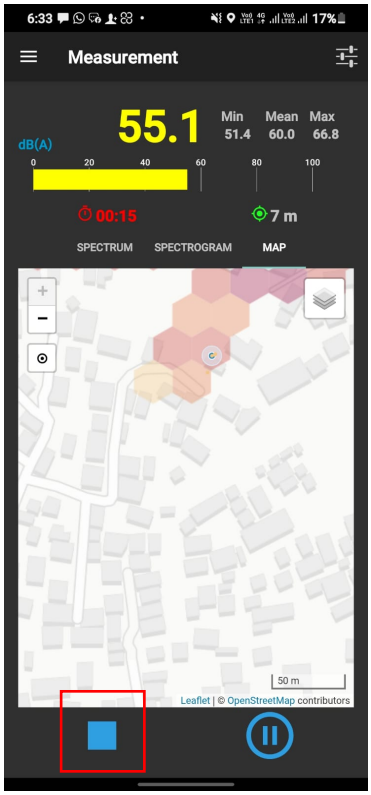


Figure 118 -Stop the Recording

Step 5: Add Description and press validate.

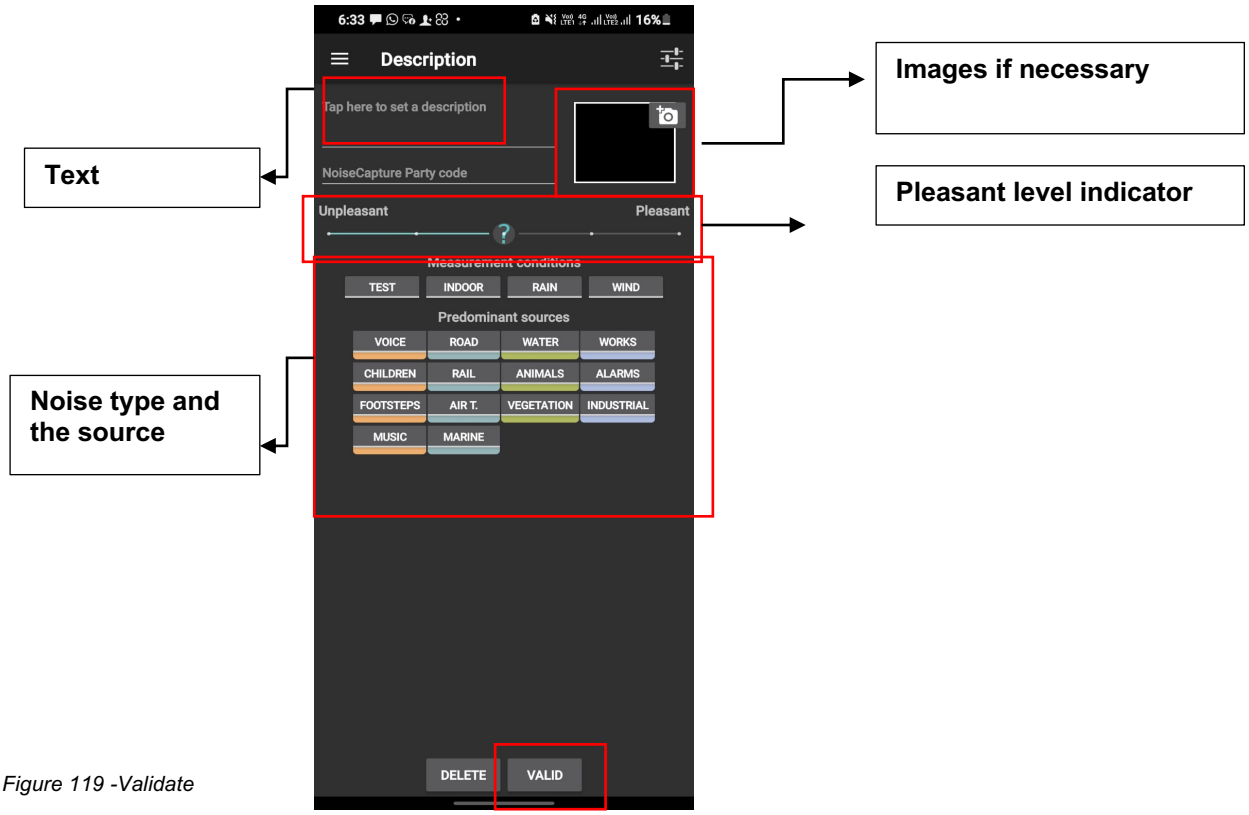


Figure 119 -Validate

Then you can view the results as shown in the figure

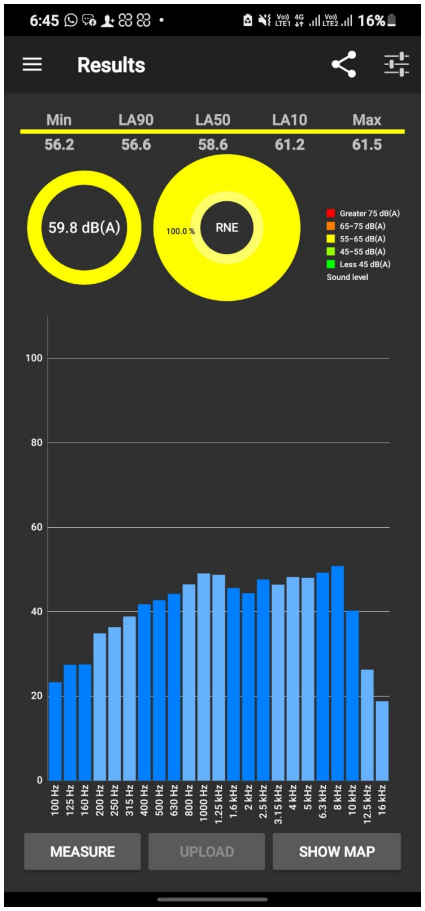


Figure 120 -Results

Step 6 – Map features

Click on "Show Map" to visualize your location and access the editing features for your map.

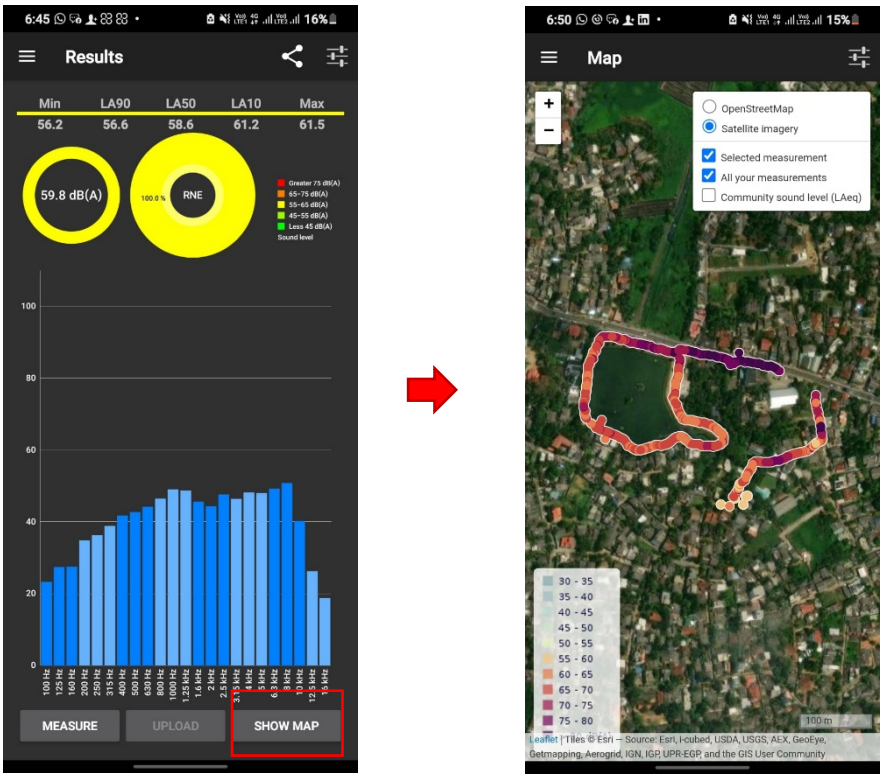


Figure 121 -Map Features

Step 7 – Export Data

To export the data, follow the below steps

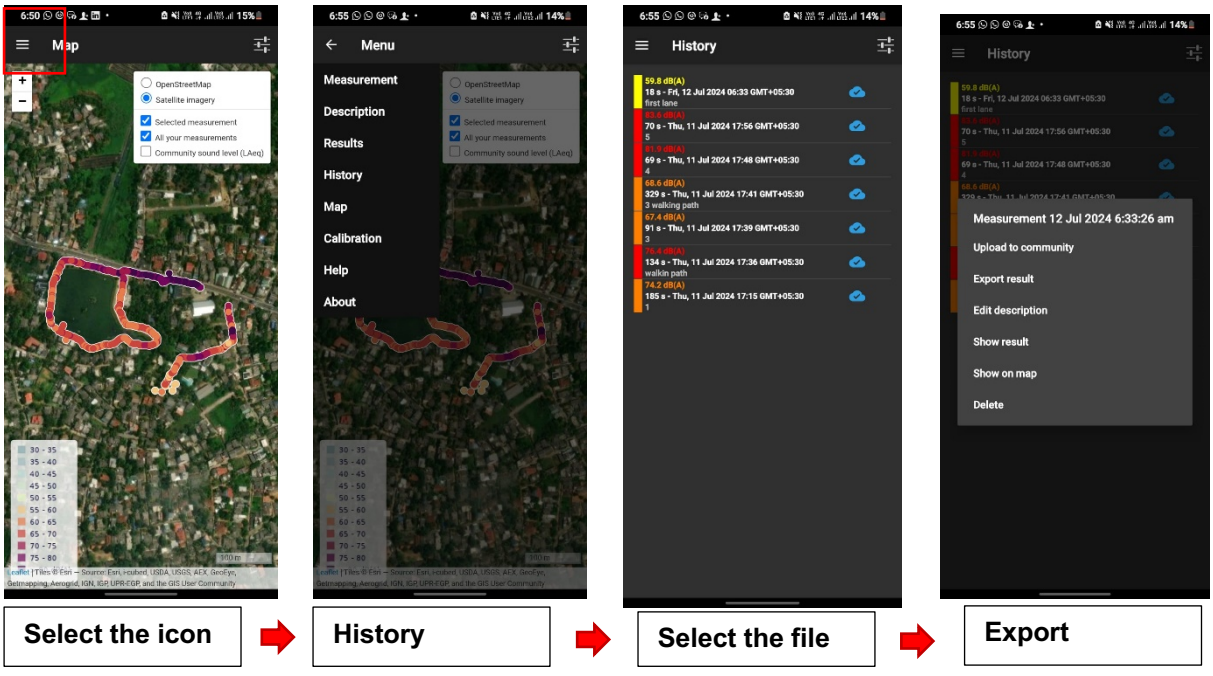
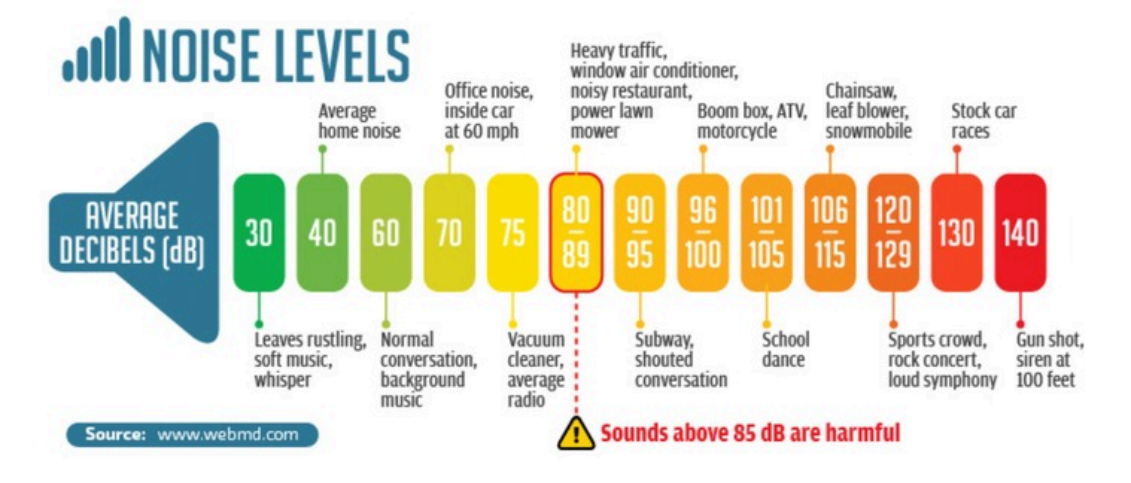


Figure 122 -Export Data

What is a Decibel (dB)?

A decibel (dB) is a unit of measurement that indicates the intensity of a sound. It is a logarithmic scale used to describe sound pressure levels, where each 10 dB increase represents a tenfold increase in sound intensity.



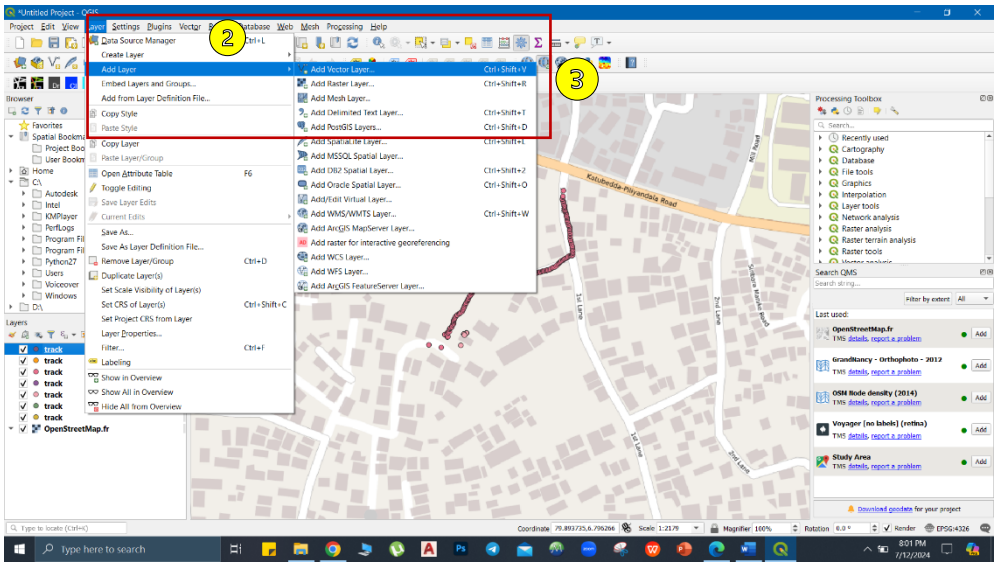
Noise Standards for Specific Locations:

Various organizations have established guidelines and standards for acceptable noise levels in different environments. These standards aim to protect public health and welfare by minimizing noise pollution.

- World Health Organization (WHO) Guidelines: https://www.ruidos.org/Noise/WHO_Noise_guidelines_4.html#:~:text=To%20avoid%20hearing%20impairment%20in,field%20equivalent%20sound%20pressure%20levels.
- Occupational Safety and Health Administration (OSHA) Standards https://www.osha.gov/noise/exposure-controls
- Environmental Protection Agency (EPA) Recommendations : https://www.epa.gov/archive/epa/aboutepa/epa-identifies-noise-levels-affecting-health-and-welfare.html#:~:text=The%20document%20identifies%20a%2024,preventing%20activity%20interference%20and%20annoyance.

Step 8 – Add Data into QGIS

1. Start QGIS on your computer.
2. Go to the Layer menu.
3. Select Add Layer, then choose Add Vector Layer.
4. In the dialog that opens, set the Source type to File.
5. Click Browse to locate your **GeoJSON** file on your computer.
6. Select the **GeoJSON** file and click Open.
7. Finally, click Add to load the GeoJSON file into QGIS.



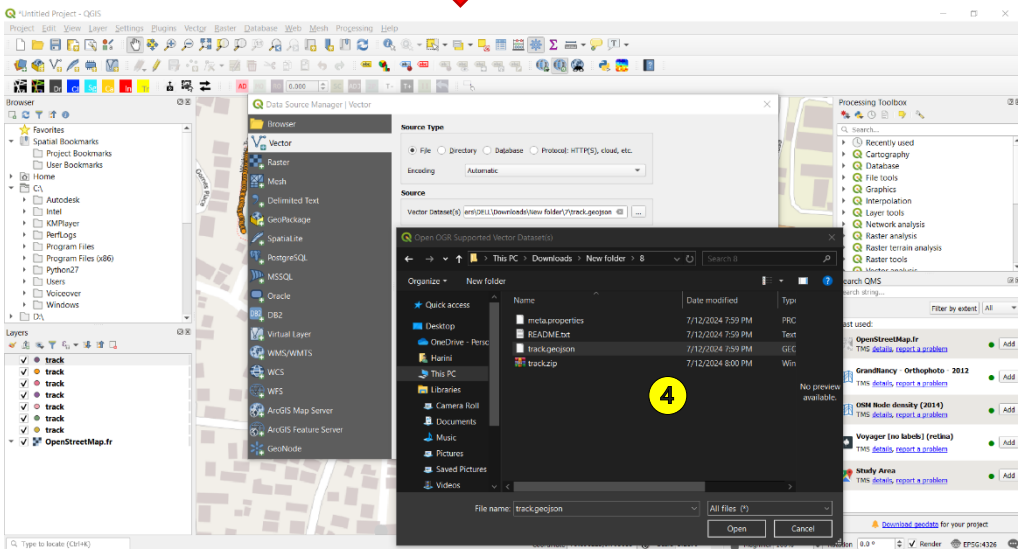


Figure 123 - Add to QGIS

Step 9 – Categorized the data

1. Go to properties in the data and select "Graduated" in the Symbology panel.
2. Choose the leq_mean (leq_mean appears to be the mean equivalent continuous sound level, which is a common metric used in noise studies to represent average noise levels over a specified period) field as the value to be used for the classification.
3. Select a Color Ramp that will represent the range of noise levels.
4. Classify the data by clicking the "Classify" button.
5. Apply the settings and visualize the data on the map

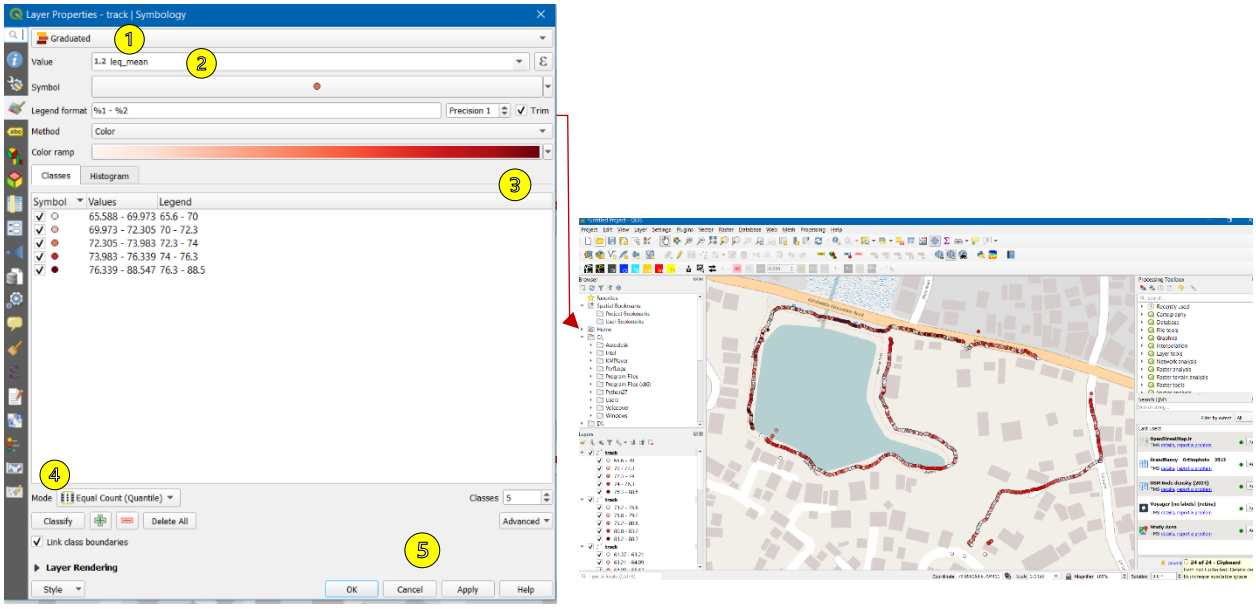


Figure 124- Add Symbology