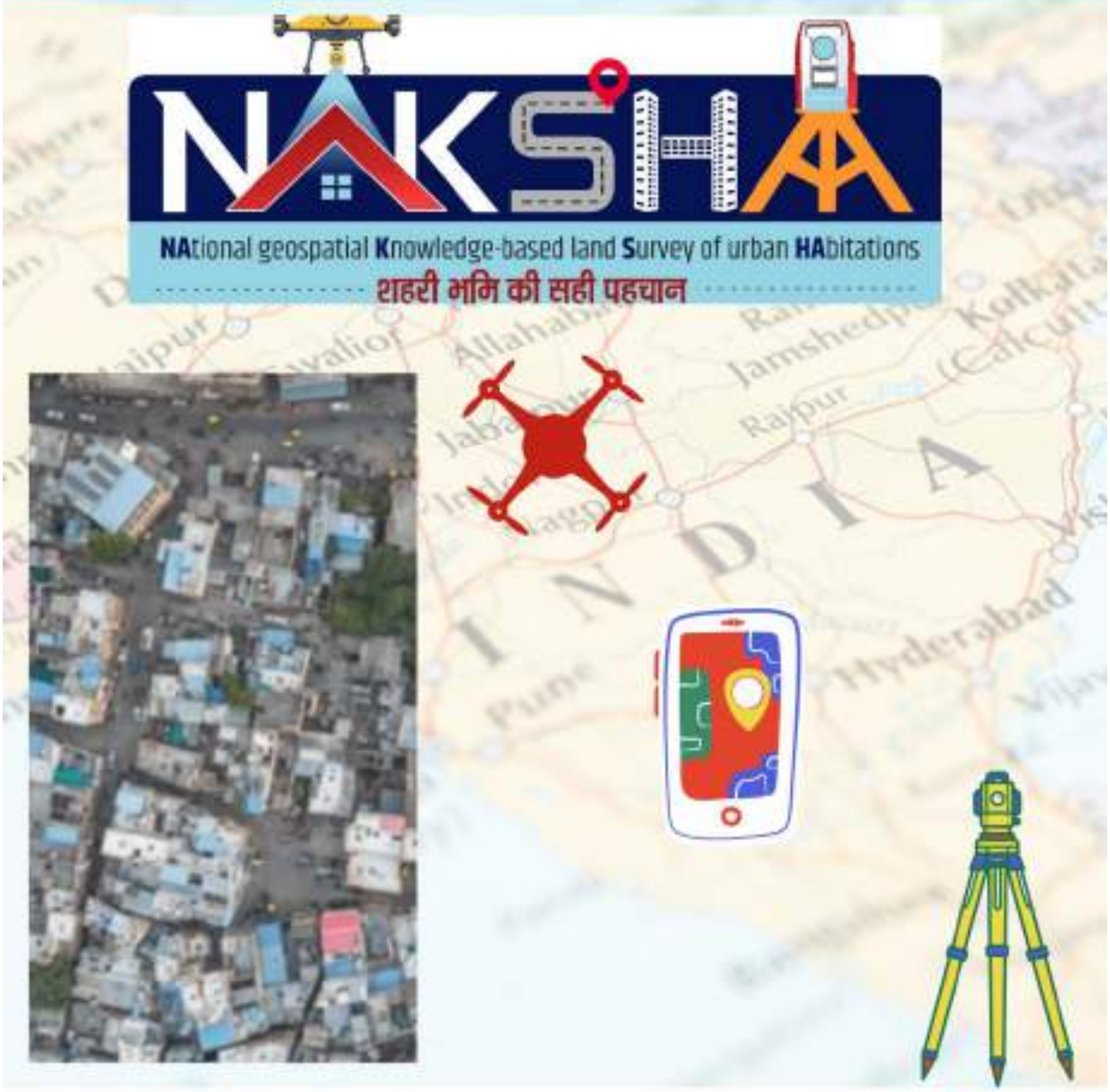
भूमि संसाधन विभाग
DEPARTMENT OF LAND RESOURCES
MINISTRY OF RURAL DEVELOPMENT
GOVERNMENT OF INDIA

भारतीय सर्वेक्षण विभाग
Survey of India
विज्ञान और प्रौद्योगिकी विभाग
Department of Science & Technology

Six Days Training Programme for Master Trainers



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भारतीय सर्वेक्षण विभाग | Survey of India
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Course Name	Training of Field level Officials- Master Trainers under NAKSHA Programme			
Training Module Name	Field Survey Using GNSS and ETS Integrated with Mobile Application			
Description	This document covers the training module designed and executed by NIGST, Survey of India to train the Field Level Officials-Master Trainers under NAKSHA Programme in modern ground survey techniques using modern survey equipment's and tools including GNSS, CORS, ETS, and a GIS based Field Survey Mobile application. It equips them with the skills to accurately capture and validate land parcel vertices during post-MAP1 surveys, ensuring reliable spatial data for further processing.			
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Note: All presentations/SOP/User Manual related to this content material are provided in the drive:

https://drive.google.com/drive/folders/17tnCf1JezkD7o64s5P-KIaNnO10diVlD?usp=drive_link

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1. Introduction

The **NA**tional geospatial **K**nowledge-based land **S**urvey of **u**rban **HA**bitations (NAKSHA) is a pilot programme has been initiated by the Department of Land Resources (DoLR), Ministry of Rural Development (MoRD), Government of India. It aims to create and digitize urban and peri-urban land records through an integrated solution which leverages modern surveying and mapping technologies.

The NAKSHA programme is planned to be implemented in collaboration by the Department of Land Resources (DoLR), Government of India; Ministry of Housing and Urban Affairs (MoHUA), Government of India; Survey of India (SoI), Dehradun; State Revenue & Urban Development Department/ Local Self Government; Madhya Pradesh State Electronics Development Corporation (MPSEDC), Bhopal; National Informatics Centre Services Inc OR (NICSI).

The NAKSHA pilot programme workflow involves use of aerial platforms with most modern payloads covering optical (single camera), oblique (five camera) and Lidar technologies, CORS Network solutions and Enterprise web GIS solution approach for programme implementation. The end-to-end workflow also involves rigorous field validation, ground truthing for spatial and non-spatial information involving State/UT Governments to ensure that accurate, updated and ground verified data is created and finalised following due process of notification, inquiry and objection resolution as per applicable regulatory provisions in State/UT Governments across the country. The aim is to create the integrated spatial & non-spatial database or cadastre for these urban and peri-urban areas to realize an Integrated Land Information and Management System (ILIMS) for effective urban planning, monitoring and dispute resolution.

The Programme has been initiated in 152 ULBs/Local Self-Government across the country with Survey of India (SoI) as the Technical Partner with responsibility for the aerial survey and feature extraction works. The State/UT Governments (29 State/UTs as of now) would complete the field survey, ground truthing and final publication of urban and peri-urban land records.

Capacity building and Training is one of the very critical components of the programme and considering this criticality, the capacity building activities at various levels (National and

State/UT level) have been conceptualized and planned for all the stakeholders under the programme.

National level, training activities under the programme have been planned at various institutes viz National Institute of Geo-informatics Science & Technology (NIGST), Survey of India, Hyderabad; Yashwantrao Chavan Academy of Development Administration (YASHADA), Pune, Maharashtra and Mahatma Gandhi State Institute of Public Administration (MGSIPA), Chandigarh; Lal Bahadur Shastri National Academy of Administration (LBSNAA), Mussoorie, Uttarakhand; Northeast Region Centre of Excellence, Guwahati, Assam and Administrative Training Institute (ATI),Mysuru, Karnataka. Similarly, State/UT level trainings for ULB staff level (level 5) will be designed and implemented by the respective State/UT Administrative Training Institute (ATI) for all State/UT officials.

Capacity building plan for the NAKSHA programme has divided target officials from Central Ministries, State/UTs, NPMU (DoLR), SPMUs (State/UTs) and CoEs in various categories for National and State/UT level training activities. All senior officials (Centre/State/UT/CoEs/NPMU) are kept at Level 1; Middle level officials (Centre/State/UT/CoEs/NPMU/SPMUs) are kept at Level 2; Field Level officials as Master Trainers (State/UT/CoEs/SPMUs) are kept at Level 3; SPMU officials at Level 4 and ULB level staff (State/UTs) are kept at Level 5 for various training activities under the programme.

Presently, Level 3 training for Field Level officials as Master Trainers (State/UT/CoEs/SPMUs) for six days is being organized by National Institute of Geo-informatics Science & Technology (NIGST), Survey of India, Hyderabad. These Master trainers will be responsible for training the ULB Level staff in their State/UTs.

2. Scope of the Document

This document has been prepared for the Level 3 training for Field Level officials as Master Trainers (State/UT/CoEs/SPMUs) for six days by National Institute of Geo-informatics Science & Technology (NIGST), Survey of India, Hyderabad. This document will complement the NAKSHA Standard Operating Procedure (SOP) prepared by the Department of Land Resources (DoLR), a copy of the NAKSHA SoP document has been provided to all the trainees as part of training material.

This material pertains to the training course for training the field level officials for implementing the field survey process mentioned in **Chapter 6 MAP-2: Field Survey and**

Ground Truthing of the above SOP for collecting land parcel or property extent vertices from the field using surveying technology solutions based on CORS (Continuous Operating Reference Station) Network infrastructure, GNSS (Global Navigation Satellite System) Rovers, Electronic Total Station (ETS) and Web GIS solution (Mobile & Desktop application). It covers all training modules prepared to train the field survey officials in all field activities (to capture or update spatial as well as non-spatial information) to be carried out by the State/UT officials as per the responsibility matrix outlined in the NAKSHA SOP. These field activities under MAP-2 stage as per NAKSHA process implementation flow are carried out on receipt of MAP-1 output deliverables from Survey of India (SoI) Geospatial Directorate (GD) for an ULB under the NAKSHA pilot programme.

3. Training Programme for Field Survey & Ground Truthing

NIGST, Survey of India has designed this training programme for Field Level Officials-Master Trainers from the State/UTs for **MAP-2: Field Survey and Ground Truthing** to be carried out by the field survey officials of the State/UT under NAKSHA programme. These experienced field survey officials from the State/UT on completion of this training will be equipped with requisite knowledge and skills to act as Master Trainers and will be responsible for imparting the **MAP-2: Field Survey & Ground Truthing** training to the ULB level staff in their State/UTs under the Capacity Building plan activities of the NAKSHA programme.

Field survey activities under **MAP-2: Field Survey & Ground Truthing** primarily involves collection of land parcel or property extent vertices with associated ownership information (in textual or attribute form) and preparing the land parcel or property (or ownership) data set using latest surveying technology solutions covering CORS Network, GNSS Rovers, ETS, Mobile & Desktop application etc.

The primary objective here is to equip these field survey officials with the knowledge & skill to carry out the necessary field measurements, record the field measurements and to analyse & utilize the latest technology inputs like Ortho-rectified imagery & vector data (representing the actual ground features in correct position measured with desired accuracy) during the field survey. These field surveyors are expected to make the maximum use of these valuable ground witness points or markers (which can be validated during the ground truthing) in advance in office itself while carrying out the field survey planning along with existing available primary survey records, cadastral records, and

other official records for the area of survey. The ultimate objective is to accurately and correctly capture the property or land parcel extent during the field survey means the location, shape and size (dimensions & area) of the property along with the ownership (owner name, ownership type etc.).

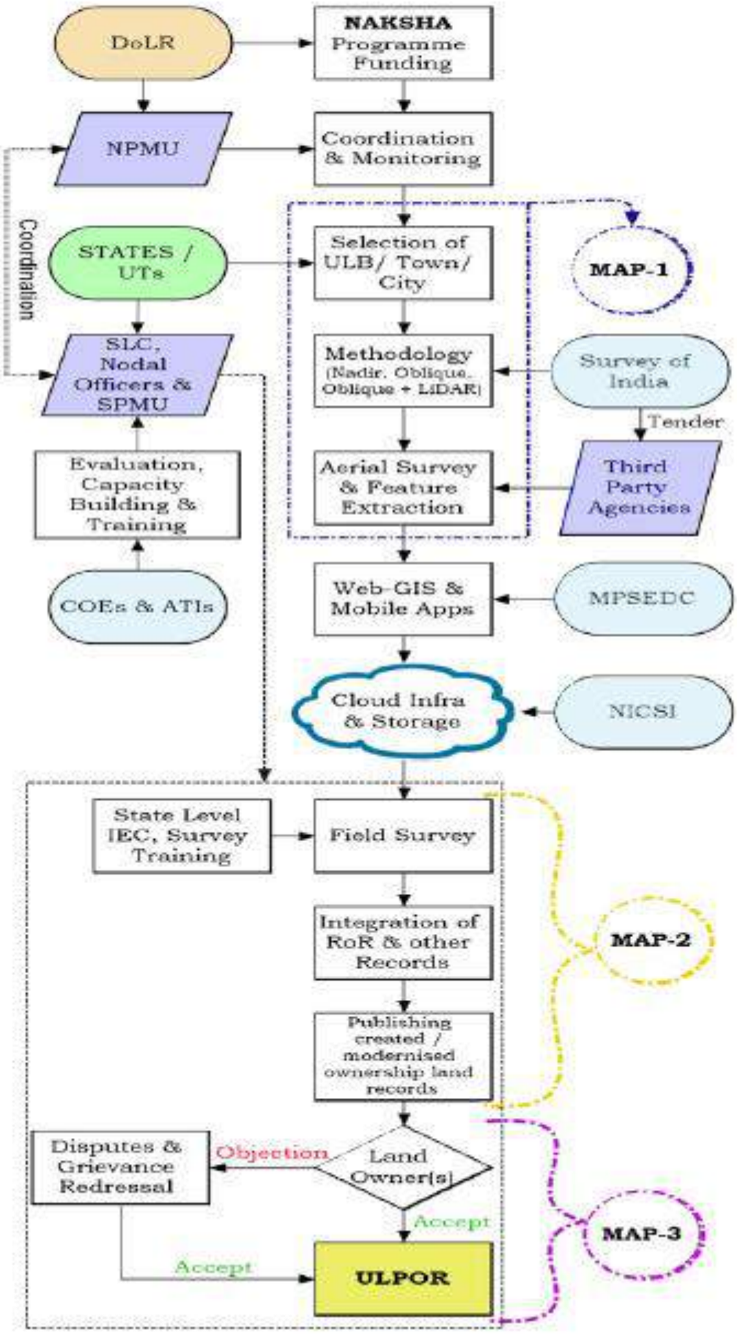


Figure:1 NAKSHA Programme Implementation Workflow

(Source: NAKSHA SoP by DoLR)

As per programme implementation workflow shown above, the field survey stage under MAP-2 is to be carried out by State/UTs.

Field Survey Methodologies to be followed for field survey & ground truthing are as under:

Option-1: Field Data Collector (FDC) Integrated with GNSS Rover Receiver and CORS Network,
Option-2: GNSS Rover Receiver and CORS Network,
Option-3: Electronic total Station (ETS) with GNSS Rover Receiver and CORS Network,

Option-1: Field Data Collector (FDC) Integrated with GNSS Rover Receiver and CORS Network involves use of *Mobile & Web application* developed *by the MPSEDC, Govt of MP* for *Ground Truthing & Field verification* using GNSS Rover Receiver and CORS Network.
Option-2: GNSS Rover Receiver and CORS Network methodology is to be used in cases Mobile *& Web application* of *MPSEDC, Govt of MP* for *Ground Truthing & Field verification is either not available for use or it is not feasible to use this application, or some other mobile & web application is to be used by the State/UT*. The field survey for data capturing in this method must be carried out using GNSS Rover Receiver and CORS Network. The coordinates thus observed in the field survey will be recorded using rugged laptop/FDC installed with other custom or open Source or proprietary Mobile & Desktop GIS application.
Option-3: Electronic total Station (ETS) with GNSS Rover Receiver and CORS Network is to be used in cases requiring use of ETS along with GNSS Rover Receiver and CORS Network to capture land parcel or property vertex points having obstructions (full or partial coverage with canopy or other object) for GNSS Rover observations. The coordinates observed in the field survey will be recorded using rugged laptop/FDC installed with MPSEDC /other custom/open Source or proprietary Mobile & Desktop GIS application.

Field Survey & Ground truthing activities under MAP-2 stage can be divided into Pre-Survey, Survey & Post Survey activities as under:

3.1 Pre-Survey Activities:

- To organize the Public Meetings for field survey well in advance as per extant process,
- Collection of MAP-1 deliverables for the area of survey i.e. Ortho-Rectified Imagery (ORI), Feature Extracted (2D/3D data as applicable) Map data along with

Topographical Property Markers, Elevation data and 3D Mesh Model (wherever applicable), Hard copy maps of ORI with features (as per requirement),

- Collection of existing maps, legal documents, cadastral records, property tax details, Integration of existing State/UT specific Web GIS City Survey Module with MPSEDC GIS platform for seamless integration (as applicable),
- Geo-referencing of cadastral maps, lay out plans etc., wherever applicable for use during the field survey,
- Field Survey Instruments (FDC, NRTK GNSS Rover, ETS, ETS Prism, Bipod/Tripod for GNSS Rover etc.), Equipment's (Rugged FDC with camera &/or Laptop), Software's (Mobile & Web Application software's), Small Paint box & Brush (To mark ground points during fields survey), Field items bag, an umbrella, Pen and Note pad as per the survey methodology being used i.e. ***Option-1/2/3***,
- To check the calibration and operation of all field instruments,
- Field Team (as per the constitution) with field vehicle,

3.2 Survey Activities:

- Land-parcel or property boundary points/features visible (refer topographical markers) in the Map or ORI should be identified and verified or updated (as the case may be) on the ground as per Urban Property Card format given in NAKSHA SoP by the survey team during the field survey using field instruments (GNSS Rovers, FDC with Mobile application and ETS etc.) depending on the terrain conditions and availability of the field instruments with States/UTs using either ***Option-1/2/3*** survey methodology .
- In cases, distinguishing feature of a land parcel/property are visible on ORI/Map, it can be used/vectorized for creating or updating the ground verified property data set.
- Survey team should refer all points given in the **NAKSHA SoP: 6.22-Land Parcel Survey Execution - Boundary Point Measurement and 6.27- Government Properties/Land** during the field survey execution.
- Land-parcel or property boundary points not visible (or missing) in the Map or ORI should also be surveyed, observed and recorded on the ground by the survey team.
- In cases, the boundaries of a field are not demarcated on ground, the boundaries must be demarcated with recorded observations by the surveyor in the presence of the

landowners, neighbours, panchayat officials etc. with its classification, revenue number etc. as per the latest revenue records and/or as per the present enjoyment.

- Ownership and other details collected during the field survey is to be verified with information contained in official documents available with the Government/land holders like Record of Right, Sale Deed, Lease Deed, Gift Deed, Relinquishment Deed, Settlement Deed, Occupancy Certificate, Deed of Partition, Lay out Plan, Property Tax Receipt, Building Sanction Plan, Will, General Power of Attorney (GPA), Agreement to Sell(ATS), Utility Bills, Mutation Certificate etc.
- Field survey team should also ground validate some of the prominent features extracted from the ORI such as utilities, buildings etc. for correctness.
- Survey team will have to take the front view geotagged photographs of the land parcel/property using a high-resolution camera.
- In general, as a thumb rule, areas with poor GNSS satellite signals (Signal outage or poor PDOP) due to dense structures, narrow roads, canopy areas, HT lines etc., the point coordinates data shall be collected using ***Option-3*** methodology i.e. ETS measurements.
- The finalization of the ownership or property data layer of land/property parcel boundaries shall be carried out using desktop GIS software in laptop.

3.3 Post Survey Activities:

- Metadata of the final Property layer data is to be created including Survey details, Projection & Datum, Survey Instruments used, Survey Methodology used, CORS network details and Reference stations used etc.
- The created final property layer data should be stored and archived with backup and security.
- Integration of property tax and RoR (if exists) details with land parcel data is to be done. For integration purpose, the states should use Web GIS application developed by MPSEDC under NAKSHA programme. The web GIS solution will have the functionalities to integrate the Record of Rights (RoR) data through APIs, however in absence of such API based integration feasibility with some of the State/UTs, it is expected that such RoR data will be available with the field officials while carrying out the field survey.

- Quality check of the land parcel data is to be carried out at various levels by State/UT officials as per State/UT statutes/Rules or norms/practices.

4. Training Programme for Field Level Officials-Master Trainers Design & Outline:

This Training Course has been designed for the knowledge & skill upgradation of the field level officials of State/UT, who will further train the field level manpower in their respective State/UT. The current training program is focused on preparation of MAP-2: Field Survey and Ground Truthing activities to be executed on receipt of MAP-1 deliverables from Survey of India (SoI) Geospatial Directorate (GD) for carrying out field survey and ground truthing to collect land parcel/property boundary and cadastral information.

The six-day training program has been designed with Theory lectures, Practical demonstrations, Hands-on field exercises and Group field survey activity. Training was imparted by Experts, Practitioners, NIGST Faculty and SoI field surveyors.

4.1 Training Objectives:

- To provide **NAKSHA Programme** overview and understanding of key components.
- To provide basics of Surveying, GNSS & CORS Technology, GNSS Survey (NRTK Method), ETS Survey and GIS applications (Web & Mobile),
- To upskill the field level officials with latest field survey methods & techniques using GNSS Rovers with CORS Network, ETS and Web-Mobile GIS applications.
- To train the participants in **processing and creation of land parcel or property data layer** using GIS tools.

4.2 Training Curriculum:

The training program covered following topics and skills:

- Overview of NAKSHA programme,
- Basics of surveying,
- Aerial data acquisition Methodologies,
- Introduction to GNSS Survey, GNSS Rover, Demonstration on GNSS Rover followed with hands on practice session,
- Basics of GIS, Web GIS, Other GIS (Mobile & Desktop) Applications,
- Demonstration and hands-on sessions on MPSEDC WebGIS solution,

- Demonstration on Drone instrument, its components, Drone Payloads and MAP-1 deliverables,
- Introduction to ETS, Demonstration and hands on practice sessions,
- Field exercises for land parcel or property vertex points collection for creating property data layer,
- Experience sharing on legal and administrative procedures involving objection and conflict resolution.

4.3 Teaching Methods:

- Blended lectures, Interactive sessions, discussions, and presentations.
- Hands-on practical and field sessions for practice,
- Group project, Objective assessment,

4.4 Learning Approaches to be Adopted in the Training:

- Experiential learning approach combining traditional face-to-face classroom sessions blended with demonstrations followed with hands-on sessions and real-world experiences. This approach provides flexibility and allows learners to apply theory to practice.,
- Microlearning approach with content delivery in small, digestible units. This method is effective for quick training sessions and reinforces learning through repetition and questions or discussions.
- Interactive Learning approach encourages engagement through discussions, group projects, and interactive tools it enhances collaboration and communication skills.
- Assessment and Feedback involving regular assessments and constructive feedback from participants, it helps in gauging the understanding and provide inputs & direction for improvement.

Implementing above approaches will be helpful to create a more comprehensive and effective training program, leading to better outcomes and skill retention.

5. Training Infrastructure & Equipment Requirements

5.1 Training Infrastructure Requirements

- One Classroom with LED display Screen or overhead projector, White board and basic AV system with capacity for sitting for 25-30 trainees.

- One GIS lab with at least 10 entry level desktop systems installed with desktop GIS software for use by trainees in groups for Pre-survey and post survey activities.
- Expert Resources and Field Survey trainers for field survey demonstrations followed with hands-on practice sessions.

5.2 Equipment & Instruments Requirements:

- NRTK enabled GNSS Rover along with a field data collector (with camera) loaded with software – For collecting the co-ordinates of the Land Parcel Vertices.
- ETS with Prism - For collecting co-ordinates of the Land Parcel Vertices.
- Controller with installed & configured Mobile Field application- for capturing the field data.
- Laptop installed & configured with Desktop application - for creating or editing the property data.

6. Details of NAKSHA Training Programme for FIELD LEVEL OFFICIALS-MASTER TRAINERS:

6.1 General overview of NAKSHA Programme

The **NAtional geospatial Knowledge-based land Survey of urban HAbitations (NAKSHA)** is a pilot project launched under the **Digital India Land Records Modernization Programme (DILRMP)** by the **Department of Land Resources**. The initiative aims to transform the management of urban land records through modern geospatial technologies, ensuring transparency, accessibility, and accuracy.

The **Survey of India (SoI)** serves as the project's **technical partner**, utilizing advanced mapping technologies, while private agencies are involved through **Request for Proposals (RFPs)/tenders**.

6.1.1 The key stakeholders:

- **States and Union Territories (UTs)**, particularly departments responsible for **Revenue, Urban Development (UD), and Local Self-Government (LSG)**.
- **Urban Local Bodies (ULBs)** that will integrate NAKSHA into their land management practices.
- **The Ministry of Housing and Urban Affairs (MoHUA)**, which oversees the national urban governance framework.

6.1.2 Need for NAKSHA – Why It Matters?

Urban land management in India faces significant challenges, including:

- **Lack of systematically maintained urban land records**, except in states like **Tamil Nadu, Maharashtra, Gujarat, and Goa**.
- **Rapid expansion of urban and peri-urban areas**, both **horizontally and vertically**, leading to an unstructured growth pattern.
- **Unclear ownership of land**, resulting in **disputed property claims and prolonged legal battles**.
- **Obstacles to planned infrastructure development**, as poor land records delay projects and raise costs.
- **High land value**, making land the most critical asset for citizens, necessitating a clear ownership framework.
- **Difficulty in accessing credit**, as banks and financial institutions require verifiable land records for loans and mortgages.

  By implementing **NAKSHA**, the government aims to **modernize urban land records**, reducing disputes, facilitating faster property transactions, and promoting efficient urban planning.

6.1.3 Implementation Strategy & Financials

The NAKSHA initiative is funded under **DILRMP** with an allocation of **₹1,464 crores** (as of **25.06.2024**). The rollout is planned in a phased manner:

- **Phase I:** Focus on **1,000 Urban Local Bodies (ULBs)**, implementing geospatial surveys and digital record-keeping.
- **Expansion Plan:** Based on the **outcomes and learnings from Phase I**, the program will be scaled to **all 4,612 ULBs** in India.

  The project involves:

- **Geospatial mapping and high-resolution surveys** to create a reliable digital land record database.
- **Integration with existing land administration systems** at state and local levels.
- **Use of advanced technology** such as **satellite imagery, drones, and GIS (Geographic Information System)** for precision mapping.

6.1.4 Core Features of NAKSHA

The project is designed to improve land governance with several key features:

A. **Digital Urban Land Records:**

- Creation of **tamper-proof, GIS-based digital records** for urban areas.
- Elimination of **paper-based, fragmented** land documents.

B. **Online Accessibility & Transparency:**

- Landowners, buyers, and financial institutions can verify records online.
- Reduction in corruption and fraudulent transactions related to land.

C. **Automated & Fast Processing:**

- AI-based verification and validation of land records.
- Automated approval systems for property registration and transfers.

D. **Interoperability with Government Systems:**

- Seamless integration with municipal records, revenue departments, and infrastructure databases.
- Smart city initiatives can leverage this data for better urban planning.

E. **Dispute Resolution & Legal Compliance:**

- Easier resolution of property disputes with digital proof.
- Strengthening of legal frameworks related to land ownership.

F. **Support for Urban Development & Credit Access:**

- Banks and housing finance companies can use verified digital records for loan approvals.
- Real estate developers can plan projects more efficiently.

6.1.5 Roles & Responsibilities of Stakeholders

To ensure the success of NAKSHA, various organizations and entities will play a role:

A. **Survey of India (Technical Partner):**

- Leads geospatial surveys and mapping initiatives.
- Implements advanced land surveying techniques using modern technology.

B. **Urban Local Bodies (ULBs) & State Governments:**

- Adopt the system for local governance and land administration.
- Ensure compliance with legal and procedural standards.

C. **Ministry of Housing and Urban Affairs (MoHUA):**

- Provides policy direction and national-level coordination.

▪ Supports expansion and scaling up of NAKSHA across states.

D. Centres of Excellence (CoEs):

▪ Conduct land governance evaluation and research.

▪ Document best practices and recommend improvements.

E. Madhya Pradesh State Electronics Development Corporation (MPSEDC): MPSEDC plays a crucial role in the implementation of NAKSHA by providing **enterprise software solutions, WebGIS integration, and technical support**.

Key Responsibilities of MPSEDC:

1. **Enterprise Software Development:**
   - Developing software solutions tailored to the needs of **state governments and urban local bodies (ULBs)**.
   - Ensuring that the software aligns with existing digital land records systems.
2. **Customization & State Integration:**
   - Dovetailing the software as per **state-specific land governance requirements**.
   - Facilitating seamless integration with **municipal and revenue department databases**.
3. **Training & Support on WebGIS:**
   - Providing **technical assistance and capacity building** for state officials.
   - Offering **training programs** on the usage of **WebGIS platforms** for urban land management.
4. **Survey Data Management & Processing:**
   - Supporting **data synchronization, validation, and publication** of survey records.
   - Managing modules related to **ground truthing, data verification, and Record of Rights (RoR)**.
5. **Development of IT Infrastructure & Dashboards:**
   - Creating **real-time dashboards** for monitoring survey progress.
   - Implementing **testing, training, and go-live support** for the digital platforms.

MPSEDC acts as a **technology enabler**, ensuring that geospatial land survey data is efficiently processed, stored, and made accessible for urban land governance.

F. **Role of NICSI in NAKSHA:** The **National Informatics Centre Services Incorporated (NICSI)** plays a vital role in **data management, IT infrastructure development, and cloud services** for the NAKSHA project. Its expertise in **cloud computing, data center management, and technological integration** ensures the smooth operation of geospatial land records systems.

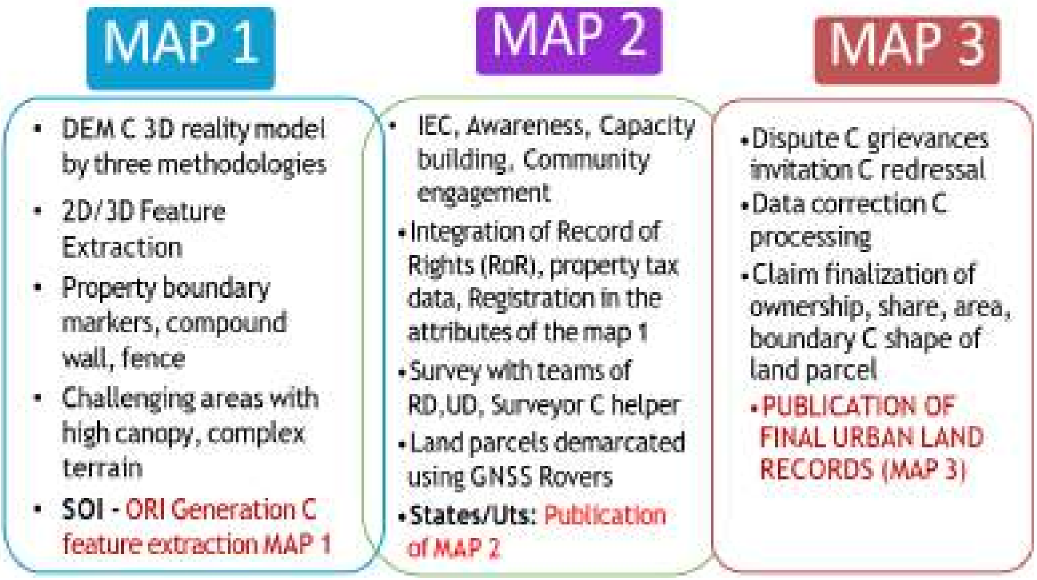


Figure: NAKSHA Workflow

Key Responsibilities of NICSI:

1. **Data Management & Infrastructure Support:**
   - Developing **comprehensive data management systems** for efficient collection, storage, and processing of **geospatial data**.
   - Enhancing the accuracy of **urban land surveys and records** through robust IT infrastructure.
2. **Cloud Computing & Capacity Expansion:**
   - Serving as a cloud service provider for the project, ensuring scalability and accessibility for government departments.
   - Expanding cloud capacity to accommodate growing demands, ensuring seamless service delivery.

3. **Integration of Data centres:**
    - Unifying cloud services across multiple government departments through centralized data centres.
    - Managing National Data centres in Bhubaneswar and Hyderabad, providing secure and high-quality cloud solutions.
4. **Technological Integration & Real-Time Access:**
    - Integrating modern geospatial technologies with traditional land records to improve accuracy.
    - Enabling real-time data access for stakeholders, including urban local bodies, financial institutions, and policymakers.
5. **Project Supervision & Compliance:**
    - Acting as a strategic controller, ensuring project execution within timelines and budget constraints.
    - Overseeing compliance with IT standards and data security protocols.
6. **Public-Private Partnership (PPP) Implementation:**
    - Collaborating with Indian Cloud Partners (ICP) to develop resilient IT infrastructure.
    - Managing service providers within the government cloud ecosystem, ensuring transparency and operational excellence.

NICSI ensures that NAKSHA's **IT backbone is secure, scalable, and efficient**, enabling effective land records modernization across India.

6.1.6 Challenges & Future Roadmap

Potential Challenges in Implementation:

- **Resistance to Change:** Local government officials and landowners may take time to adapt to a digital system.
- **Data Security & Privacy:** Digital records must be safeguarded against cyber threats.
- **Coordination Across Multiple Agencies:** Effective integration of land records across **various government departments** is necessary.
- **Technological & Infrastructure Barriers:** Some states may require additional resources and training for implementation.
-

Future Enhancements & Expansion Plans:

- **Use of AI & Blockchain for Land Records:** To ensure data integrity and prevent tampering.
- **Expansion Beyond ULBs:** Inclusion of rural and semi-urban areas in future phases.
- **Global Best Practices Adaptation:** Benchmarking against international standards for land records management.

NAKSHA represents a **transformational initiative** in India's urban land governance, leveraging modern technology to enhance transparency, efficiency, and accessibility in **land records management**. With phased implementation and continuous improvements, the project aims to reduce land disputes, promote structured urban planning, and facilitate economic growth.

The initiative's success will depend on **effective collaboration among government bodies, technical experts, and private stakeholders**, along with robust policy implementation and public awareness.

Refer to the Presentation on "NAKSHA Overview" in the drive

6.2 Basic Concepts of Surveying

6.2.1 Introduction to Surveying

Surveying is the **art and science of measuring distances, angles, and heights** to determine the relative positions of points on the Earth's surface. The results of these measurements are then represented on a map or a digital platform, showcasing both **natural and artificial features**.

In technical terms, surveying involves:

- **Quantified and qualified measurements**,
- **Interpretation of those measurements**,
- **Meaningful presentation of results** for various applications like construction, land records, and geospatial analysis.

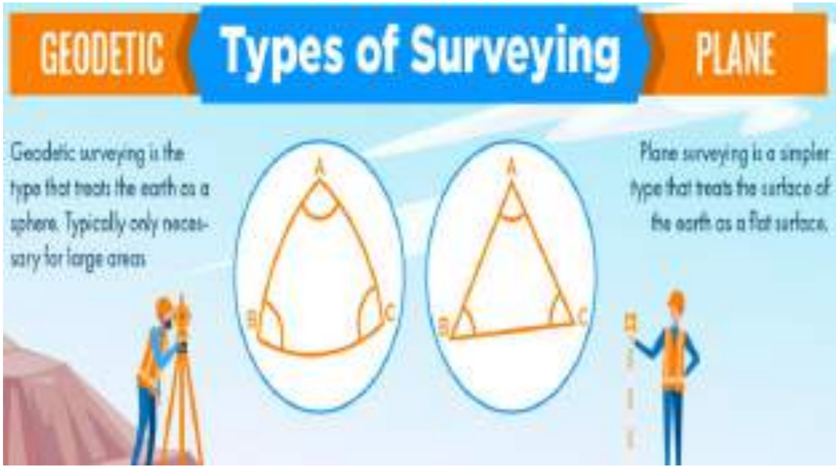
6.2.2 Types of Surveying

There are two types of surveying:

1. **Plane surveying:** Earth surface is considered a plane of x-y dimensions (flat surface).
   - Z-dimension (height) referenced to the mass spherical surface of the earth (Mean Sea Level).

- Most engineering and property survey are plane survey, correction to curvature is made for long strips (e.g. Highway).
- Horizontal distances are measured in Plane survey.

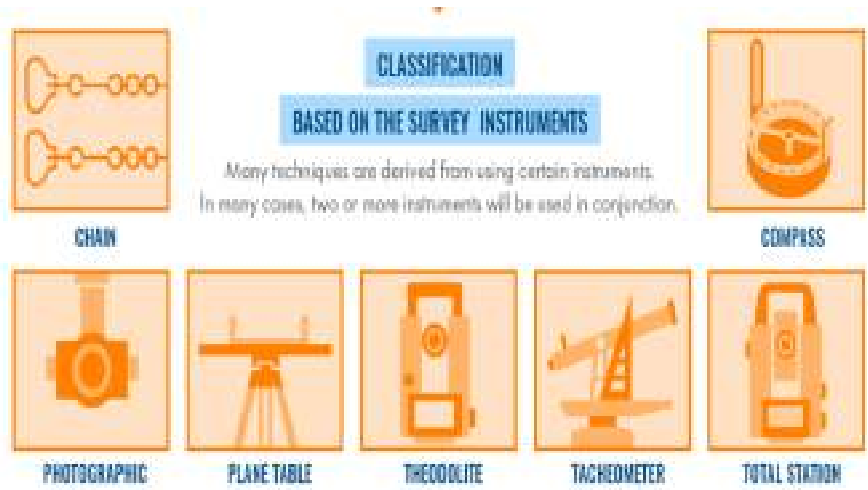
2. **Geodetic surveying: E**arth surface is considered spherical in revolution (ellipsoid).
   - Z is referenced to MSL (surface of earth),
   - Very precise surveys (boundaries and coastal networks) for large areas.
   - Curved distances are measured in Geodetic Survey.



6.2.3 Methods of Surveying

- **Classification based on Nature of Field:** Astronomical Surveys, Boundary or Land or Cadastral or City Surveys, Topographical Surveys, Hydrographic Surveys.
- **Classification based on Purpose of Survey:** Mining Surveys, Control Surveys, Archaeological Surveys, Geological Surveys, Engineering Surveys, Route Surveys, Photogrammetric Surveys.

- **Classification based on Instruments:** Chain Surveys, Compass Surveys, PT Surveys, Triangulation Surveys, Theodolite Surveys, ETS Surveys, GNSS Surveys, Photographic (Manned or Unmanned platform based) Surveys.



6.2.4 Types of Location

Surveying deals with various **types of locations**, including:

1. **Absolute Location:** A fixed, precise coordinate-based location on the Earth's surface.
2. **Relative Location:** A point described in relation to other places or landmarks.
3. **Temporal Location:** A position in time, referring to past, present, or future references in surveying.

6.2.5 Measurement Systems in Surveying

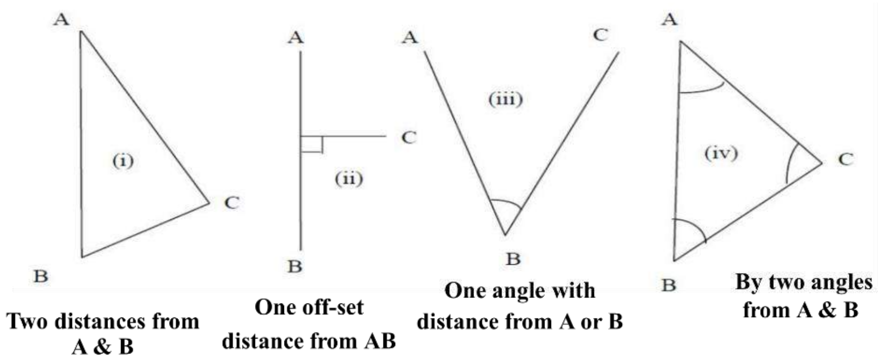
Surveying relies on different measurement systems, categorized into:

1. **Absolute Measurement:** Requires a **defined quantity and unit of measurement**, such as **length, area, mass, volume**.
2. **Referential Measurement:** Requires a reference along with the measured quantity and unit, such as **time, temperature, direction, position, potential energy**.

6.2.6 Surveying Measurement

Surveying measurements focus on:

- Determining distances between **two known points**,
- Identifying the **location of an unknown point** using surveying instruments and methods.



6.2.7 Fundamental Principles of Surveying

To ensure **accuracy and reliability**, surveying follows certain fundamental principles:

1. Working from Whole to Part

- Establishing a **control network** first, ensuring overall accuracy.
- Minimizing errors and preventing **error accumulation** across the project.

2. Locating New Stations

- New reference points (stations) are established using two independent measurements (linear or angular) from known points.

3. Redundancy of Measurement

- Multiple measurements are taken to reduce systematic errors and increase reliability.

4. Consistency of Accuracy

- Large survey projects involve multiple surveyors, methods, and instruments.
- A standardized accuracy framework ensures uniform results across different teams.

5. Independent Checks

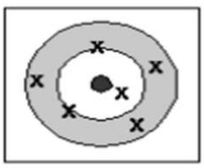
- Checkpoints (horizontal, vertical, or full) are introduced to verify survey accuracy.

6. Economy of Accuracy

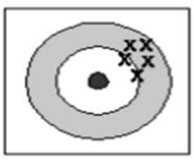
- Choosing the most cost-effective and time-efficient surveying method while maintaining the required accuracy level.
- Example: Fit-for-Purpose (FFP) Approach considers the Cost-Accuracy-Time balance.

6.2.8 Other Key Concepts in Surveying

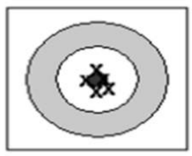
- **Accuracy**: How close a measurement is to the actual value.
- **Precision:** The level of refinement in measurement.



Accurate, not Precise
(the average is accurate)



Precise
not accurate



Accurate
and
Precise

Example:

	True Distance	Measured Distance	Error
Cloth tape	157.22	157.3	0.08
Steel tape	157.22	157.23	0.01

A more precise instrument may **not always** result in a more accurate measurement if errors exist.

- **Right Angle Triangle and Pythagorean Theorem**
  - Right angles (90°) are **commonly used in land surveying**.
  - The **Pythagorean Theorem** ($a^2 + b^2 = c^2$) helps calculate distances.
  - The **3:4:5 triangle rule** simplifies angle calculations in surveying.

- **ERRORS:** No measurement (except count) can be free of error. True value is determined statistically (mean) to calculate error.
  a. **Systematic error:** error whose magnitude and algebraic sign can be determined and eliminated (temp. error).
  b. **Random Error:** This error is random in nature and primarily is there due to due to surveyor skills. These errors tend to cancel each other. This error is of little significance except for high precision survey. Unskilled or careless surveyor can make problem and add random errors in measurements. Large random error doesn't result in accurate work even if they cancel.

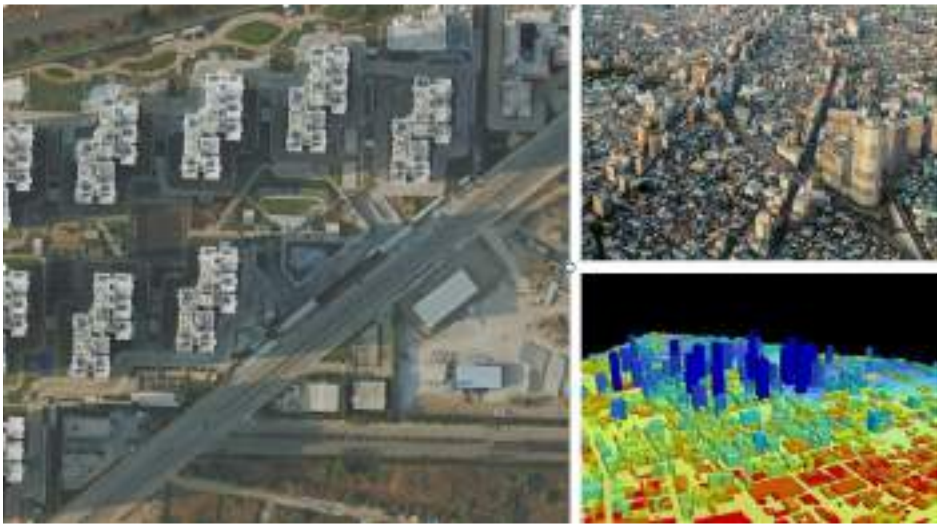
  Refer to the presentation on "Basic concepts of Surveying" in the drive.

6.3 Methodologies of Aerial data acquisition

- Aerial data acquisition is a crucial method used for capturing information about the Earth's surface from above, using platforms such as satellites, drones (UAVs), and aircraft. This process allows for the collection of images and elevation data without direct contact with the ground, enabling large-scale mapping and analysis. The key components involved in aerial data acquisition include the platform, which determines coverage and resolution, and the sensors used to capture different types of data. Common sensors include traditional photography for visual mapping and LiDAR (Light Detection and Ranging) for creating precise 3D models of terrain and infrastructure.

Aerial sensor utility	**2D Nadir Camera ORI for** planned cities, flat roofs, 1-2 storey, clear roads, used in SWAMITVA
	Oblique Angle Camera: more vertical cities with apartment complexes and congested cities
	Oblique Angle Camera and LiDAR sensor: mountainous, very congested old cities, tree canopy density
Flying instrument (UAVs)	**Drones**: Slower, smaller swathe, less stable, low investment, Damages
	Aeroplanes or Copters: Faster, larger swathe, more stable, high investment

- For the NAKSHA project, various methodologies have been adopted to optimize aerial data acquisition. Nadir imaging is one such method, where images are captured directly downward with a 90-degree angle to the ground. This technique minimizes distortion and is highly effective for creating orthoimages, which are essential for accurate geographic mapping. Another method, oblique imaging, involves capturing images at an angle (typically between 30° to 60°), providing a more detailed perspective of structures, including vertical elements like building facades. This technique is particularly useful in urban environments where nadir images may not capture hidden details.



- An advanced approach combines oblique imaging with LiDAR technology to create more comprehensive datasets. LiDAR uses laser pulses to measure distances and generate high-resolution 3D point clouds, making it ideal for mapping rugged terrains or densely vegetated areas. The combination of oblique imagery and

LiDAR enhances both visual and elevation data, facilitating the creation of Digital Surface Models (DSMs) and accurate 3D models. The workflow for generating orthorectified images (ORI) and 3D models includes defining the area of interest, planning the flight path, capturing data, processing the collected information, and delivering the final product.

- The processed outputs from aerial data acquisition serve various applications, including Geographic Information Systems (GIS), urban planning, infrastructure development, and environmental monitoring. True Orthorectified Images (ORI) ensure uniform scale across the images, allowing for accurate distance measurements. Additionally, 3D reality models provide interactive visualizations of physical environments, supporting informed decision-making in architecture, construction, and city planning. With advancements in aerial data acquisition technologies, projects like NAKSHA can achieve high-precision mapping and enhanced spatial analysis, contributing to better resource management and planning efforts.

  Refer to the presentation on "Methodologies for Aerial data Acquisition'' in the drive

6.4 Introduction to GNSS, GNSS Rover Receivers, Demonstration and Hands on practice

6.4.1 Introduction to GNSS

Global Navigation Satellite System (GNSS) is a satellite-based positioning system that provides accurate location data worldwide. It includes multiple satellite constellations such as **GPS (United States), GLONASS (Russia), Galileo (European Union), and BeiDou (China)**, ensuring reliable positioning, navigation, and timing (PNT) services. GNSS technology is widely used in geospatial applications, including land surveying, mapping, aerial data acquisition, and precision agriculture. **Network Real-Time Kinematic (NRTK)** is an advanced GNSS positioning technique that significantly improves accuracy by using a network of reference stations to provide real-time corrections.

6.4.2 GNSS Rover Receivers

Modern GNSS receivers support multi-frequency and multi-constellation tracking, which enhances positioning accuracy and reliability. The key specifications of GNSS systems include:

1. **Multi-Constellation Support**:
   - **GPS** (L1, L2, L5 bands)
   - **GLONASS** (L1, L2)
   - **Galileo** (E1, E5)
   - **BeiDou** (B1, B2, B3)

   Supporting multiple constellations improves **satellite visibility and reduces signal obstructions**, particularly in urban or forested environments.
2. **Multi-Frequency Capability**:
   - **L1, L2, L5 (GPS)**
   - **E1, E5 (Galileo)**
   - **B1, B2, B3 (BeiDou)**
   - **L1, L2 (GLONASS)**

   Using multiple frequencies mitigates ionospheric delays and improves measurement accuracy, making GNSS systems more reliable for precision applications.
3. **High-Precision RTK and NRTK Support**:
   - RTK provides centimeter-level accuracy using a single base station.
   - NRTK improves upon RTK by using a network of reference stations to deliver real-time corrections.
   - Correction Data Protocols: RTCM (Real-Time Correction Messages), NTRIP (Networked Transport of RTCM via Internet Protocol).

4. **Advanced GNSS Receiver Features**:
   - High-precision geodetic antennas for enhanced satellite signal reception.
   - Dual- or triple-frequency tracking for reducing atmospheric errors.
   - Support for SBAS (Satellite-Based Augmentation Systems) like WAAS, EGNOS, and GAGAN for additional accuracy.
   - Low-latency real-time corrections via 4G/5G connectivity.

6.4.3 Continuously Operating Reference Stations (CORS) Network

The Continuously Operating Reference Stations (CORS) network is a critical infrastructure for high-precision Global Navigation Satellite System (GNSS) applications.

It eliminates the need for users to establish their own reference stations by providing real-time and post-processing services for accurate positioning.

Understanding GNSS and Its Limitations

GNSS enables users to determine their location by measuring distances from multiple satellites orbiting the Earth. However, positioning accuracy is affected by several error sources, including:

- Orbit errors
- Satellite clock inaccuracies
- Receiver noise
- Atmospheric delays (ionospheric and tropospheric)
- Satellite geometry over the receiver
- Multipath errors

These errors can reduce GNSS accuracy to approximately 10–11 meters. To enhance positioning precision, geospatial professionals use various techniques such as Differential GNSS (DGNSS), Static GNSS Surveying, Real-Time Kinematic (RTK), Satellite-Based Augmentation Systems (SBAS), Ground-Based Augmentation Systems (GBAS), and Precise Point Positioning (PPP).

Role of CORS in Precise Positioning

In applications requiring high accuracy, GNSS users typically pair their receivers with a known reference station to obtain corrections for improving positional accuracy. The CORS network eliminates the need for individual users to set up a reference station by providing a country-wide, consistent reference framework.

Survey of India's CORS Network

The Survey of India has established a nationwide CORS network that offers:

- Real-Time Kinematic (RTK) and Network RTK (NRTK) corrections, achieving accuracy of approximately ±3 cm.
- Continuous streaming of GNSS data from permanently installed reference stations to a central server.
- Online processing services for users who submit static GNSS survey data.
- Support for real-time data formats such as RTCM 2.4 and RTCM 3.2.

How CORS Works?

1. **Real-Time Positioning**: The CORS network provides NRTK corrections through a central server that processes satellite observations and transmits refined position data to users.
2. **Post-Processing**: Users can retrieve stored GNSS data for enhanced accuracy in offline applications.
3. **Subscription-Based Access**: Users can subscribe to the CORS network on a monthly or yearly basis to access corrections without setting up their own base stations.

Advantages of Using CORS

- Eliminates the need for setting up temporary base stations.
- Provides a stable and consistent reference frame for precise geospatial applications.
- Enhances the accuracy and reliability of GNSS positioning.
- Offers continuous service availability (24X7X365), subject to network and satellite conditions.

6.4.4 NRTK (Network RTK) Technique and Its Advantages

Network RTK (NRTK) is an advanced positioning technique that uses a network of GNSS reference stations to deliver highly accurate real-time positioning corrections. Unlike traditional **RTK**, which depends on a **single base station**, NRTK uses **multiple reference stations of CORS network** to calculate corrections, providing more stable and reliable positioning.

Key Specifications of NRTK System:

1. **Correction Delivery Methods**:
   - Virtual Reference Station (VRS): Generates a virtual base station close to the rover, minimizing distance-dependent errors.
   - Master-Auxiliary Concept (MAC): Utilizes multiple reference stations to enhance error modelling and correction accuracy.
   - Flächen-Korrektur Parameter (FKP): Applies network corrections based on regional error modelling.

2. **Accuracy Levels:**
   - Horizontal Accuracy: 1–2 cm
   - Vertical Accuracy: 2–5 cm
   - Latency: 1–2 seconds for real-time corrections
3. **System Components:**
   - CORS (Continuously Operating Reference Stations) for constant GNSS data collection.
   - NTRIP (Networked Transport of RTCM via Internet Protocol) for streaming real-time corrections.
   - IMU (Inertial Measurement Unit) Integration for GNSS stability in areas with poor satellite reception.
4. **Operational Benefits:**
   - Eliminates the need for a local base station, reducing setup time and costs.
   - Provides consistent accuracy over large distances (up to 50–70 km from the nearest reference station).
   - Mitigates multipath errors and atmospheric disturbances through network-based error modelling.
   - Enables real-time geo-referencing for applications such as aerial surveys, machine control, and precision farming.

6.4.5 Applications of GNSS and NRTK

GNSS and NRTK technologies are essential for **high-precision geospatial applications**, including:

- **Aerial Data Acquisition**: Enhancing UAV and LiDAR-based surveys with real-time positioning corrections.
- **Land Surveying & Mapping**: Delivering centimetre-level accuracy for cadastral and infrastructure mapping.
- **Construction & Smart Cities**: Enabling automated machine control and real-time project monitoring.
- **Precision Agriculture**: Supporting auto-guidance and variable-rate applications for efficient farming.
- **Disaster Management & Environmental Monitoring**: Assisting in flood mapping, erosion studies, and disaster response planning.

GNSS and NRTK technologies provide **highly precise, real-time positioning solutions** for various industries. With **multi-constellation, multi-frequency support**, and **network-based correction methods**, NRTK significantly enhances positioning accuracy while reducing operational complexities. These advanced specifications make GNSS-based surveying and mapping more efficient, reliable, and scalable for modern geospatial applications.

6.4.6 Using GNSS Rover Receiver for Measurements

GNSS Rover Receiver is to be used for field observations of coordinates. Following steps are to be followed while carrying out the field observations:

a. One time user Registration in SoI-CORS Service portal has to be completed first, this is essential for configuring and connecting the GNSS Rover for field measurements.

b. Set up the GNSS Rover instrument and Controller with CORS network for field uses.

Note: First time CORS network user will have to enter the CORS Service Portal credentials in the GNSS Rover, subsequently this login may not be sought as controller will save this information. **Detailed SOP for above steps is placed as Annexure-II**

c. Set up the mobile application for field survey. Refer 6.5.3 for setting up the mobile application as per the chosen field survey methodology i.e. Option-1/2/3.

d. To carry out the GNSS Rover measurements.

- The surveyor team will visit the area of interest (AOI) and identify the land parcel related to an individual property. He will first identify the land parcel vertices on the ground.
- Once land parcel vertices have been identified, surveyor will assess that the co-ordinate of land parcel vertex can be picked up by GNSS or by ETS method.

  Once the surveyor decides to determine the coordinates of land parcel vertices using GNSS rover the SOP to integrate GNSS rover with any custom/ open source/ proprietary mobile application has been provided in **Annexure-I**

If the desired accuracy is not achieved using the GNSS due to canopy cover and various other reasons then the ETS shall be used for measuring the co-ordinates of the land parcel vertices.

To determine the co-ordinates of parcel vertices & control points for orientation & setting up of ETS follow the SoP at **Annexure-II** using GNSS NRTK method.

Refer to the Presentation on "Introduction to GNSS & NRTK" in the drive

6.5 Introduction to GIS and WebGIS Solution

A Geographic Information System (GIS) is a computer-based tool designed for capturing, storing, analysing, and displaying spatial data. It integrates various elements such as hardware, software, people, data, and procedures to support spatial decision-making. GIS enables users to analyse geospatial relationships and patterns, making it essential for mapping, land-use planning, environmental monitoring, and infrastructure development.

6.5.1 Basic Elements of GIS

GIS comprises several key components:

- **People:** GIS users and professionals who develop methods, analyze spatial data, and interpret results.
- **Data:** The core of GIS, data is categorized into

  Spatial Data (geographical coordinates, points, lines, polygons.

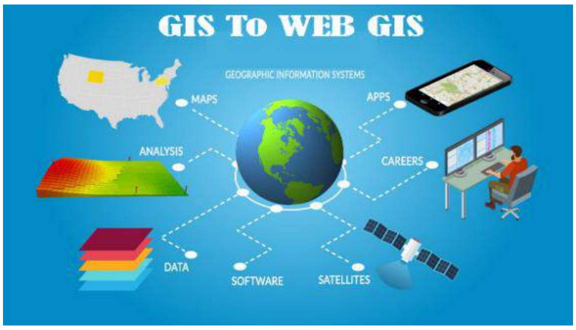
  Non-Spatial Data (attribute data providing additional details about spatial features)

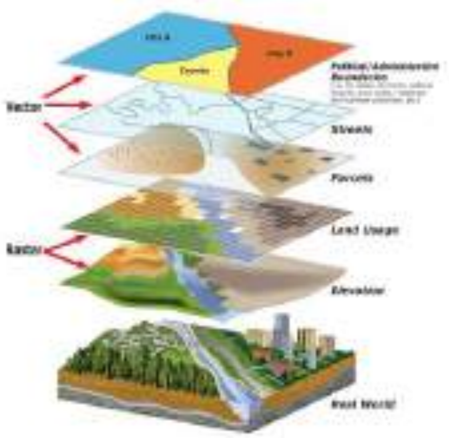
  Metadata (information about the data's source, creation date, accuracy, and projection).
- **Software:** GIS software provides tools for data processing and visualization. Popular GIS platforms include ArcGIS, QGIS, Erdas Imagine, ENVI, ILWIS, and IDRISI.
- **Hardware:** Includes computers, servers, GPS devices, and remote sensing tools that support GIS operations.
- **Procedures:** Methods and workflows used for data collection, processing, querying, and analysis to ensure accuracy and reproducibility.

GIS Data Types and Models

GIS data is classified into **Raster and Vector** models:

- **Raster Data**: Composed of pixels arranged in a grid format. Examples include satellite imagery, aerial photographs, and digital elevation models (DEMs). Raster data requires significant storage space and is used for continuous data representation.
- **Vector Data**: Uses geometric elements like points, lines, and polygons to represent discrete features.
    - **Point Features**: Represent objects with no dimension (e.g., well locations).
    - **Line Features**: Represent linear objects with length (e.g., roads, rivers).
    - **Polygon Features**: Represent enclosed areas (e.g., land parcels, lakes).





6.5.2 Applications of GIS

GIS is widely used in various fields, including **Urban Planning**, **Environmental Management, Agriculture, Transportation and Logistics**, **Disaster Management.**

The Emergence of WebGIS

WebGIS extends these traditional GIS functions by utilizing the internet. Instead of relying solely on desktop software, WebGIS platforms deliver interactive maps and spatial data directly through web browsers. Key features include:

Accessibility: Users can access GIS data and tools from anywhere with an internet connection, breaking geographic and device-related barriers.

Collaboration: WebGIS fosters real-time sharing and collaboration among multiple users. Stakeholders can update, review, and interact with spatial data concurrently.

Integration with Other Technologies: WebGIS easily integrates with other web services and databases, providing enriched and dynamic spatial analyses.

Mobile GIS Applications: The Next Step Building on the capabilities of WebGIS, mobile GIS applications bring spatial analysis directly to the field. Modern smartphones and tablets, equipped with advanced sensors like GPS and high-resolution cameras, enable users to: Real-Time Data Collection: Field teams can collect and update spatial data on-site, ensuring that the information remains current.

On-the-Go Analysis: Mobile GIS apps offer powerful analysis tools that help in making immediate decisions, whether it's mapping environmental hazards or surveying urban infrastructures.

Enhanced User Experience: With user-friendly interfaces, mobile GIS applications simplify data interaction, allowing even non-experts to engage in spatial analysis.

The evolution from traditional GIS to WebGIS and mobile GIS applications is a natural progression driven by the need for accessibility, collaboration, and real-time data integration:

Data Fluidity: While GIS traditionally relied on static datasets managed in a controlled environment, WebGIS ensures that spatial data is constantly updated and available to a broad audience. Mobile GIS takes this a step further by providing immediate access to dynamic data during fieldwork.

User-Centric Approach: WebGIS platforms democratize access to spatial data by providing an intuitive web interface. Mobile GIS applications, designed for on-the-go usage, allow users to interact with spatial data in real time, facilitating quicker decision-making.

Enhanced Collaboration and Efficiency: WebGIS and mobile GIS reduce the lag between data collection and analysis. Field teams can immediately upload georeferenced data, which is then available for analysis and decision-making across multiple platforms.

Refer to the presentation on "Fundamental of GIS" in the drive

6.6 Web GIS Tools

As discussed, in the point. 2 there are three combinations of option1/2/3 for carrying out the field activity. In option 1, the web/mobile GIS solution developed by the

MPSEDC will be used. In option 2/3, other custom or open Source or proprietary Mobile & Desktop GIS application will be used.

The MPSEDC Web GIS Solution

The MPSEDC WebGIS tools developed for NAKSHA offer a comprehensive digital framework, integrating desktop and mobile applications for seamless data processing. The core functionalities include:

- **WebGIS Portal Development**: Provides interactive visualization, query management, and reporting.
- **State & User Onboarding**: Implements role-based access and data synchronization for secure operations.
- **Survey Data Management**: Supports **secure data upload, verification, and ground truthing** to ensure accuracy.
- **Advanced Geospatial Integration**: Utilizes **aerial and satellite data** for high-precision mapping.
- **Desktop Utility Development**: Enables **data file uploads, validation checks, and processing** for effective land record management.
- **Mobile App Development**: Features **CORS (Continuously Operating Reference Stations) and GPS device integration** for real-time field data collection.

MPSEDC Web GIS Platform Modules

The NAKSHA WebGIS platform includes several key modules designed for end-to-end urban land record management:

1. **Urban Property Card (UrPro)** – A digital property management tool to facilitate land ownership verification.
2. **Dashboard** – Provides real-time insights into survey data and system activities.
3. **Survey & Mapping Module** – Ensures high-accuracy geospatial data collection and validation.
4. **User Management Module** – Implements access control for different stakeholders, ensuring data security.
5. **Data Processing & Validation Module** – Enables efficient handling of survey data and rectification of errors.

The WebGIS tools developed under the **NAKSHA project** play a crucial role in modernizing **urban land records** using **cutting-edge geospatial technologies**. By integrating **desktop, web, and mobile platforms**, the system ensures **accuracy, efficiency, and transparency** in land survey management. These advancements contribute to better governance, urban planning, and infrastructure development across India.

Refer to the MPSEDC Representation on "Overview of WEBGIS TOOLS AND ITS MODULES " in the drive

Open-Source GIS TOOLS

The Open source GIS tools will be used in the Option 2 & 3 as discussed in the section - 2. The Quantum-GIS (Q-GIS) and Q-field has been used for illustration purposes.

Open-source GIS tools have transformed geospatial analysis by providing free, flexible, and community-driven alternatives to proprietary software. These tools support a wide range of spatial data formats, allowing users to visualize, edit, analyze, and manage geographic information efficiently. With continuous updates and a collaborative development model, open-source GIS platforms ensure accessibility and innovation in various fields, including environmental management, urban planning, agriculture, and disaster response. Popular tools like QGIS, GRASS GIS, and gvSIG offer extensive functionality, enabling users to conduct spatial analysis, automate workflows, and integrate with other geospatial technologies.

QGIS (Quantum GIS) is a widely used open-source GIS software that provides powerful mapping and spatial analysis capabilities. It supports vector and raster data, database integration, and geoprocessing tools for various geospatial applications. One of QGIS's key strengths is its extensibility through plugins and Python scripting (PyQGIS), allowing users to customize workflows and automate tasks. The software includes advanced cartographic tools, 3D visualization, and web mapping support, making it suitable for professional GIS users and researchers. With strong community support and frequent updates, QGIS is a cost-effective and highly adaptable solution for GIS professionals.

QField is the official mobile application for QGIS, designed for field data collection and editing. It enables users to carry GIS projects from QGIS to mobile devices, allowing real-time data capture, attribute editing, and GPS-based mapping. QField works offline, synchronizing collected data with the main QGIS project when an internet connection is available. With an intuitive interface optimized for touchscreens, it is widely used in environmental monitoring, land surveying, agriculture, and infrastructure mapping. QField enhances fieldwork efficiency by providing seamless integration with desktop GIS, ensuring accurate and streamlined data collection directly from the field.

- For more details about the MPSEDC **Web GIS Modules**, Refer the "User Manual on Web Application" in the google drive using the link provided in this document.
- Refer **Desktop application user manual** in the drive, for Desktop GIS functionalities and step by step procedure for using Desktop GIS Module.
- It is very important to use the **Survey & Mapping Module** provided by the MPSEDC for NAKSHA Programme field survey work. The field data capturing is to be carried out using GNSS Rovers in this mobile GIS module. **Refer the Mobile application user manual** in the drive for the step by step SoP for setting up the mobile application and using this mobile application for field survey
- In cases**,** option-2/3 is being used for field survey, one can either use their State/UT specific mobile application solution or they may also use the open-source Desktop & Mobile GIS solutions i.e. Q-Field & QGIS. **Refer Annexure-III and Annexure-IV for detailed SOP for all details about setting up and use of the Q-field and QGIS open-source GIS applications.**

7. Demonstration of Drone Instrument, Payloads and MAP-1 deliverables.

Aerial data acquisition using drones has revolutionized the field of geospatial mapping and urban planning. This provides an overview of **drone platforms, payloads, data processing strategies, and deliverables** used in modern **urban surveys**. The integration of **optical cameras, LiDAR sensors, and advanced photogrammetry techniques** ensures high-precision mapping and 3D model generation for effective decision-making.

7.1 Drone Platforms and Payloads

UAV (Unmanned Aerial Vehicle) platforms play a crucial role in aerial data collection, equipped with different payloads for various survey requirements. The primary payloads include:

1. **Optical Cameras**:
    - **Nadir Camera**: Captures images from a vertical perspective for orthophoto generation.
    - **Multi-Camera/Oblique Camera**: Uses five cameras to capture urban landscapes from multiple angles, enhancing accuracy.
    - **Photogrammetry-Based Imaging**: Creates precise 3D models by leveraging overlapping images.
2. **LiDAR (Light Detection and Ranging)**:
    - Generates **high-density point clouds** for terrain modelling.
    - Provides accurate **Digital Surface Models (DSM) and Digital Terrain Models (DTM)**.
    - Enhances **feature extraction** for urban planning applications.

7.2 Data Collection and Processing Workflow

To ensure accurate and efficient aerial mapping, a structured approach is followed for **flight planning, data capture, and processing**:

Flight Planning & Data Capture

- **Optimized Flight Paths**: Consider **flying height, pattern, forward and lateral overlaps** for maximum coverage.
- **Ground Control Points (GCPs)**: Used for georeferencing, ensuring precise alignment of aerial imagery.
- **Real-Time Monitoring**: Ensures UAV **position tracking and immediate adjustments** for accuracy.

Processing Workflow

The collected data undergoes multiple processing stages:

1. Georeferencing & Camera Parameter Optimization
2. Structure-from-Motion (SFM) Processing

3. 3D Dense Point Cloud Generation
4. Digital Surface & Terrain Model (DSM/DTM) Creation
5. 3D Mesh (TIN) and Textured Model Construction
6. Building Extraction & 3D Vectorization

7.3 MAP-1 Deliverables

The processed data results in high-quality geospatial products, including:

- 3D Solid & Textured Models: High-resolution 3D representations of urban areas.
- DSM & DTM: Accurate elevation models distinguishing between ground and above-ground structures.
- Orthomosaics & ORI (Ortho-Rectified Images): High-precision georeferenced aerial maps.
- Building Footprint Extraction: Automated vectorization and extrusion of 3D structures for GIS applications.
- Quality Control (QA/QC): Ensures accuracy, consistency, and usability of spatial data.

The use of advanced drone payloads, photogrammetry, and LiDAR technology enhances aerial data collection and urban mapping. The MAP-1 deliverables provide high-resolution 3D models, orthomosaics, and accurate elevation datasets, crucial for applications in urban planning, infrastructure management, and environmental monitoring. These advancements streamline geospatial analysis, ensuring efficiency and precision in modern land surveys.

Refer to the Presentation on "Drone Instruments, Pay load and MAP-1 Deliverables" in the Drive

8. Introduction to ETS, Demonstration and Hands on practice

8.1 Introduction to Electronic Total Station (ETS):

Total station technology has been a game-changer in the field of surveying and mapping. From its humble beginning to its current state, this technology has evolved and come a long way.

Electronic Total Station (ETS) is an electro-optical instrument used in modern surveying and building construction works. ETS is combination of electronic theodolite and electronic distance meter (EDM) integrated with microprocessor based electronic data collector and storage system.

ETS are also known as Electronic Tachometers as they are used to measure slope distances, horizontal angles and vertical angles. The onboard Microprocessor based controller unit stores data and carries out the computations and calculates the horizontal or vertical distance components, elevations and coordinates of a point and display the results on screen. Data can also be stored in external data collectors.

Data collected from total station can be downloaded into desktop computer or laptop for further processing of information.

The EDM instrument component installed in a Total Station is relatively small but still has distance ranges adequate for most work. Lengths up to about 2 km can be measured with a single prism, and up to about 6 to 7 km with triple prism.

The angle resolution of available Total Stations varies from as low as a half-second for precise instruments suitable for control surveys, up to 20 ″for instruments made specifically for construction stakeout.

Working Principle for Distance Measurement: Distance measurement is carried out by sending a laser signal to a reflector or a specific target and the time taken till the reflected signal is returned is measured for calculating the distances.

Measurement with Electronic Total Station (ETS): The ETS is used to measure precise distance and angles (Horizontal/Vertical). If co-ordinates of two points are known, then using bearing of the backward station/ Azimuth and measuring the distance of the unknown point, the co-ordinates of unknown point can be computed.

ETS can be used in following scenarios:

1. When two points are given.
2. When only one co-ordinate is given then coordinate of the back station is determined by other
   suitable method.
3. When no co-ordinates are given, then we can use the arbitrary system of coordinates.

8.2 Applications of Total Stations in Land Surveying and Mapping

A. **Topographical Surveys:** Total stations are widely used in topographical surveys, which involve mapping the natural and man-made features of the land. They are used to measure elevations, distances, and angles between points, which are then used to create detailed maps of the land.

B. **Construction Surveys:** Total stations are also widely used in construction surveys, which involve the measurement and mapping of the land for construction projects. They are used to determine the location of buildings, roads, and other structures, as well as to calculate land area and volume.

C. **Boundary Surveys:** Total stations are also used in boundary surveys for determining the location and extent of property boundaries. They are used to measure angles and distances between points, which are then used to create maps that show the location of property lines.

D. **Engineering Surveys:** Total stations are also used in engineering surveys, which involve the measurement and mapping of the land for engineering projects. They are used to determine the location of roads, bridges, and other structures, as well as to calculate land area and volume.

E. **GIS Surveys:** Total stations are also used in GIS (Geographic Information System) surveys, which involve the collection and analysis of geographic data. They are used to measure angles and distances between points, which are then used to create maps and databases that can be used for a variety of purposes, such as land management, planning, and resource management.

F. **Detail Survey:** Given two points, whose coordinates are known; a total station can be used to get the coordinates of various other points based upon those two co-ordinates. Care should be taken that the new point survey is carefully coded. The Map of the area can be obtained after downloading and processing.

G. **Height measurement (Remote Elevation Measurement- REM):** To find out the relative height of any object.

H. **Remote distance measurement (RDM) or Missing line measurement (MLM):** Distance between two points can be determined where direct distance measurement is not possible.

I. **Relocation of missing pillars (or) Setting out (or) Stake out:** If ground Point / feature/pillar is missing, can be relocated if we have the coordinates of those points.

8.3 Advantages of Total Stations in Land Surveying and Mapping

A. **Increased Accuracy:** Total stations provide increased accuracy in land surveying and mapping, as they can measure angles and distances with high precision. This ensures that the data obtained is accurate and reliable, which is essential for making informed decisions about land use and development.

B. **Reduced Costs:** Total stations can help reduce costs in land surveying and mapping, as they are efficient and require minimal maintenance. This can help save time and money, which can be used to fund other aspects of the project.

C. **Increased Productivity:** Total stations can help increase productivity in land surveying and mapping, as they are easy to use and can cover large areas of land quickly. This can help ensure that the project is completed on time and within budget.

D. I**ncreased Flexibility:** Total stations can help increase flexibility in land surveying and mapping, as they can be used in a variety of applications, including land surveying, engineering, construction, and mapping. This makes them ideal for use in a wide range of industries.

E. **Traverse Survey**: A traverse survey is a surveying method used to establish control networks by measuring distances and angles between points, allowing for the calculation of positions and the creation of a map or plan. A traverse survey involves a series of connected lines (traverse legs) with known lengths and angles between them. Surveyors measure the distances between points (traverse stations) and the angles between these lines. These measurements are then used to calculate the coordinates or positions of the traverse station.

8.4 Types of Traverses:

A. Open traverse: Starts from a known control point and ends at unknown point.

B. Closed traverse: Starts from and ends at known control points.

C. Closed Circuit traverse: Starts from and ends at known control points.

The steps involved in Traverse Survey are:

1. Reconnaissance
2. Selection of Traverse Stations
3. Linear and Angular Measurements

Step 1: Reconnaissance

Reconnaissance is defined as a preliminary field inspection of the entire area that needs to be surveyed. This involves:

1. The surveyor goes to the field and checks the entire area.
2. He decides the best plan of working.
3. He checks the inter-visibility of the traverse stations
4. He decides the method of traversing to be adopted
5. Based on the method chosen, the instruments and accessories are selected accordingly.

Step 2: Selection of Traverse Stations

The basic principle followed in surveying is "working from whole to part "and it is adopted.

1. A minimum number of traverse stations should be selected.
2. Take the length of the traverse line as long as possible to reduce the time and cantering effect of stations.
3. Try to select stations on a level and firm ground
4. After selecting the stations, mark them using pegs.

Step 3: Linear and Angular Measurements:

The distances between the stations are measured using a tape or chain or the Tachometric method or EDM instruments. The angular measurements are done using a compass or theodolite. Using Electronic Total Station, both linear and angular measurements can be made and recorded at the same time.

8.5 ETS Setup & Use

- **A detailed SOP on ETS setup and use is attached as Annexure-V**

9. Field Survey & Ground Truthing

Field survey and ground truthing activities under **MAP-2: Field Survey & Ground Truthing** stage involves collection of land parcel or property extent vertices with associated ownership information (in textual or attribute form) and preparing the land parcel or property (or ownership) data set using latest surveying technology solutions covering CORS Network, GNSS Rovers, ETS, Mobile & Desktop application etc.

The primary objective here is to acquire the knowledge and practice the skill to make qualified field measurements, record the measurements using latest survey tools &

techniques i.e. GNSS, GNSS Rovers, ETS, Mobile GIS software and capture Geo-tagged photos of the property etc during the field survey.

The field survey official should become conversant in analysing the ORI, Digital vector data (2D/3D feature extracted data) while planning the field survey. These inputs facilitate the field survey planning as they truly represent the actual ground depicting all ground features (manmade or natural) in correct position with desired accuracy.

This ORI depicting actual ground is to be used for field survey planning along with primary survey records, cadastral records and other official records for the area, to segregate the target survey areas in different categories considering the varying degree of complexities* for undertaking the field survey and requiring distinct strategies for ground truthing activity.

*** Complexity types:**

a. *Terrain specific challenges,*
b. *Congestion of properties,*
c. *Accessibility constraints,*
d. *Government lands & properties including all public services & public use assets with ownership details available in primary or secondary official records with any government organization or authority,*
e. *Community owned assets (if any),*
f. *Areas with no primary survey records,*
g. *Areas with non-reliable primary survey records,*
h. *Availability of secondary records like approved plan or layouts,*
i. *Information available for old survey markers (existing, lost or obliterated with time),*
j. *Sensitive areas with law & order challenges,*
k. *Properties with court prohibitions in undertaking surveys,*
l. *GNSS or Internet signal outage resulting in higher measurement effort involved*

The ultimate objective of the field survey is to accurately and correctly capture the property or land parcel extent during the field survey i.e. location, shape and size

(dimensions & area) of the property with the ownership (owner name, ownership type etc.).

All survey measurements undertaken during the survey and the official records (primary or secondary) referred with the assigned weightage for deciding and finalising the property ownership data should be duly recorded or logged by the survey officials as per prevalent survey practices in their respective States/UTs for revenue surveys.

9.1 Field work Preparation

1. The field survey & ground truthing is the most important and vital activity of MAP-2 stage. In-fact, the success of the entire NAKSHA programme would predominantly depend upon the timely completion of the field survey & Ground truthing work within desired accuracy.

2. In this process, all Pre-survey activities need to be carried out first in the following order:
   - **Constitution of the field team** for the field survey activities,
   - **Co-ordination among all agencies** involved in the programme implementation through SLC (State Level Committee), Supervisory Committee (for each ULB by SLC), SPMU needs to be firmly established to realize the conducive environment required at the ground for field survey activities,
   - **Notification for the field survey** is to be issued by the State/UT Government as per the applicable statute/rules,
   - **Prior IEC (Information education and communication) activities** would be the key for effective success of the field survey activity considering the challenges a field team is likely to face due to outdated records, fragmented land holdings, complex inheritance systems, inherent legacy problems with existing records.
   - **Effective sensitization efforts** like public meetings with citizens and all concerned state officials need to be organized for instilling the public confidence by clearing all concerns and taking the community feedback. The objective of such public meetings must be, to generate the belief in public about the fairness and transparency of the field survey process.
   - **Public meetings** would be the right forums to inform, listen, understand, discuss and review the field verification process with community. **Refer Para 6.11 of the NAKSHA SoP** for more details about Public Meetings.

- **Readiness of the Survey team** with logistics (Field vehicle & support staff) and survey equipment's for carrying out the field survey is another very important step involving obtaining the CORS Network services subscription, configuring & testing GNSS Rovers, GNSS controllers or Field Data Collector (FDC), Mobile Applications software (being used for field survey), ETS Instrument, ETS Prism, Camera (if being taken separately) etc.

Note: ***Field Readiness Checks*** for the field equipment's: **a.** CORS Service Portal Registration is carried out and CORS network service credentials are obtained for use to configure the GNSS Rover Receiver, **b.** GNSS Rover Receiver is checked & tested for proper operation with CORS network, **c.** FDC or Rover Controller is ready & configured with the appropriate (as the case may be) GNSS Rover mobile application software, Field survey mobile application is integrated with GNSS Rover for easy observation (NRTK mode) of co-ordinates in field, **d.** Mobile application user login credentials for use are created and activated in the application i.r.o. survey team or surveyor for use during field survey, **e.** ETS with all accessories is tested and checked for proper operation RTK enabled GNSS, **f.** Geotagged photo capturing (high quality) is tested for use with camera (standalone or of FDC/Controller).

- **Field Plan** for the notified field survey area which includes division of work area (if applicable) between various survey teams and respective survey team plan for completing the work of the allocated AoI in time.
- **User Role Creation** is to be activated for a survey team with allocated AoI in the Web GIS Platform/Solution adopted for use by the concerned State/UT authorities.
- **Collection of Records:** The survey team must ensure that all relevant details of the Area of Interest (AOI) are collected and made ready for use in the field. This may require use of these records, maps and documents in either hardcopy (or physical form) and/or softcopy (or digital form), hence the survey team has to ensure that

depending upon the process they have decided to adopt for the field survey, these official records & data is also prepared in the desired form and made ready for field uses.

<u>It is advised to prepare a checklist by all State/UT covering all official records available & relevant for the purpose in alignment with their process for the field survey.</u>

As a principle, any official record pertaining to the Area of Interest (AOI) as available with any of the State/UT Government authorities and likely to be useful in field survey enquiry & verification purpose should be obtained and kept ready for the use in desired form i.e. Physical or Digital form by the field team during the field survey.

Note: Ownership and other details to be collected or observed with measurement in the field must be verified for correctness by survey team. For this purpose, official records (primary or secondary) available with the Government/land holders like Record of Right (RoR), Sale Deed, Lease Deed, Gift Deed, Relinquishment Deed, Settlement Deed, Occupancy Certificate, Deed of Partition, lay out Plan, Property Tax Receipt, Building Sanction Plan, Will, General Power of Attorney (GPA), Agreement to Sell (ATS), Utility Bills, Mutation Certificate etc need to be referred by the survey team.

- **<u>Collection of Map-1 Deliverables:</u>** Following Map-1 deliverables for the AoI are to be either collected (if no Web GIS solution is to be used) or configured for use in the Web GIS Platform (if applicable) or hard copy plots to be prepared for field use. It may be noted that MPSEDC Web GIS Platform facilitates the uploading of the Map-1 deliverables by the SoI directorates into the platform and any State/UT user (including Survey team) can us these deliverables:
    a. Digitized Vector Layer of the AoI.
    b. ORI (Ortho rectified Image) of the AoI.

Note:

In cases, State/UT decided to use their own Web GIS solution (or some Open-Source solution or tools) for this programme in field survey, Map-1 deliverables uploaded into MPSEDC Web GIS Platform can also be downloaded and used in other Web GIS Platform or solution.

- **<u>Preparatory Field Survey discussions:</u>** Survey team should discuss, analyse and plan for the field survey by referring all available official records i.e. Map-1 deliverables, Geo-referenced Cadastral maps, Survey Records and other official records and prepare the field survey strategy as under:
  a. **ORI and vector data can be overlayed and analysed to segregate various areas with varying complexities as under:**
     - Information available regarding old survey boundary pillars or markers (existing, lost or obliterated with time) is to be given the highest priority as these are the primary points used for undertaking survey measurements in past (whether original or subsequent surveys). This is very important in areas with existing survey markers (if any) as it ensures that the correctness of the absolute position of the available survey records or revenue map on ground. In areas with unreliable existing survey markers, these points would help to ensure the limited correctness of the absolute position of the available survey records or revenue map on ground as it is practically feasible. **Best possible efforts should be made to trace these survey record points during the field survey,**
     - Areas with significant terrain challenges like undulations, mounds or portions of hills etc would require more time for ground survey,
     - Government lands & properties including all public services/assets with available ownership record (primary or secondary) with any government organization or authority,
     - Areas with congestion of properties and poor access (or very narrow by lanes) will offer problems in GNSS Rover measurements. This could be due to obstructed open sky view, hence, ETS based/manual measurements would be

required during the survey. These areas can be further segregated into areas with no availability or availability of survey records during the field survey preparations,

- Areas with congestion of properties and good access (proper roads) and availability of official survey records,
- Congestion of properties with good access (proper roads) will not offer significant problems in GNSS Rover measurements, so measurements can be done in relatively faster manner. will offer problems in GNSS Rover measurements.
- Multi-story building properties with available approved layouts (but no clearly identifiable survey record) from respective planning authorities can be segregated for survey as these areas would require different strategy for ground survey. We should refer and use only 3D feature extracted ORI data in these areas for finalising the property boundaries,
- Multi-story building properties with no approved layouts from respective planning authorities would primarily require use of 3D feature extracted ORI data and secondary official records data available with other local government authorities,
- Sensitive areas with law & order challenges and may be court prohibition for undertaking any ground survey can be identified and marked during field survey preparation,

b. To analyse all available Primary official records (Past Field Survey Records, Cadastral maps, RoR data etc) or Secondary official records (Taxation records, Approved plan/layouts, Roads, Public Assets/Services etc.) thoroughly involving all concerned officials (to the extent practically possible) as these discussions and interactions would be very crucial in gathering the:

- Historical background about the land use change (manmade or natural) taken place in the area.

  For Example: A meandering river in the area would bring lot of changes due to change in the course and formation of new alluvial deposit areas. Similarly, setting up of an industrial area will bring lot of land use changes with associated development in a short span of time,

- History of the past surveys, Survey record, Cadastral record and its updation in the area.

  For Example: Availability of a good condition Survey record would ensure relocation of survey markers (or boundary points) on ground. With these boundary points, surveyor can trace back the land parcel corners given in the cadastral maps. However, due to unavailability of useful Survey record in many parts of the country, we are generally left with cadastral maps and associated field survey records like Tippans for use in resurvey. These cadastral maps in majority of cases are very old and undergone significant wear & tear, paper distortions and irregular updation for changes in parcel extents & ownership. Hence, it is practically very challenging to identify the land parcel corners or vertex given in existing cadastral map record on ground within acceptable accuracy.

- **To analyse the cadastral map information with ORI:** This analysis is to be carried out to find out correlation (to the extent feasible) between land parcels and ORI features. For this analysis, it would be very useful if cadastral map is geo-referenced and overlayed on ORI for analysis.

  The first & foremost analysis to be carried out on cadastral maps is to identify the ORI areas showing significant matching with a parcel shape or corner. If we can identify at least 3-4 such matching parcel corners or shapes in assigned survey area, that means we are positioned in the correct location on the ground vis-i-vis the cadastral map of the area.

  Once we have identified a parcel corner with matching positions on cadastral map and ORI, we can navigate to that corner point first in ground and carry out the position measurement using GNSS Rover. This would give as the absolute location of the parcel corner, now we can make some more one more point measurement on matching parcel and use these pair of known position co-ordinates to retrace parcel sides and corners as given in the cadastral map.

Once we can relocate the parcel corners, we can undertake the survey measurements of existing property boundaries & ownership for the entire area. During these survey measurements of existing property boundaries & ownership information in the area, if we come across another (different from the matching parcel corner we started the field survey) matching parcel corner point identified during the pre-survey analysis, we can use this point as check and record for our survey accuracy assessment purpose.

NOTE:

Majority of the States/UT implementing the DILRMP programme have digitized all cadastral maps under COMPUTERIZATION OF LAND RECORDS component of the programme, hence geo-referenced cadastral maps in these States/UTs would be available and these maps can be used during the field survey activities.

- To analyse and find out the land ownership related issues prevalent in area as this information would be useful in segregating and handling these areas with different strategy considering the legal aspects and anticipated challenges,
- Areas with legal prohibitions (if any) for undertaking the survey to be segregated clearly from the rest of the field survey area,
- Clear understanding about Government owned assets from various records held by PWD, Municipal authorities (Corporations/Councils/Committees), Planning Authorities, Town Area Committees, Townships, Cantonment Boards (wherever applicable), Special Purpose Agencies, Port Trusts, Public service agencies, PHE, Irrigation, Water Supply, Electricity etc would be helpful in preparing the strategy with assignment of due weightage to a particular record while verifying and finalising the property extent and ownership information.

9.2 Field Survey & Ground Truthing

The field survey & ground truthing activity is to be carried out in the actual area by the survey team. It is very important to keep proper records of all field survey measurements carried out by the survey team in the field. Survey team must plan the ground survey to complete the survey work in given timeline and within desired accuracy. The Primary job of the surveyor and survey team under NAKSHA Programme shall be to:

1. Identify and establish the spatial extent (location, shape & size) of the individual land parcels in their AOI.
2. To verify & update the ownership details of the land parcel or property.
3. To collect other details as required as per the fields given in the adopted **UrPro** schema for the property database by respective State/UT.

The step-by-step procedure to be followed during the ground survey is a sunder:

- To relocate the survey markers or Boundary points (as per primary Survey Record data- if such data is available) in the area, in case no such official record/data is available for the area, we will use cadastral map/data of the area as per our field preparation strategy,
- Survey team should follow the strategy prepared during the pre-survey field preparation for undertaking the field survey & ground truthing work.
- First, navigate to the matching parcel corner in the ground, remember this point was identified during pre-survey analysis for starting the field survey work.
- Start survey activity by establishing more known points on ground using GNSS Rover observation, followed with survey measurements (distance or offset or co-ordinate using GNSS Rover/ETS) to find out the co-ordinates of other parcel corners or sides for getting clear understanding about the variations existing on ground in terms of new properties vis-i-vis cadastral map. These new properties are the changes taken place over a long period of time and new must accurately capture all these properties extent with ownership information during this field survey.
- Field survey involving new capturing, verification, ground truthing is to be carried out by survey team for the given area. All measurements are to be carried out using latest field survey methods & techniques learned during the training i.e. GNSS Rover Receiver & ETS based measurement techniques for measuring distances and finding unknown point co-ordinates. It is very important to record (or note down) all details related to use of single or multiple official record (with assigned weightage) while taking a decision for recording a property location (position or size) as acceptable position for considering as a property in property database for the area.

- **High priority must be accorded to the Government lands, properties & assets while carrying out the field survey** and clearly record their location, shape, coordinates and area.

  List of Government Lands to be Surveyed (Refer to NAKSHA SOP 6.27)

  - Vacant government plots
  - Land allocated for public infrastructure projects
  - Areas under municipal corporations or urban development authorities
  - Government offices, administrative buildings, and educational institutions
  - Land occupied by Public Sector Undertakings (PSU)
  - Land allotted for Special Economic Zones (SEZs)
  - Industrial estates managed by government agencies
  - Roads, railways, and highways
  - Airports and ports
  - Public transportation hubs and utility corridors (electricity, water, gas, etc.)
  - Public parks, green belts, and recreational spaces
  - Government-owned land suspected of encroachment (especially in urban areas)
  - Government land under litigation or dispute requiring clear boundaries
  - Reserved/protected forests, wildlife sanctuaries, conservation zones, wetlands, etc.
  - Land earmarked for biodiversity conservation and heritage sites
  - Government-owned agricultural land leased or cultivated for public purposes
  - Revenue land under the purview of district administration
  - Land under defence establishments (subject to permission for civilian surveys)
  - Border and sensitive areas requiring special surveying permissions
  - Land allocated for religious, cultural, or historical purposes
  - Land under public healthcare facilities and community centres

- Establish a skeletal property map with Govt lands and assets covering all roads, drainages, public service assets, parks, grounds etc. This would simplify subsequent private land surveys. It is very important to refer and use all available official records during this survey activity.

- Use surveyed road boundaries as references to divide the area into smaller chunks, which can later be subdivided into individual land parcels.
- Surveying smaller chunks from corner land parcels would be a good strategy, as such properties would often bordering other parcels or roads on 2-3 sides.
- Use pre-fixed road boundaries as established references.
- If property markers (e.g., compound walls, fences, hedges, building footprints) are visible, these can be directly used to define parcel boundaries after verification.
- If no markers are extracted but a feature (e.g., a property stone) is clearly visible, record the coordinate of the feature as the parcel vertex from the ORI
- In cases where neither markers nor clear features exist, use GNSS/ETS methods (Refer to SOP for in Annexure –I, II & VI GNSS/ETS) to obtain the coordinates.
- Do not add extra vertices along a straight edge unless there is a clear bend or change in the angle, this is important to keep our digital parcel data clean with defined nodes & edges.
- When a boundary has a bend, you must survey the precise point of change/bend.
- Ensure that common edges between adjacent parcels are collected /digitized only once to avoid sliver polygon errors.
- **Data collection for UrPro (Urban Property Card):**
    a. Collect detailed property information from the parcel owners.
    b. All required fields in the **UrPro** (Urban Property Card) must be fully completed.
    c. Capture geotagged photographs of properties using cameras integrated with FDC or mobile phone.
- **Challenges in Land Parcel Verification**

  Listed below are the some of the scenarios that a surveyor /survey team will encounter while finalizing the property layer:

1. **Case-1:**
   - Both area and boundaries largely match government records (within a reasonable disparity of ~5% in area).
   - This accounts for 90-95% of cases, only minor adjustments

2. **Case-2:**
   - The land area matches available records, but the boundaries differ.
   - With mutual consent from adjacent owners (and ensuring no encroachment on government land), boundaries may be finalized as observed on the ground.
3. **Case-3:**
   - Neither the area nor the boundaries of the land in possession match available records.
   - In this case, the survey team should request additional supporting records/documents from the landowner and verify whether the enjoyment is as per the records available, check for the legacy records. Decide whether the records are matching with the government records. This process will help the survey to come to conclusion on the actual extent on the ownership.

Note: Refer to **Module 6.28 (a) of the NAKSHA SOP** for guidelines on property title confirmation and area mismatch resolution.

- **Independent Checks during Ground Truthing**

  Independent checks are essential for ensuring survey accuracy:

  a. **Point Feature:**

  Identify prominent features on both the ORI and the ground, measure their coordinates with GNSS/ETS and with ORI, compare ad check if the difference in the measurement is within acceptable limits (less than 5cm).

  b. **Linear Feature:**

  Compare lengths of features (such as compound walls or building edges) measured from the ORI and on the ground. The difference in the reading between Ground measurement and ORI must be within the permissible limits (say10 cm). These independent checks help confirm both the instrument's accuracy and the reliability of the ORI data.

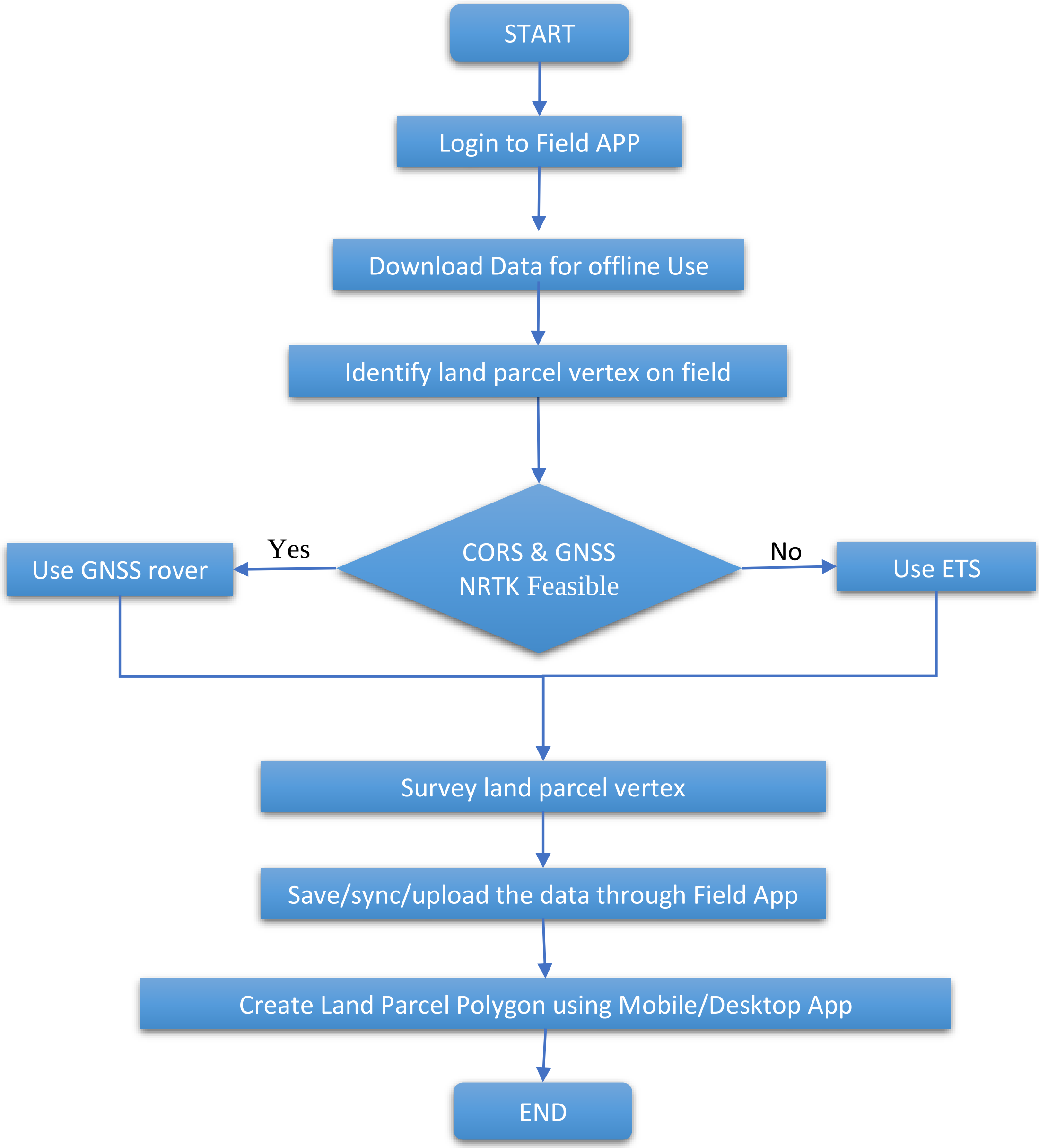


Figure: Fied Survey & Ground Truthing

9.3 Post Survey Activities

- Once the field exercise for land parcel data collection has been completed. The co-ordinates of the vertices shall be directly viewed in the MPSEDC desktop application. In case of the custom open-source application the co-ordinates must be imported into the desktop application.
- By utilizing the vertex co-ordinates collected on the ground, land parcel polygons can be digitized.

- The UrPro data collected in the ground shall be filled in the attribute table attached to the land parcel polygon.
- Care must be taken that there are not any missing or wrong entries while filling the UrPro details.
- The ROR records and property tax details etc. shall be attached to this fields based on the user requirement. Refer to **Annexure –IV** for detailed SOP on the Desktop activities.

10. Experience Sharing on Legal and Administrative Procedures involving Objection Handling and Conflict resolution.

"Objections and Conflict Resolution" explores the challenges of handling disputes in land surveys and urban planning. It covers the sources of conflict, the powers and responsibilities of inquiry officers, the legal framework for appeals and revisions, and the complexities of adverse possession. The discussion emphasizes the importance of structured processes in managing conflicts efficiently.

One of the primary concerns arises from a lack of awareness among the public. Many individuals misunderstand the purpose of surveys, often assuming they are linked to land acquisition, road widening, or increased bureaucratic hurdles. This misconception fuels resistance, with concerns about corruption, delays in property transactions, and additional administrative burdens. Poor communication and delays in serving notices further contribute to public apprehension, making cooperation difficult.

During the inquiry process, disputes over property boundaries, ownership rights, and overlapping claims become prominent. Mistrust in government agencies can escalate tensions, making resolution challenging. Inquiry officers play a crucial role in ensuring transparency, adhering to legal frameworks, and maintaining impartiality. Proper documentation, timely notices, and structured grievance mechanisms are essential to prevent unnecessary escalation of conflicts.

Legal avenues such as appeals and revisions allow individuals to challenge survey findings or administrative decisions. Adverse possession adds another layer of complexity, where long-term occupation without formal ownership may lead to legal claims. Handling such cases requires extensive verification of records, historical claims, and judicial scrutiny to ensure fairness in property rights.

Addressing these challenges demands better communication strategies, streamlined legal procedures, and well-trained officials. Transparency in governance, efficient dispute resolution mechanisms, and proactive public engagement can foster trust and cooperation, ensuring smoother execution of land surveys and urban planning initiatives.

Case study -1 (Govt. of Andhra Pradesh Resurvey programme)

The document details the legal and administrative framework for handling objections and conflicts in land resurvey projects in Andhra Pradesh. It outlines the structured approach taken to minimize disputes, ensure transparency, and streamline the process through a combination of statutory procedures, technological interventions, and public participation. The initiative aims to improve land governance by accurately recording land boundaries, resolving disputes efficiently, and maintaining updated spatial and textual records.

To preempt objections, the resurvey process follows a Standard Operating Procedure (SOP) that includes ground truthing, ground validation, and records preparation. Formal notices are issued during Grama Sabha meetings, and extensive communication efforts are made via WhatsApp, SMS, and phone calls to ensure maximum landholder participation. The survey teams determine undisputed boundaries under Section 9 of the Andhra Pradesh Survey & Boundaries (S&B) Act, 1923, while disputed boundaries are recorded under Section 10. The ground truthing phase involves detailed boundary verification, using village maps, traverse maps, and correlation statements, with disputes addressed through prescribed legal processes.

The survey process incorporates multiple layers of quality checks to ensure accuracy. Mandal-level teams conduct verifications on a sample basis, while additional checks are performed by higher-level officials, including the Tahsildar, Inspector of Survey, and Revenue Divisional Officer (RDO). Any discrepancies identified are updated in the digital records, and once all quality checks are completed, the final spatial data is uploaded to the Bhunaksha portal. The correlation process ensures that newly generated land parcel numbers correspond with previous survey records, facilitating smooth integration of old and new datasets.

Ground validation serves as the final verification stage before formalizing survey records. A general notice is issued through public meetings and displayed for landholders to review. If any discrepancies remain, landowners can file objections, triggering a reassessment process. Boundary disputes are resolved through re-measurement using advanced survey instruments or traditional methods. This ensures that any objections raised during ground truthing are adequately addressed before finalizing the survey records.

The legal framework governing objections and appeals is based on the Andhra Pradesh Survey and Boundaries Act, 1923, and the AP Rights in Land and Pattadar Passbooks Act, 1971. Special Executive Magistrates, appointed from among the Deputy Tahsildars, have delegated powers to settle disputes. The dispute resolution process follows a structured approach, classifying cases under Sections 9 and 10 of the S&B Act. Landholders receive notices regarding survey decisions, and if they dispute the demarcation, they can file objections in prescribed forms during the field survey itself. These objections are reviewed by a separate survey team, which conducts an inquiry, issues notices, and updates records accordingly.

The appeal process allows affected landholders to challenge decisions through the Special Executive Magistrates. Appeals must be filed within 21 days, and hearings are conducted in accordance with the Civil Procedure Code. Government-related disputes require coordination with respective departments, and a set of official forms governs the inquiry and decision-making process. The appeal disposal mechanism mandates resolution within 30 days, ensuring timely redressal of grievances. Final appeal decisions result in boundary re-fixation, record updates, and communication to affected parties, with unresolved cases directed to civil courts.

Following the resolution of appeals, the updated spatial and textual records are integrated into the digital land management system. The correlation statement is finalized, and GIS software is used to update land parcel data. The Tahsildar is responsible for updating textual records, incorporating changes into the Draft Land Register (DLR). The process concludes with approvals from higher authorities, including the Joint Collector, and the finalized records are uploaded to the Bhunaksha portal for public access.

A pilot project in Tadepalligudem village provided practical insights into handling objections and conflicts effectively. Common challenges included disputes over land titles, missing survey records, and mismatches between textual and spatial data. The experience from this pilot helped refine the resurvey procedures, improving the efficiency and transparency of the overall process.

Overall, the resurvey initiative in Andhra Pradesh represents a structured, technology-driven approach to resolving land disputes and maintaining updated land records. The combination of legal safeguards, multi-tier quality checks, and digital integration ensures a transparent and efficient system for land management, benefiting both the government and landowners.

Case study -2 (State of Kerala)

The implementation of digital land surveys in Kerala has been a transformative step in land governance, integrating advanced technology, policy reforms, and citizen participation. The initiative follows the principles of conclusive titling, ensuring land records reflect ground reality, establish ownership conclusively, and offer state-backed title guarantees. With the introduction of the "Ente Bhoomi" mission, Kerala has focused on digitizing land records through a comprehensive survey process, leveraging GIS-based solutions and modern survey instruments such as RTK GNSS, drones, and CORS stations. This approach aims to create an accurate, continuously updated, and transparent land administration system.

One of the critical aspects of the digital survey mission has been addressing objections and conflict resolution. Various stakeholder engagement initiatives, such as the Survey Jagratha Samithi and Survey Sabha, have ensured that landowners actively participate in verifying land records. Additionally, online public portals and real-time viewing options have been introduced to enhance transparency. Structured citizen complaint modules allow for efficient dispute resolution, minimizing land-related conflicts and ensuring public trust in the system. The initiative has also focused on pre-survey awareness campaigns and exhibitions to educate the public about the process.

Challenges in land surveying, particularly in regions with historical disputes and dense vegetation, have been effectively tackled through case-specific solutions. For instance, in the Cheruvancheri and Thrippangottoor villages, issues related to surplus land allocation, encroachments, and forest boundary disputes have required coordinated efforts between surveyors, local authorities, and forest departments. Addressing such disputes systematically has reinforced the credibility of the digital land survey project.

Kerala's digital land governance model exemplifies the potential of integrating technology with citizen-centric policymaking. By streamlining land record maintenance, ensuring transparency, and facilitating seamless integration of survey, revenue, and registration records, the state has set a benchmark for other regions. The initiative not only resolves long-standing land conflicts but also empowers citizens with real-time, authenticated land data, marking a significant step toward a modernized and efficient land administration system.

Refer to the Presentation in the Drive for 'Legal and Administrative Procedures involving Objection Handling and Conflict resolution Objection'

11. Summary

This course document on Ground Survey Using GNSS and ETS Integrated with Mobile Application provides a structured approach for executing all activities involved in MAP-2 field surveys. It outlines essential processes, including hardware and software requirements, field team composition, workflow, and operational procedures for efficient data collection and integration. The survey methodology leverages advanced geospatial tools such as GNSS/CORS, Electronic Total Stations (ETS), and the Field App to ensure precise land parcel mapping.

A systematic approach to field preparation, data collection, and office-based data processing is emphasized to maintain high accuracy and consistency across all field survey teams. By adhering to these guidelines, survey teams can effectively capture and validate land parcel vertices, supporting the modernization of land records and enhancing urban land governance.

Reference
All presentations/SOP/User Manual related to this content material are provided in the drive: https://drive.google.com/drive/folders/17tnCf1JezkD7o64s5P-KIaNnO10diVlD?usp=drive_link .

ANNEXURE-I

STANDARD OPERATING PROCEDURE

for

Trimble Mobile Manager

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1. Objective

To configure and integrate the GNSS rover to the mobile application using the **Trimble Mobile Manager** (TMM) application, enabling the collection of coordinates for land parcel vertices in the field.

2. Hardware & Software

Hardware:

a) 01 no. GNSS Rover (e.g. Trimble R8s, R10 or R12i)

b) 01 Mobile Device (Android/IOS Based)

Software:

a) TMM application downloaded from Play store (Android/IoS)

b) Mobile mapping application (MPSEDC/Proprietary/ Open source).

3. Pre-requisites

The following are the Pre-requisites

a) The surveyor should know how to operate a GNSS rover.

b) The Surveyor should have a valid login Credential for accessing Survey of India CORS Network for receiving the NRTK corrections

4. Roles & Responsibilities

The surveyor will have the following roles and responsibilities.

a) The surveyor will identify the land parcel vertices on the ground, based on the records available with him.

b) Once the land parcel vertices have been identified on the ground, surveyor will Conduct GNSS survey and collect the co-ordinates of the land parcel vertices.

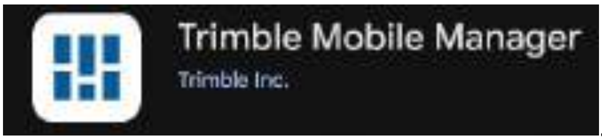
5. Procedure

The following steps are required to setup and use CORS NRTK service.

Step1: Downloading the TMM application.

a) Go to Play store/App store in your Android/ Ios device

b) Search for Trimble Mobile Manager and Install



Step 2: Connecting the GNSS Rover with Mobile Device

a) Switch on the GNSS Receiver (e.g. R8s 5929R91110: Trimble)

b) Go to Bluetooth settings of mobile/Tab

c) Scan and select the GNSS receiver.

d) On selecting it will ask for PIN to pair with Tab/Mobile. Enter 0000 (Default PIN)>>OK

e) Now the GNSS Rover has been connected with the Mobile Device via Bluetooth connection.

Step 3: Configuration of CORS network in TMM

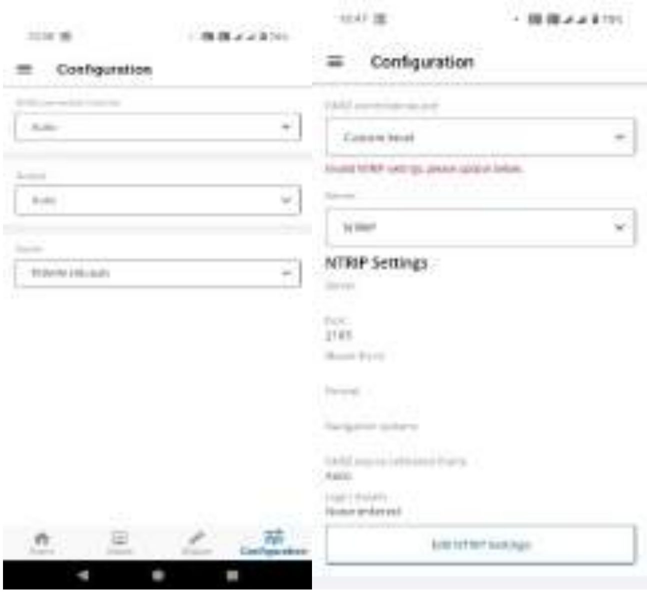
a) Open Trimble Mobile Manager (TMM) in Mobile Device

b) Connect GNSS Rover as shown below

c) Click on Configuration

d) Configure as shown below

- Select: **Geoid**>> *EGM96(Global)*
- Select: **Output**>> *Auto*
- **GNSS Correction source**>> select: *Custom Local* >> click: *Edit NTRIP Settings*



e) Configure NTRIP Settings

- o **Server settings**: enter: SoI CORS IP Address
- o **Port**: enter: *2101*

For Region 1 the IP Address is 103.205.244.106 and IP Port is 2101

For Region 2 the IP Address is 43.240.5.42 and IP Port is 2105

- o **Mount Point**: select: *RTCM_VRS*
- o **Login Details**
  - ▪ **User Name**: as per user credentials
  - ▪ **Password**: as per user credentials
- o **GNSS source reference frame:** *ITRF2005*
- o **Customize epoch:** enter epoch:*2005*
- o Click: Save and Close

f) After editing click on Home tab. The Horizontal & Vertical accuracy will be displayed.

g) By the above steps TMM has been configured to consume SoI GNSS CORS NRTK correction for collection of Co-ordinates of the parcel vertex using mobile.

Step 4: Setting Developer Options to set the Mock Location.

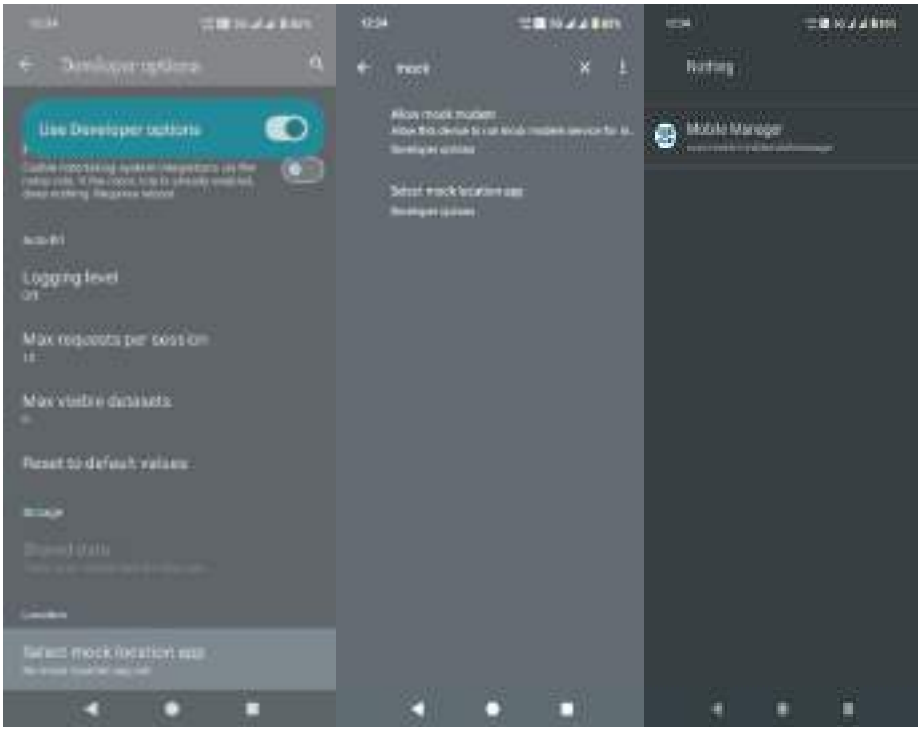
In the above steps the mobile is setup to get co-ordinate in TMM mobile app. Basically the field app (like MPSEDC mobile app or Q-field) get the position using mobile internal GPS which is not accurate. To get CORS NRTK corrected co-ordinates in the field app, it is required to enable and set up the mock location setting, to route the TMM app location in the field app directly instead of internal GPS location.

The following steps illustrate (using android OS) the procedure to be carried out in the mobile/FDC device to integrate the TMM application with the mobile application.

- Go to Mobile Settings>> About Phone >>Go to build number>> tap seven times continuously on build number.

a) Developer Options will open

- Enable Use Developer options to Yes
- Location: Select Mock Location app >> Trimble Mobile Manager



b) Setup is complete, now instead of the mobile internal GPS location, the TMM App location (which is External GPS based CORS NRTK Corrected location) will be ingested into the field app.

6. Conclusion

The field app/mobile device will utilize the precise positioning of the GNSS rover through the TMM mock location app, enabling accurate land parcel vertex coordinate collection using with any custom/ open source/ proprietary mobile application.

ANNEXURE-II

STANDARD OPERATING PROCEDURE

for

Registration on CORS Portal

&

Co-ordinate Capture using GNSS-NRTK Method

TABLE OF CONTENTS

1 Objective & Scope:

This SOP outlines the procedures for:

- Registration on the Survey of India (SoI) CORS Portal.
- Conducting Network Real Time Kinematic (NRTK) survey using the Continuously Operating Reference Station (CORS) network for capturing the co-ordinates of control points for ETS survey and land parcel vertex.

2 Hardware & Software requirements:

2.1 Hardware Requirements

- GNSS Rover: NRTK-enabled GNSS rover.
- Controller Device: for connecting the GNSS
- Internet Connectivity: Required for the controller device.

2.2 Software Requirements

- GNSS OEM application
- Web-based SoI CORS Portal: Required for login.

2.3 User Accounts & Access Permissions

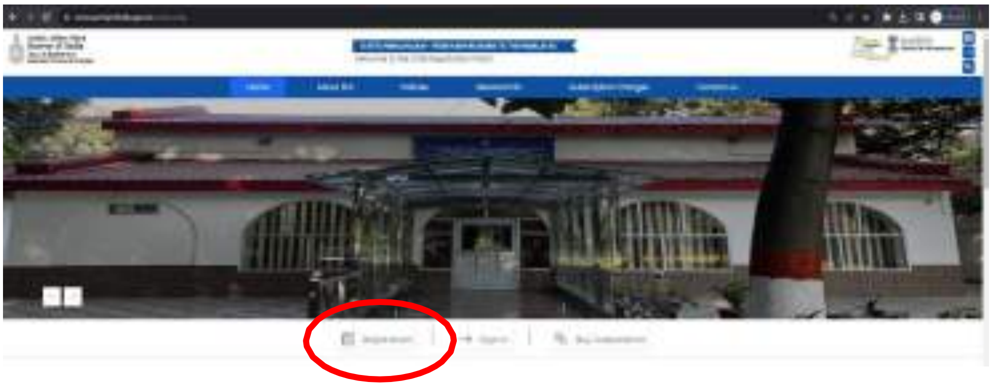
- CORS Registration Account: Users must avail an account on the Survey of India CORS web portal (https://cors.surveyofindia.gov.in).
- Login Credentials: A valid username and password are required for accessing CORS data.

3 CORS Registration Process

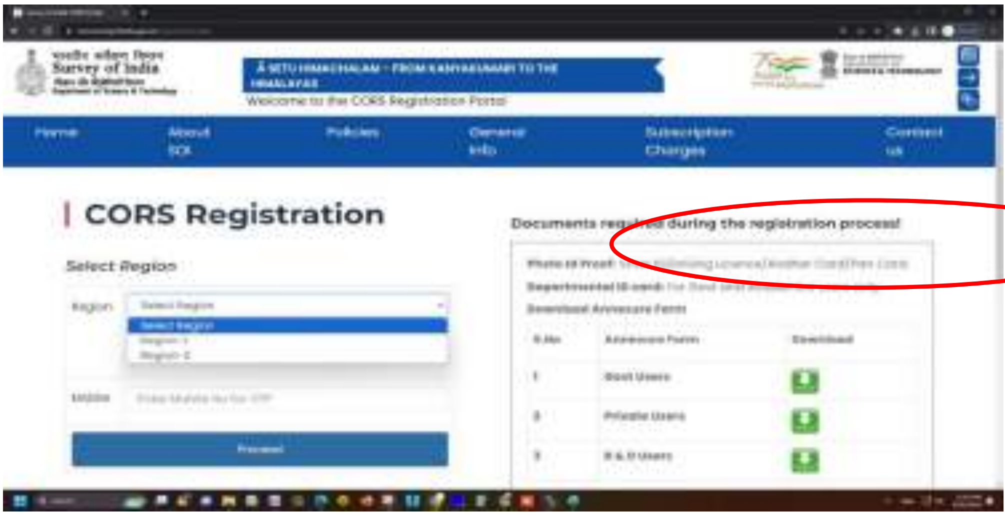
The first-time users will require registration to get the login credentials which will be used to access the CORS services.

- Go to CORS web page "https://cors.surveyofindia.gov.in/" in any browser. On the home page click on the 

Button.



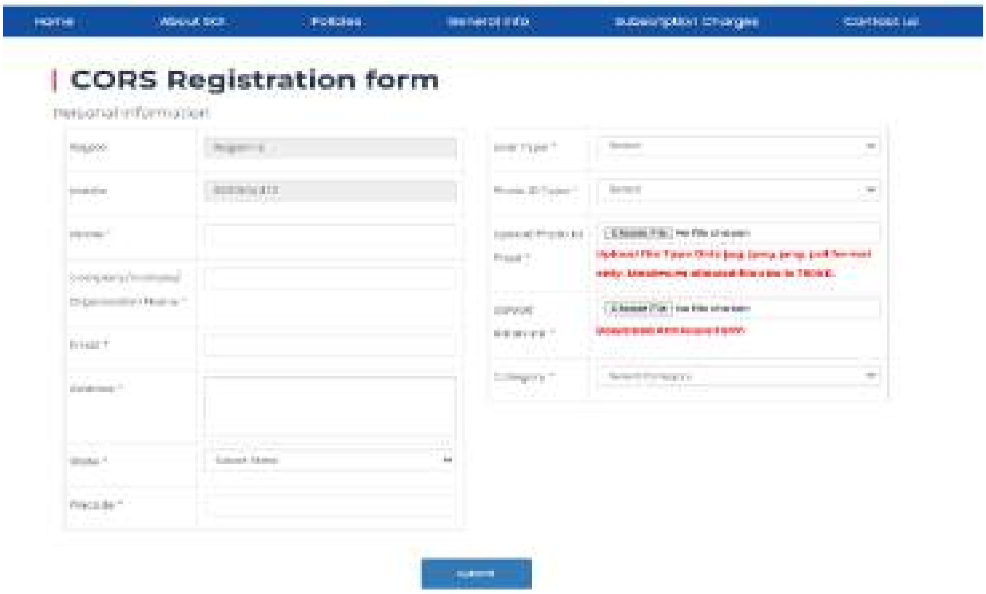
- The documents required (highlighted below) for the registration process must be ready to upload. Select Region, Enter the Mobile Number, and click on Proceed.



- Enter the OTP received on the mobile and click Verify OTP.

- Fill all required details and upload documents then click on Submit.
- After successful submission of the form the **Acknowledgement Number** will be generated. It is advised to keep the Acknowledgment Number for future reference.

- After successful scrutiny of documents, user will be allotted a unique USER ID & Password, which would be sent via E-mail.
- It is advised to raise a query at the contact details given below if the user does not receive any information regarding the user account creation after 24 working hours.



Contact Details

4 Capturing the Co-ordinates of control Points using CORS & NRTK method

Following are the most essential requirements for NRTK survey for capturing the co-ordinates of control points for ETS survey and land parcel vertex:-

- GNSS Rover must be Bluetooth compatible for uninterrupted Bluetooth connectivity between Controller Device and Rover.

- Controller must be enabled with internet facility via Wi-Fi /Cellular connections.

  The following are the steps to carry out NRTK survey using CORS. This is an example of capturing co-ordinates using Trimble R8s Receivers and windows based GTEC controller.

4.1 GNSS Instrument field Setup

4.1.1 Pre-Survey Check

a) Check working condition of GNSS receiver, data controller, mounting (tribrach) and accessories.
b) Check the battery charging level of the receiver and controller.
c) In case of internal modem, ensure the SIM card is inserted and has an active data plan for internet connectivity.

4.1.2 Hardware Assembly

a) Assemble and mount GNSS receiver to a survey pole or tribrach securely.
b) If using an external antenna, connect it properly and ensure it has a clear sky view.

4.1.3 Centring the Instrument over the Survey Mark

In case of Tripod with Tribrach Setup:

a) Place and adjust the position of the tripod roughly over the survey mark.
b) Place the tribrach over the tripod, ensuring it is securely fixed.
c) Use the optical plummet (if available) or a plumb bob to accurately center the tribrach over the mark.
d) Adjust the tripod legs carefully to achieve precise entering.

In Case of Pole Setup:

a) Place the survey pole tip exactly over the survey mark.
b) If using a bipod, adjust its legs for stability.

4.1.4 Levelling the Instrument

For Tripod with Tribrach Setup:

a) Use the levelling screws on the tribrach to center the level bubble.
b) Once levelling done check the centring done in previous step.

c) Centring and levelling is iterative process and repeat one after till the instrument is finally catered and levelled over the survey mark before start of measurement.

For Pole Setup:

a) Adjust the pole to keep the circular bubble in centre during measurement.

b) If using a bipod, adjust the leg to make the circular bubble in center during measurement.

c) Finally check the instrument is also centered and levelled before measurement.

4.2 Establish connection between GNSS Rover and Controller

Step 1: Turn on the GNSS Receiver e.g. **Trimble R8s** Rover and notice the light blinking.

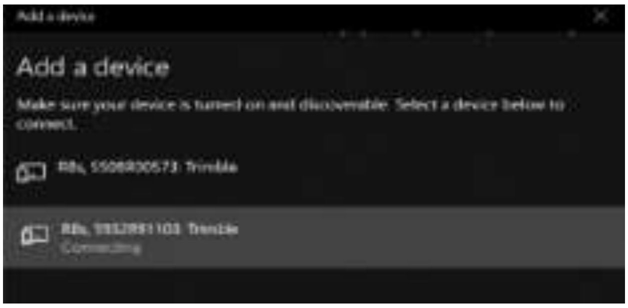
Step 2: Provide internet to the Controller.

Step 3: Pair GNSS Rover (i.e. Trimble R8s) and Controller (i.e. Windows based Gtech) using Bluetooth. Follow the below steps.

Step 4: From Quick Pane: Click on >> Bluetooth icon >> Show Bluetooth Devices

Step 4: Bluetooth and other devices: Click on >> Add Bluetooth & Other Devices

Step 5: Add a device: Click on >> Bluetooth >> Choose your device [e.g. R8s Trimble]



Step 6: Enter PIN (e.g., in case of Trimble R8s instrument Default, PIN is 0000) and click Connect tab. Your device is ready to use. A message will be displayed for paired device R8s receiver and will reflect in the Settings window.

4.3 Controller configuration for CORS NRTK service

The following steps are required to configure the GNSS receiver to receive NRTK corrections.

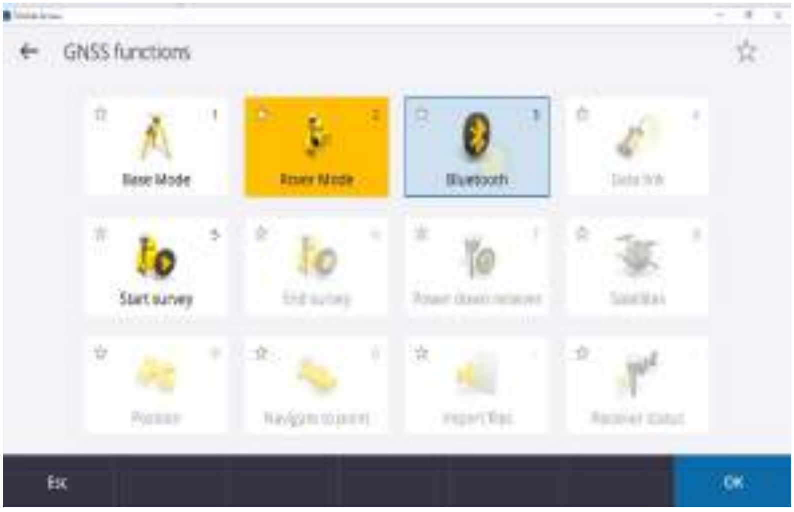
Step 1: Open Trimble Access application  in the tab.

Step 2: Main window will open. Click on **Menu** button as shown below.

Step 3: Select: **Instrument** >> GNSS **functions**

Step 4: GNSS Functions: Click **>> Bluetooth >> OK**

Bluetooth window will open up.



Step 5: Bluetooth Window:

- Connect to **GNSS Rover** >> Select [Bluetooth paired Trimble R8s Rover
- Connect to conventional instrument >> Select [Bluetooth paired Trimble R8s Rover]
- Click >> **Accept**

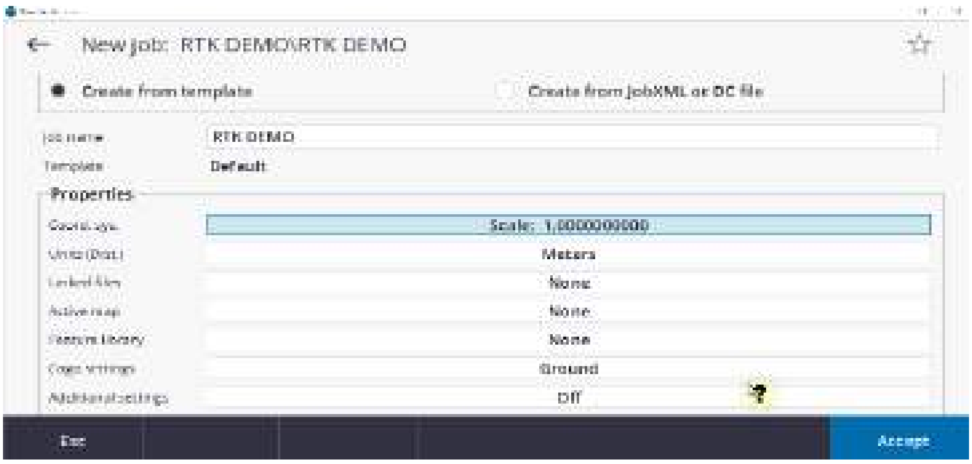
Step 6: Create a new project: Click on 

tab project window will open.

Step 7: Provide a Name (e.g. RTK DEMO) and Description (optional) to the project. Click>>**Create**

Step 8: Open created job in step 7 a Job name e.g. RTK DEMO.

Step 9: Various job parameter needs to be set as per user requirement. In step 8 a window has been opened in which under properties box set the various job parameter as illustrated below



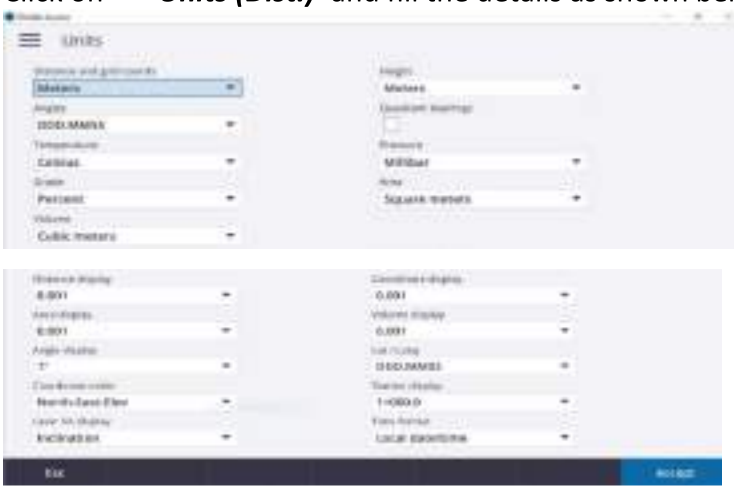
- To define Co-ordinate System of the Created Job user must

  Click on >> **Coord. Sys**.
  Select >> *Select from library* as shown below
- Click >> Next.

- Select System, Datum & Coordinates as shown below. Select the appropriate Zone and fill the approx. height of the terrain and click **Enter**. (Note: The Zone and project height will vary depending on the location of survey)

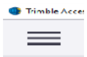
- In order to define Units of created 'Job' user must

Click on >> ***'Units (Dist.)***' and fill the details as shown below.

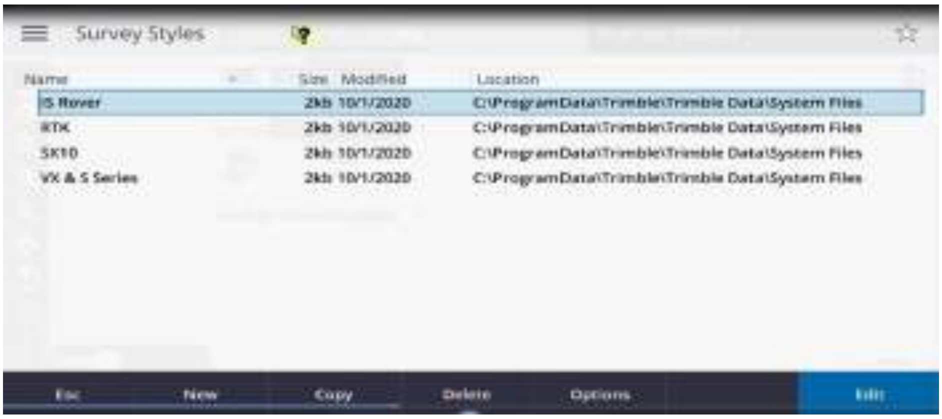


- In order to export surveyed data of above created ‘Job’, user has to provide output file name, for this purpose user must
- Select: Additional settings turn it On
- Additional Settings, Add to CSV file : Enable option to **‘Yes’** and also provide a CSV file name as shown below.

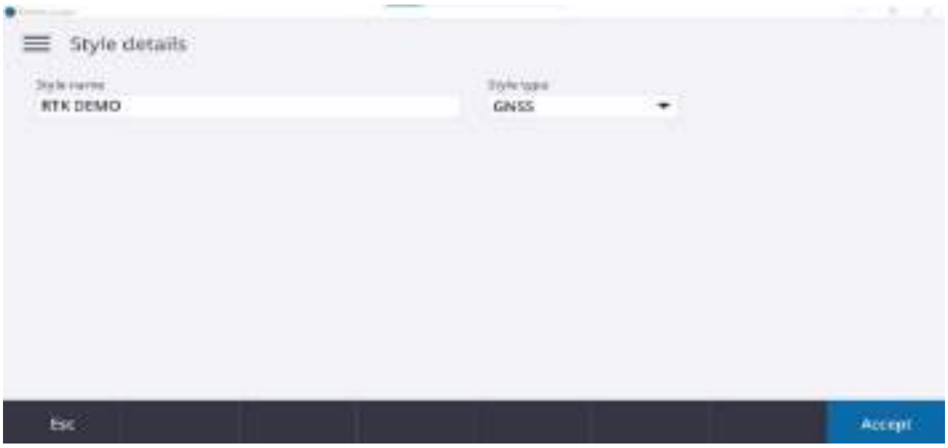
Click on >> Accept on the Job Properties window.

Step 10: Click on menu icon  (in the top left corner of the main screen) to select **Settings** and then **Survey Styles**. **Survey Styles** window will open.

Step 11: Click ***New*** tab at the bottom of the window. Style details window will open.



Step 12: Provide the Style name (e.g. RTK DEMO) and Survey type (e.g. GNSS). **Click >> Accept tab**. New window will open up.

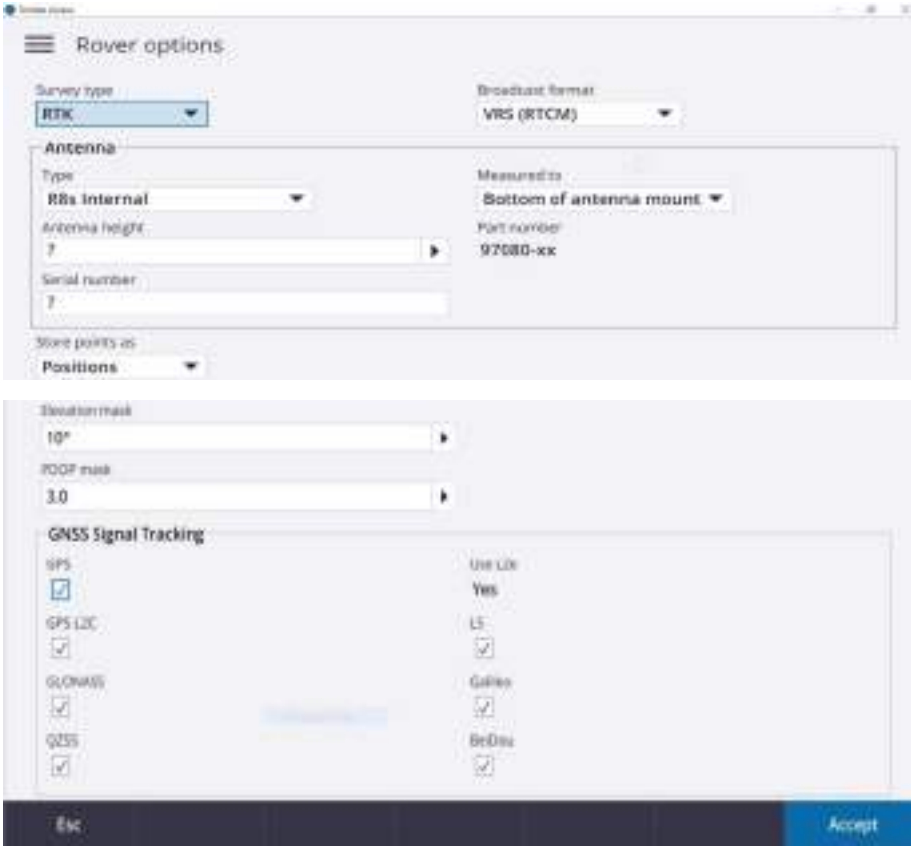


Step 13: Click **Edit** tab at the bottom of the window for Rover options. Rover options window will open up.

Step 14: For Rover option, provide the information as shown in the figure below.

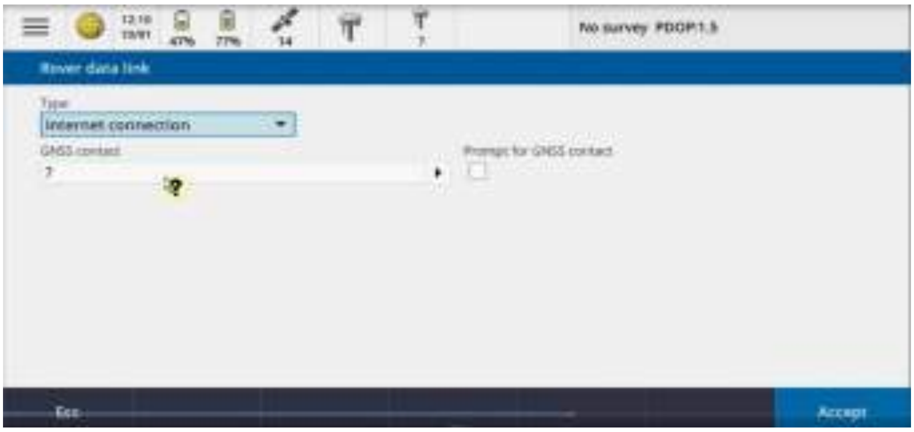
- Broadcast format: **VRS (RTCM)**
- For VRS (RTCM), the **Mount point** to be selected RTCM_VRS in Step 19.
- Provide Serial number of R8s receiver (Optional).
- Elevation mask must be set as 10 and PDOP mask default values can be altered if required.
- GNSS Signal Tracking should be checked for all constellations.

o Click >>**Accept**

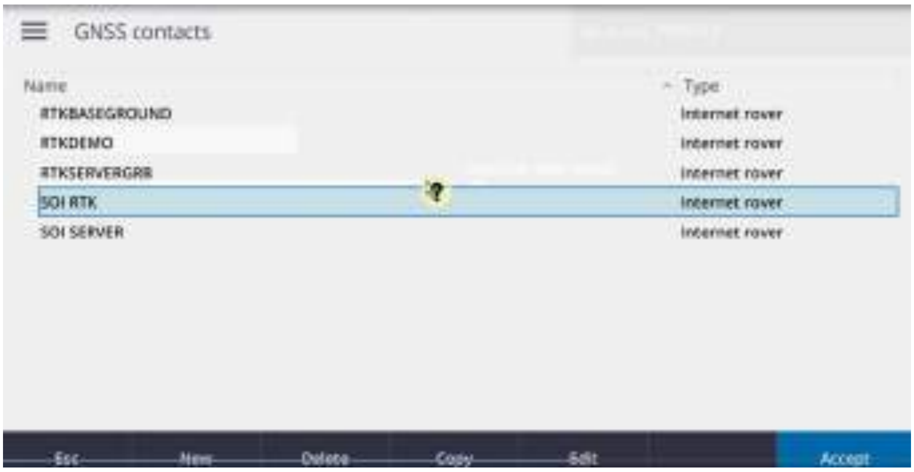


Step 15: On acceptance the following Window as shown below will appear. Click Edit tab for Rover data link. **Rover data link** window will open.

Step 16: Select **Type** as **Internet connection**. Click on GNSS contact. A GNSS contact list will POP up.

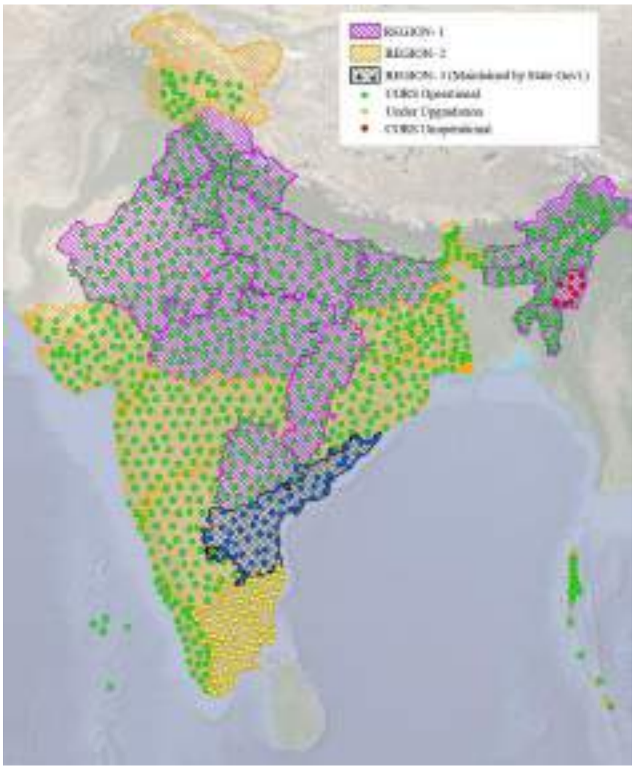


Step 17: Create a new GNSS contact. (Once created It can be used repeatedly for several different Project & Job) Accordingly, a new window will open up.

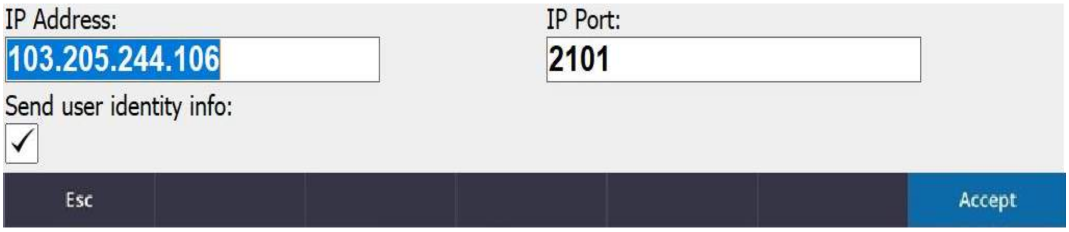


Edit GNSS Contact settings in **Trimble Access** software. Enable the **NTRIP Configuration** with your **username -------- & Password ********,** and the connection is set to use **Wi-Fi or Cellular**. The option **"Route through controller"** is turned on, allowing GNSS corrections to pass through the controller.

Note: - The **Survey of India (SoI) CORS Network** is divided into two regions for efficient GNSS data distribution and processing.



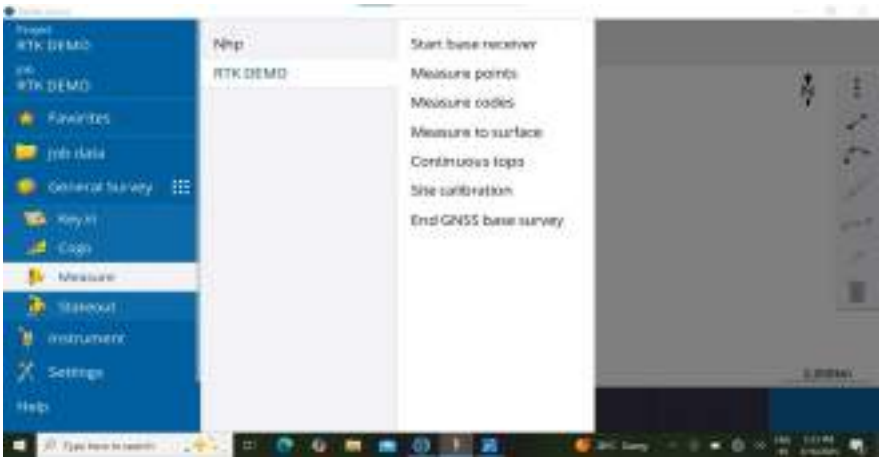
We have to provide the IP address and IP Port of control Server and then click Accept and then Store. The IP addresses for region 1 & Region 2 are different.



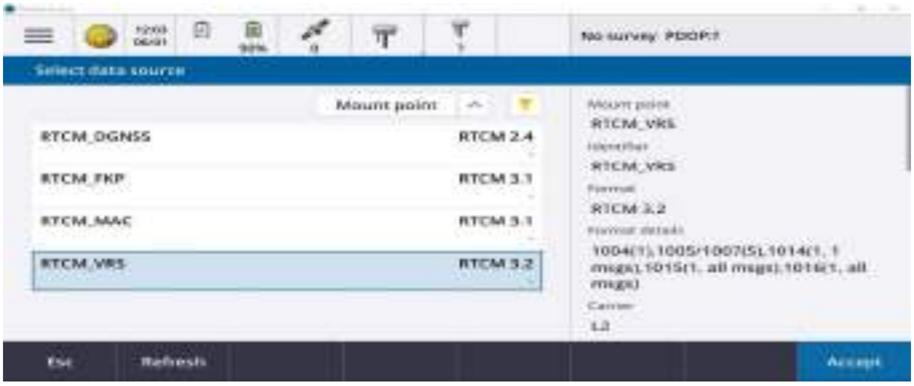
For Region 1 the IP Address is 103.205.244.106 and IP Port is 2101

For Region 2 the IP Address is 43.240.5.42 and IP Port is 2105

Step 18: Click on Menu Icon and then select **Measure** tab after that select **Survey style** e.g. RTK DEMO (created in the Step 12) and select **Measure points**.

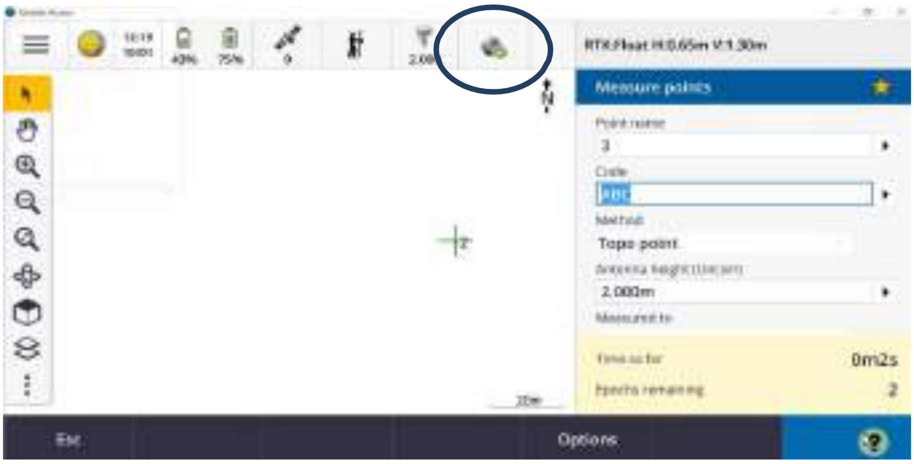


Step 19: Processing bar will appear for establishing connection to the Server. Thereafter in the next window we have to select Mount Point RTCM_VRS.

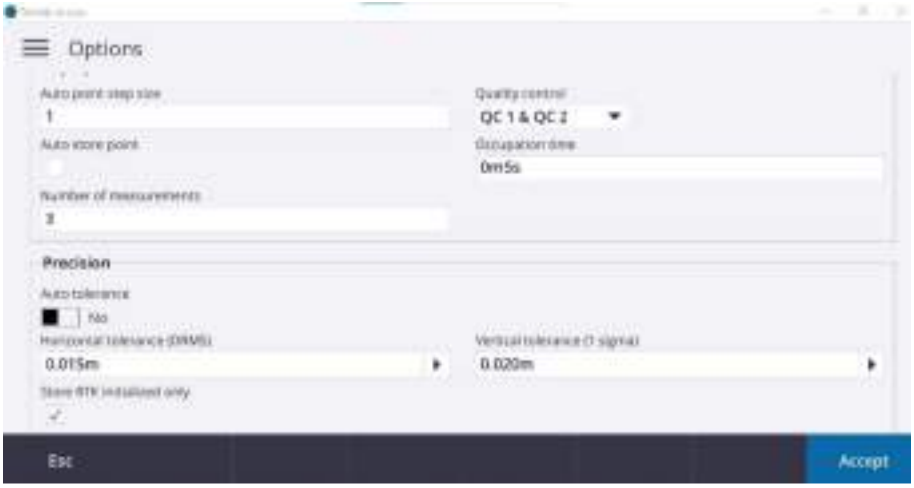


Note: The Broadcast format (selected in step -14) and Mount point (selected in Step 19), must correspond to each other otherwise the user will not receive the NRTK correction.

Step 20: A tick will be displayed after successful connection as shown below in circle.



Step 21: Click on Options tab and select Quality Control parameters QC1 & QC2 also enter other values as per below figure below and then click on Accept.



4.4 Survey mark Co-ordinate measurement

After Configuration of controller in the previous steps as per serial no. 4.3., the instrument is fully configured and ready for surveying of land parcel vertex and determining the co-ordinate of the Control points to be used for setup and alignment of ETS.

Carefully position the GNSS receiver exactly on the intended control Point. Ensure that the receiver is stable and positioned precisely over the designated point before proceeding.

Once the instrument is set up, it will process GNSS signals, and the RTK (Real-Time Kinematic) solution status will be displayed on the screen. The status will indicate whether the solution is in Float or Fixed mode.

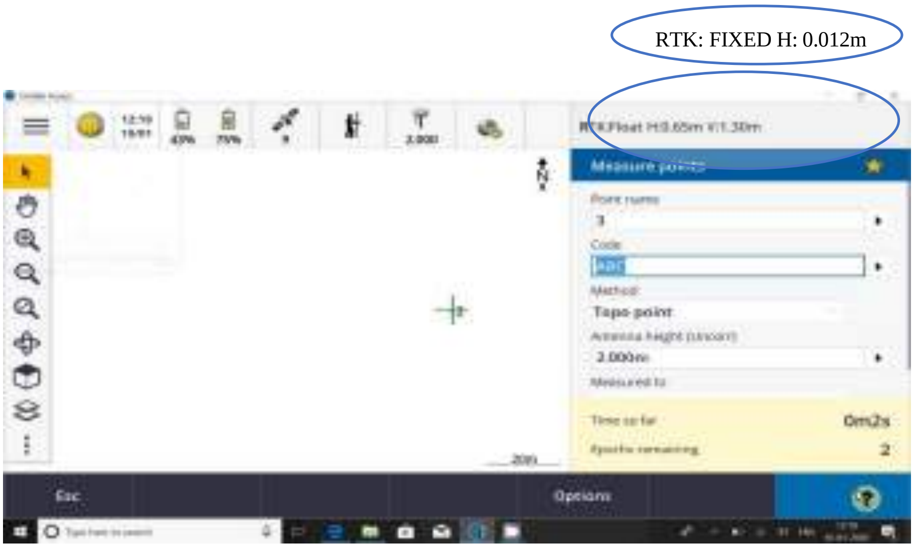
A Fixed solution ensures high-accuracy of positioning, which is essential for control point, while a Float solution suggests that further signal refinement is needed before recording the point.

Before saving the point, you can enter details such as Point Name, Code, and Antenna Height, etc. These attributes help in organizing and structuring the survey data for future reference.

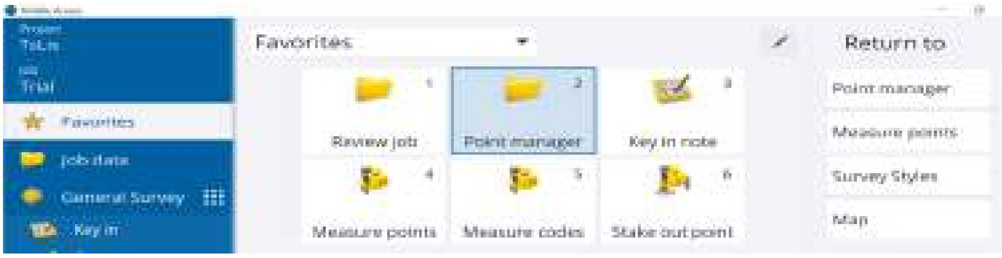
To confirm and store the point, click on the question mark tab located at the bottom right corner of the screen as shown in the interface. Continue measuring and storing additional points systematically to ensure accurate readings.

Step 1: To measure the co-ordinate of a unknown point, once the instrument is properly centred, levelled and configured. Open a project, and start measuring the point.

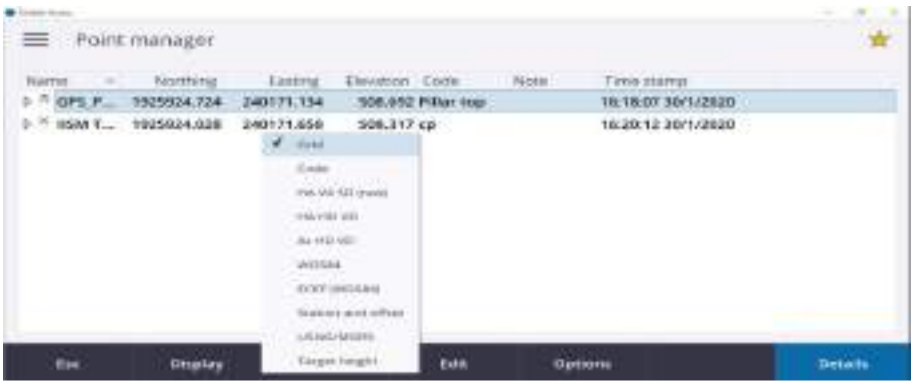
Step 2: Once the instrument has initialized (green tick), click on measure point icon to survey and store the co-ordinate of the survey mark.



Step 3: To view the surveyed point co-ordinates Click on menu button then select favourites then select Point manager



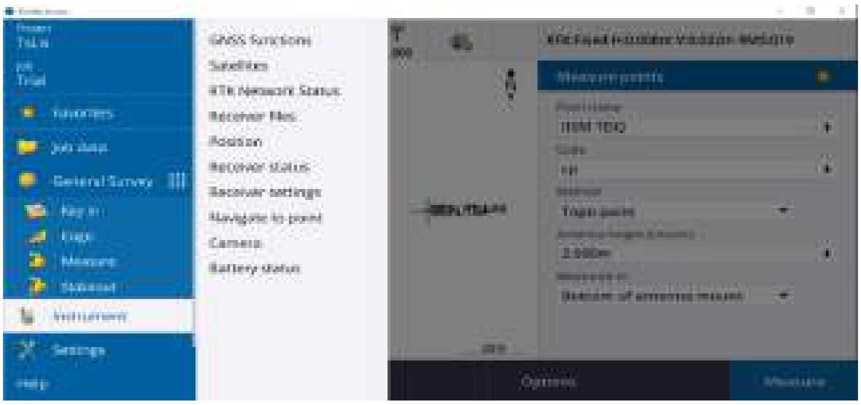
Click Display tab to view co-ordinates in different formats



Step 4: To end the Survey

- Click on Menu button and

select the Instrument tab and select GNSS functions tab

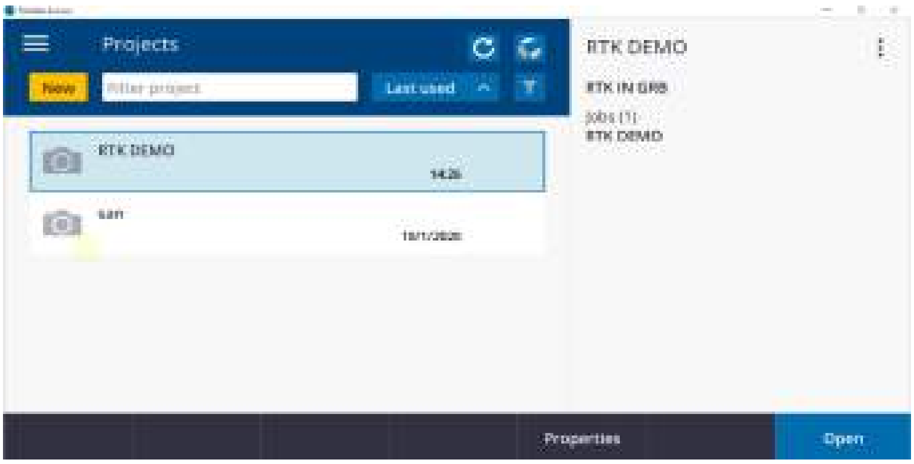


- Click on **End Survey** option

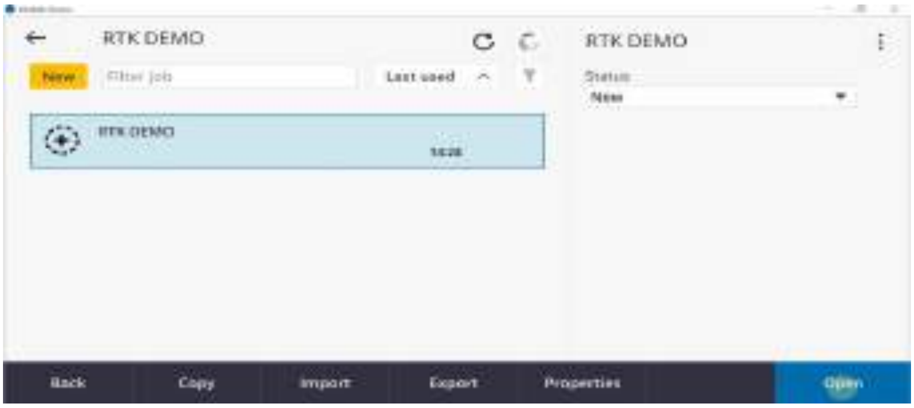
- Click on **Yes** to stop the rover

5 Exporting Surveyed Co-ordinate data

- Click on Trimble Access icon in your controller device
- Open Project (e.g. RTK DEMO)



- Select Job (e.g. RTK DEMO) created under above Project (e.g. RTK DEMO)



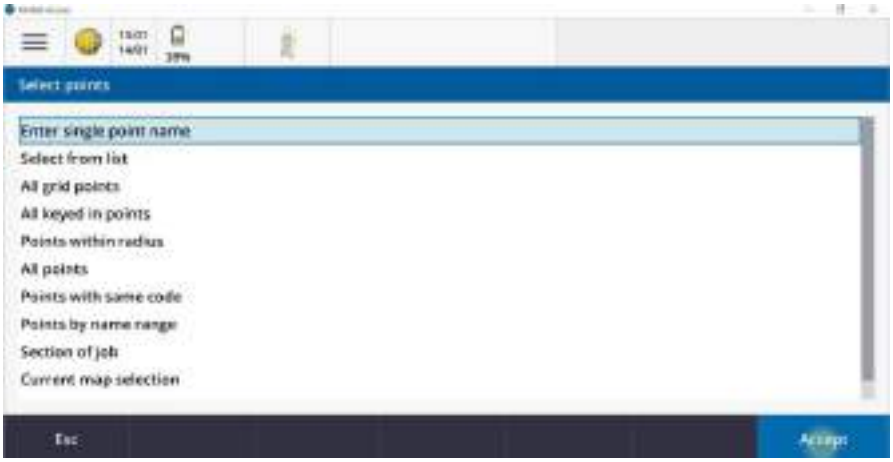
- Now click on Export tab in your controller.

- Export page will open.
- Different File formats are given. Here select file format as “CSV WGS-84 lat longs” In “File name” output file name shall be entered as it was provided in Step-9 in ‘Additional Settings’ options. The desired path to store the file may be provided.
- Select “Accept”
- Now file has been exported in Lat Long format to path given and file can be opened in MS excel.
- Again Job page will appear.

- Export page will display again

- Now if we have to store the coordinate in Easting & Northing format. Select “Comma delimited (*.CSV,*.TXT)” in File Format.

- In “File name” select the desired path and Select “Accept”
- Then the next window will appear as given below



- Select “All points” from options and click on Accept.
- Now file has been exported in Easting & Northing format as path given in CSV format.

6 Precautions

Precautions for NRTK Survey Using CORS

- **Site Selection & Environment:**

Ensure the survey area has an unobstructed sky view (minimum 15° elevation mask) to minimize satellite signal blockage.
Avoid areas near high-rise buildings, trees, water bodies, power lines, cellular towers, and reflective surfaces to reduce multipath errors.
Select survey locations away from radio interference sources that may affect real-time corrections.

- **Reference Network & Correction Services:**

Verify the CORS network availability and ensure a stable internet connection for receiving real-time corrections.

- **GNSS Equipment Setup:**

Use multi-frequency, multi-constellation GNSS receivers to improve positioning accuracy.
Ensure the receiver firmware is updated and supports the correction format (RTCM, CMR+ etc.) used by the CORS network.
Correctly centre and level the GNSS antenna over the survey point using a fixed-height tripod or pole.
Avoid holding the receiver by hand when high precision is required.

- **Survey Execution:**

Allow the receiver to initialize properly and achieve a fixed RTK solution before recording data.
Maintain sufficient observation time per point to ensure stable and reliable positioning.
Use different observation times to check for repeatability and accuracy.
Regularly monitor positional accuracy, ensuring horizontal and vertical error limits are met.

- **Environmental & Atmospheric Considerations:**

Plan surveys when ionospheric and tropospheric conditions are stable (avoid surveys during high solar activity or storms).
Be cautious of atmospheric delays, especially over long baselines.

If operating in extreme weather conditions, ensure battery life and equipment protection measures are in place.

- **Data Quality & Validation:**

Verify RTK/NRTK solutions in real time and conduct quality control checks by measuring known control points.
Use post-processing techniques if real-time accuracy is compromised.
Maintain detailed logs of corrections received, baseline distances, and accuracy reports for validation.

7 Conclusion

The integration of CORS (Continuously Operating Reference Stations) data into our survey operations plays a vital role in enhancing the precision and accuracy of the coordinates of land parcel vertices. By leveraging data from the CORS network, we ensure that all positional information is aligned with the National Spatial Reference Framework, which serves as the authoritative standard for geospatial referencing across the country.
This alignment guarantees uniformity across various datasets and promotes interoperability between different geospatial systems and platforms. As a result, the consistency and reliability of the coordinates collected during the survey are significantly improved, leading to more dependable outcomes for land management, planning and development activities.

ANNEXURE-III

Standard Operating Procedure

For

Land Parcel Measurement using Q-field Application

TABLE OF CONTENTS

1. Objective and Scope

This SOP provides a standardized workflow for collecting the coordinates of the land parcel vertices using Q-Field application integrated with GNSS Rover via Trimble Mobile Manager (TMM) application.

2. Hardware and Software Requirement

a) QGIS (Desktop version 3.28 LTR) installed for project preparation. (https://qgis.org)

b) Q-Field (Mobile app Version 3.5.1-Fangon) installed on Android or iOS. (Mobile device)

c) Trimble Mobile Manager Application (TMM Version 2024.12.7) installed in the Mobile device.

d) Trimble GNSS Receiver (e.g., R8, R10, R12i) supporting CORS RTK corrections.

e) CORS Network Access (credentials for RTCM corrections from a SOI).

3. Prerequisites and References

a) Ortho Rectified Imagery (ORI)

b) Vector Data extracted from ORI

c) Geo-referenced village/revenue map (if any)

d) Other Spatial and textual records (RoR etc.) related to the property (Land Parcel).

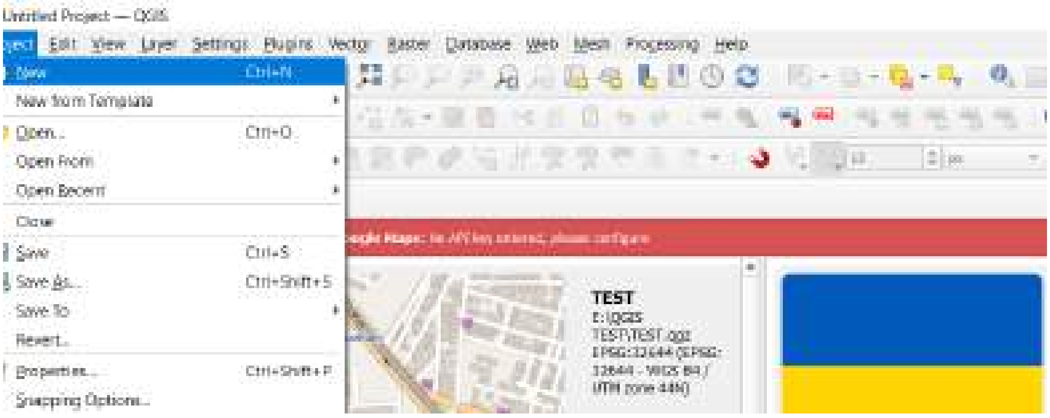
e) Install and configure the TMM Application with GNSS rover as per SOP in Annexure-I

4. Step by Step Instruction

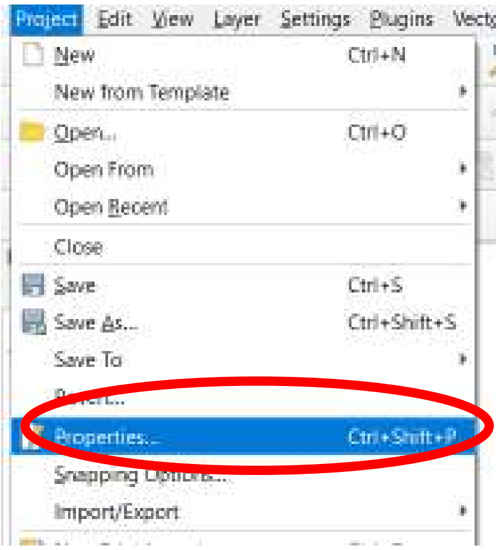
4.1 Setting up the Q-field Project in QGIS.

Creation of new project in QGIS

Open QGIS Project > click New option



Goto >> Project Tab on the menu >> click Properties



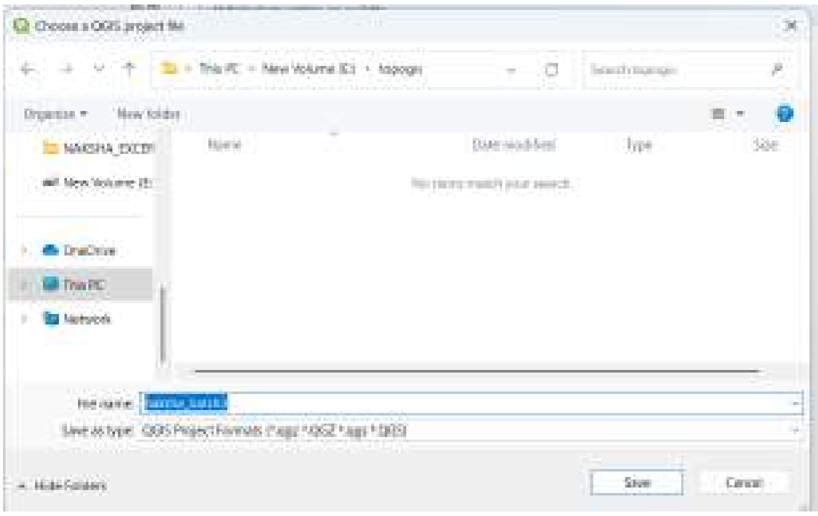
Select Project Co-Ordinate System (Ex: UTM, WGS 84 and Zone N 44).

NOTE: The co-ordinate system will depend the Area of Interest and care must be taken to input the correct Co-ordinate system details as per AOI

Click **Apply >Ok**

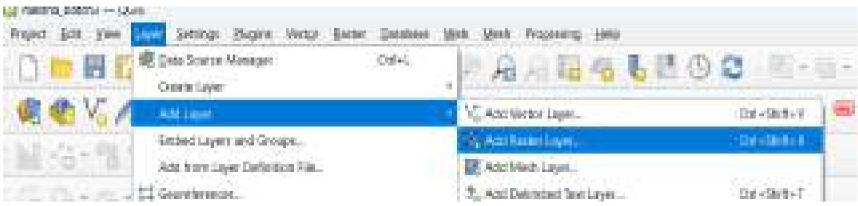
Goto **Project tab > click Save**

Provide a suitable name for the project.



4.2 Loading of Ortho Rectified Image (ORI) of the Area of Interest (AOI).

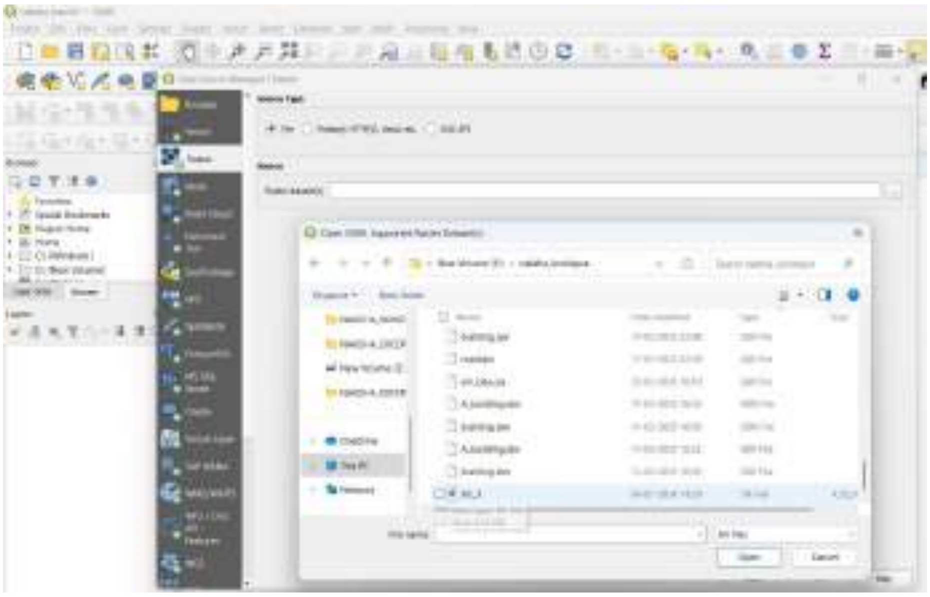
Goto Layer tab on the menu > select add Raster Layer (format .tiff or .jpg etc.)



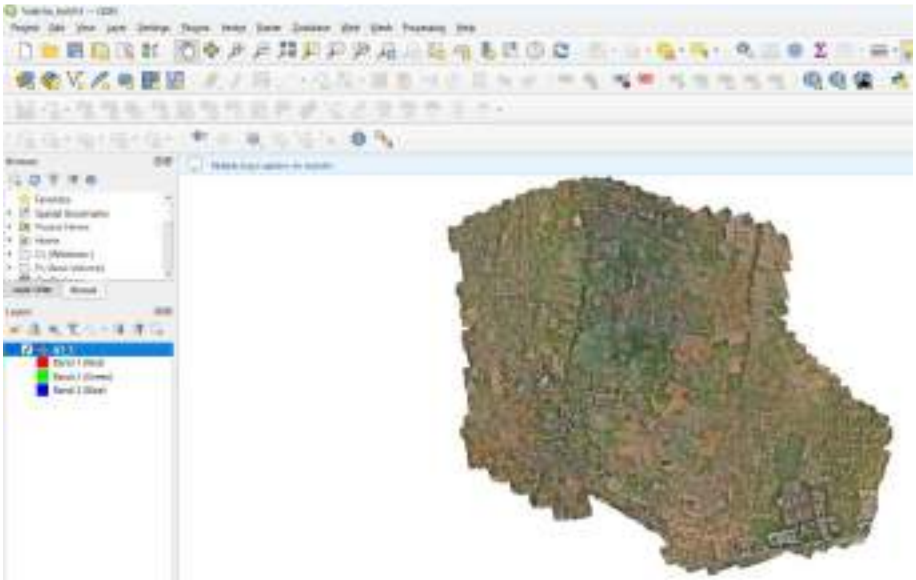
Select the path where the raster layer is stored by clicking on the three dots. (Raster layer means ORI)

Select the desired file name for. e.g. A1_1.tif (ORI)

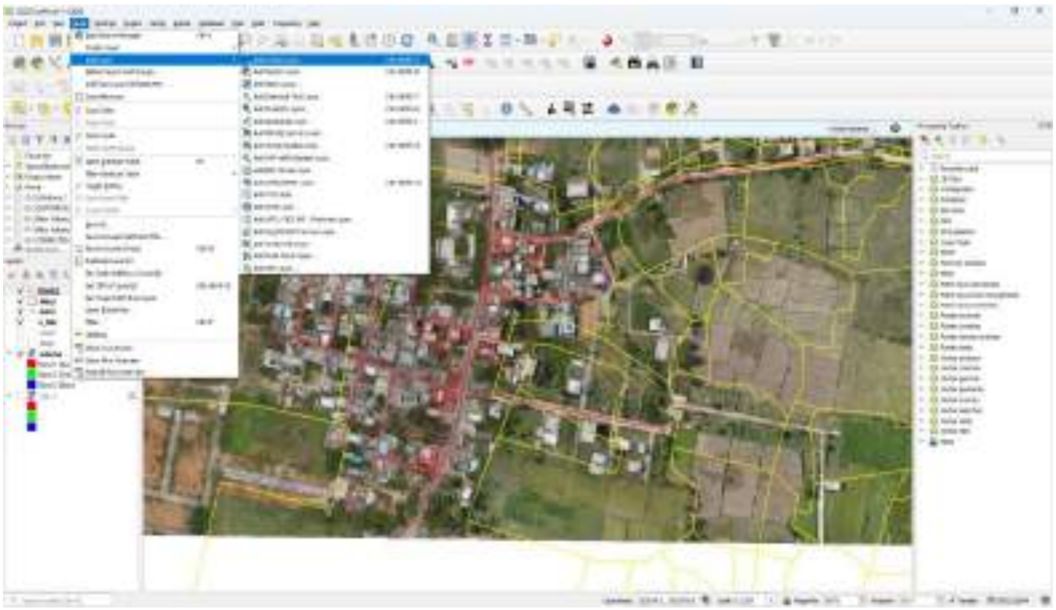
Click on Open> close (Pop window will be closed)



The added ORI is visible on the screen (canvas).



- Similar procedure shall be followed to add the vector layers (Map-1 deliverable)
- Goto Layer tab on the main menu > select add Vector Layer (format .tiff or .jpg etc.)
- Select the path where the vector layer is stored by clicking on the three dots.

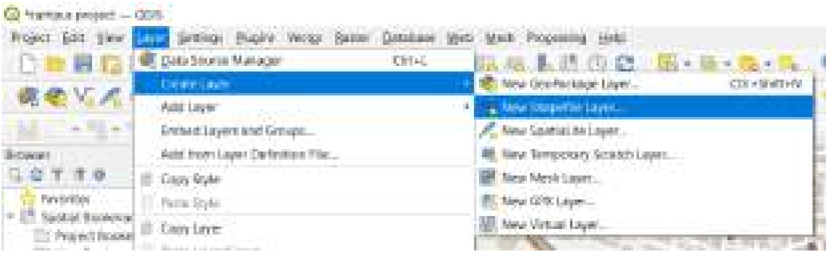


- Select the desired vector layer. (E.g. Building foot print, boundary wall etc.
- Click on Open> close (Pop window will be closed)
- The added vector layer will be visible on the screen overlaid on ORI (canvas).

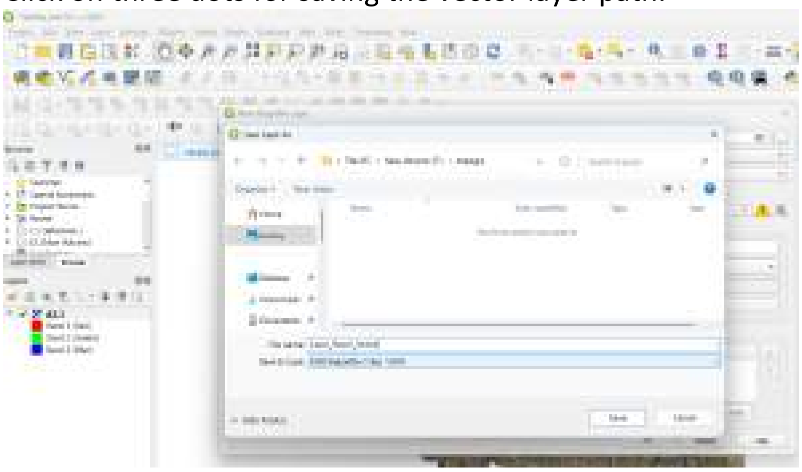
4.3 Creating new Vector Layer for field data collection (land parcel vertex)

In this section the vector layer(Point) to store the co-ordinates of the Land parcel vertices is being created and the desired attribute to be collected as per the UrPro is added to this point layer.

Goto Layer tab> Create Layer > New shapefile layer



Click on three dots for saving the vector layer path.



Key in name of the layer ex: Land Parcel Vertex **Click>Save**

Select geometry type as point.

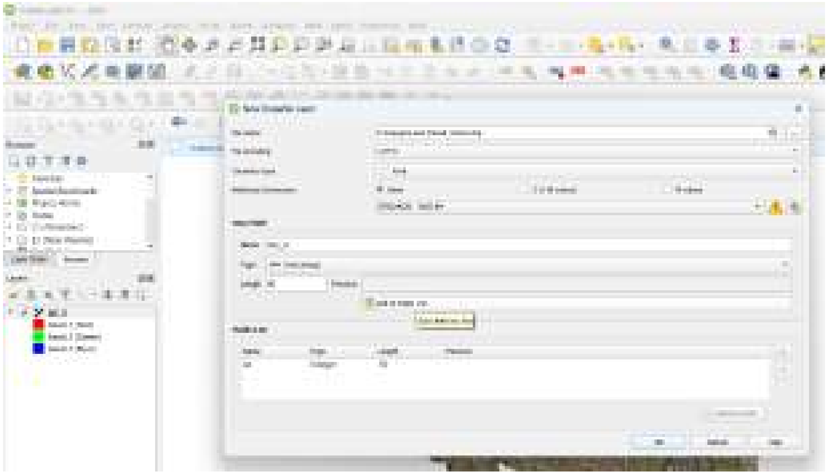
The desired attribute data i.e. Details to be collected as per the Ur Pro shall be created and added

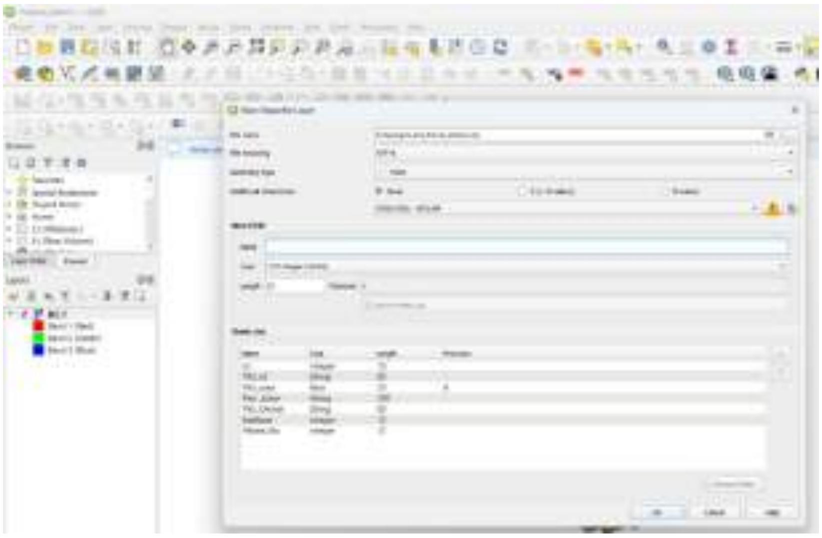
Under the **New field** Option of the window. Provide the Name, type, length of the field (i.e. Attribute)

E.g. Plot_id -string-80

Plot_area-Real-20 etc.

After entering the details. Click on '**Add to field List'**. The Added layer will be displayed to the '**Field List**'





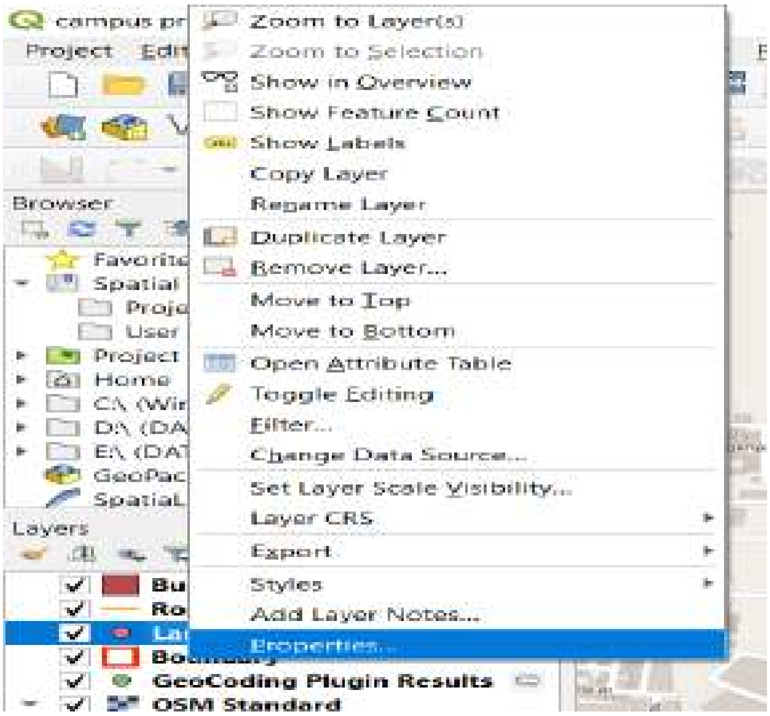
Similarly, you can add fields as required.Click **ok**

The created Vector Layers will be added in the Layers panel (LHS)

4.4 Symbolization of Vector Layer

Changing the symbol as required

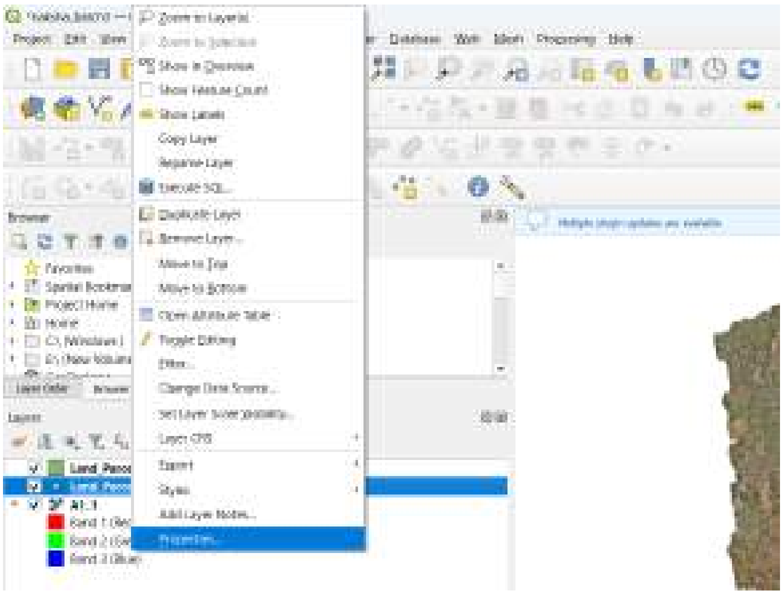
Right click on layer name '**Land Parcel'> Properties**

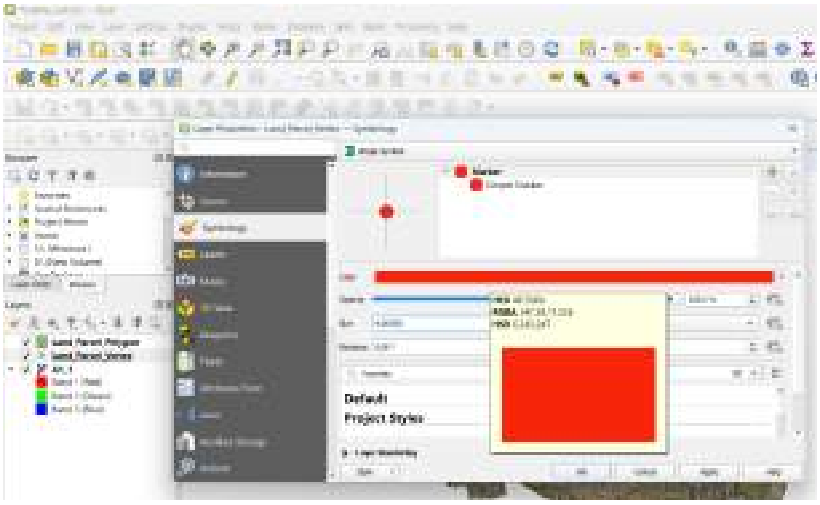


Change the symbology for Point, Line and Polygon features.

This will help to view the layer with the ORI background in the field.

I.e. for example Point color, size etc. (Note: user can change the symbology)





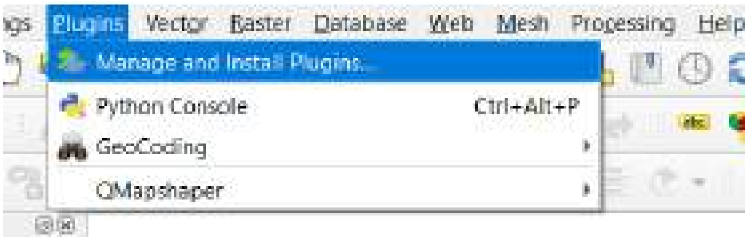
Click on **Apply>> OK**

Similarly change for any required layers

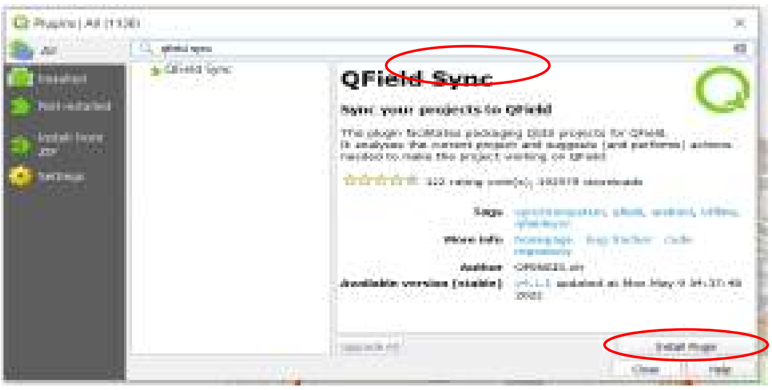
Project> Save

4.5 Adding Plugins for Q-field sync.

Go To plugins in the **main menu > click manage and install plugins**



Search for “QField Sync” and install it by clicking on “Install plugin”

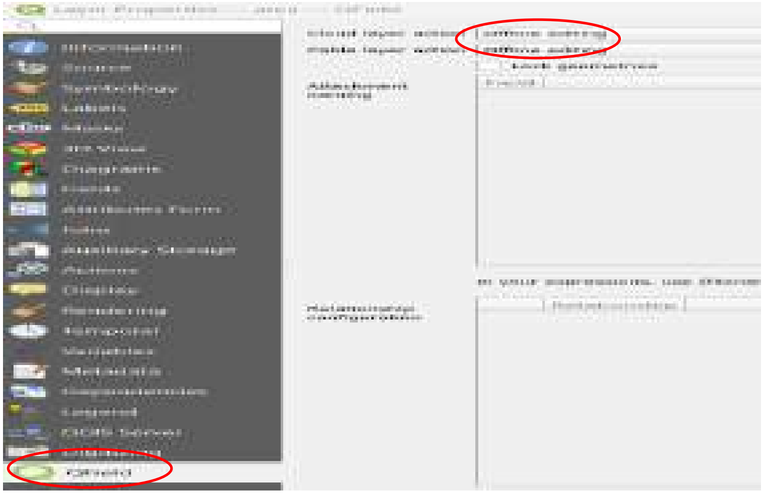


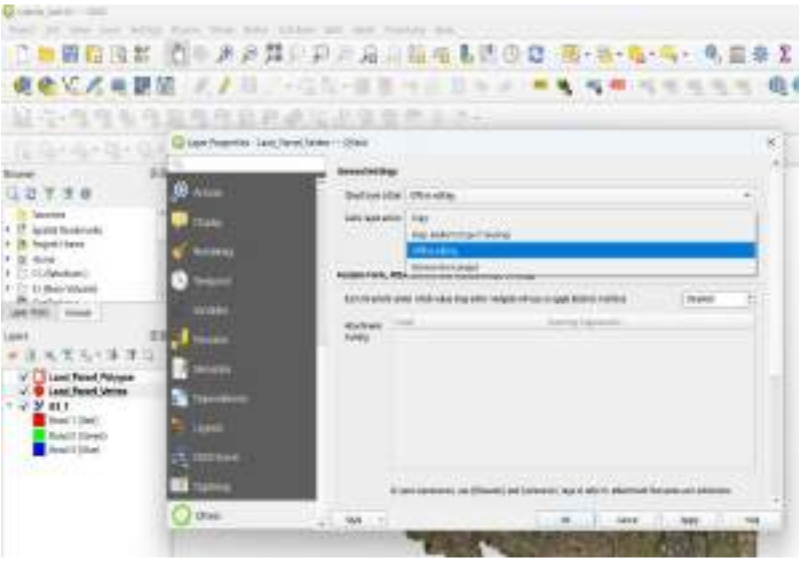
Close the popup window.

4.6 Preparation of Layers for Offline Editing.

Since the land parcel vertex layer has to be collected in the field, it has to be enabled for off-line editing as described below.

Right click on vector layer name **'land parcel vertex'> Properties>QField**





Change the "Cable layer action" to "offline editing" by selecting from the drop down menu. **Apply>OK.**

4.7 Creation of MB tiles for field

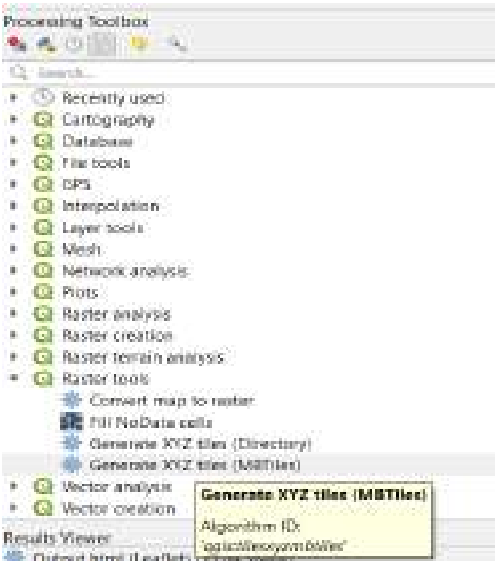
Since the ORI (raster layer) is heavy in size it must be converted to the MB tile format for easy viewing and access of the ORI layer in the mobile.

The active vector layers shall be checked off in the layer Menu (alternatively) only the ORI should be checked on

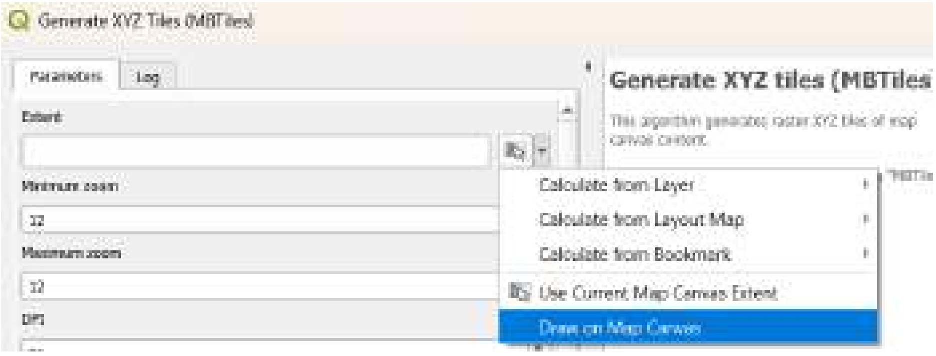
GOTO processing >tool box

Search for Raster tools

Expand it, double click on generate xyz tiles (MB Tiles)

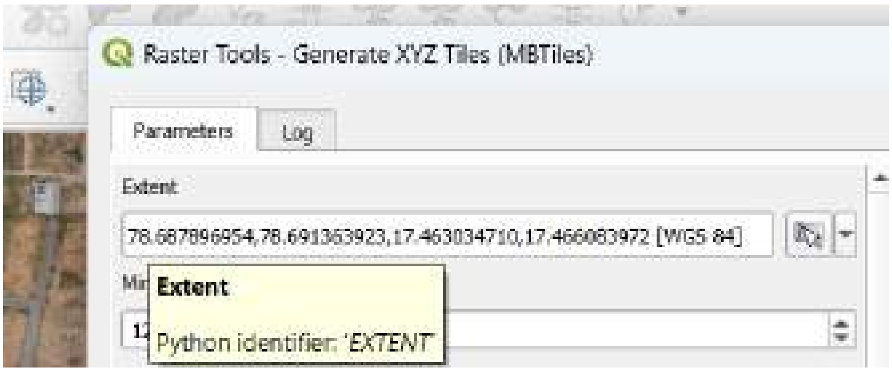


For the desired extent AOI: click on drop down menu>>select draw on map canvas



Select the required AoI on ORI using mouse (First click on NW Corner and then to SE Corner)

The limit of AoI will be displayed on in extent box.



Key in minimum zoom as 2

Maximum zoom as 18

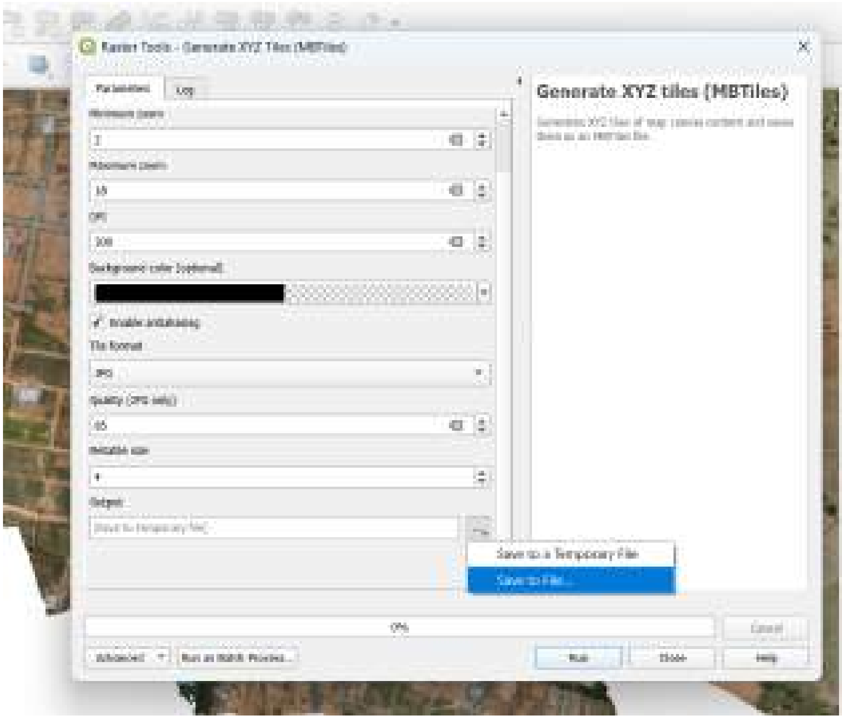
Dpi: 300

Back ground color: none

Tile format: jpg

Quality 85

Give file name for output MB tiles file (Naksha_B3)



Then click on Run

The status bar will display Complete. Close the active MB Tiles window.

Click on Project from the menu > save project

4.8 Exporting the Raster file (MB tiles) for field work

Check off all the original ORI from the layers Panel

Add the MBtiles layer created in the previous step

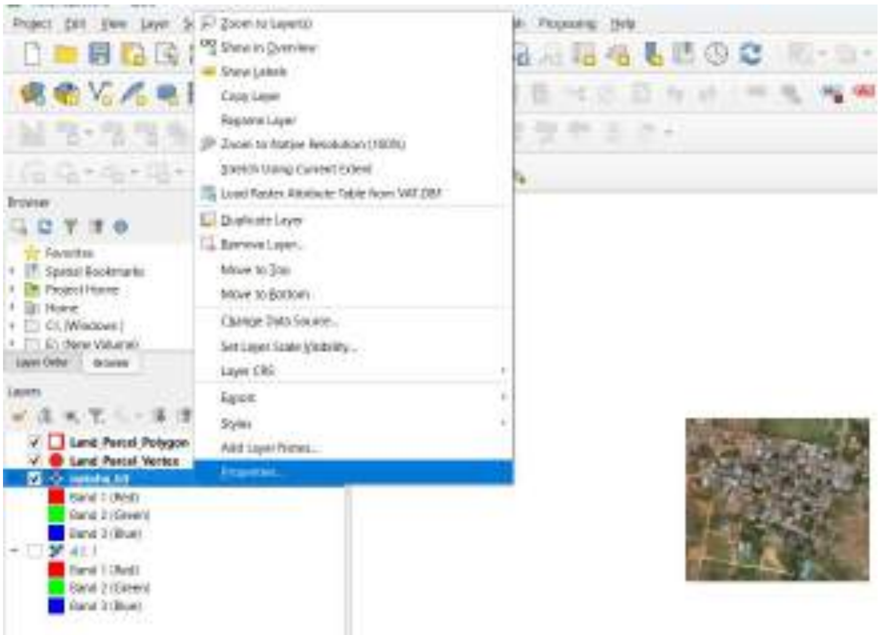
Layer>AddLayer>Add Raster layer

Select the path to MBtiles.

Open> Add

It is added to the layers panel

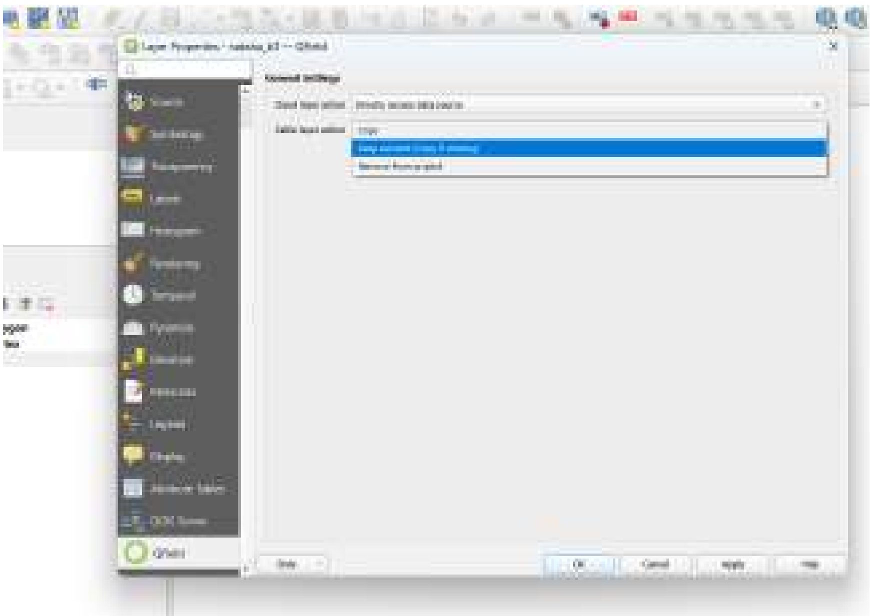
Right click on MBtiles layer name**>> click on properties**



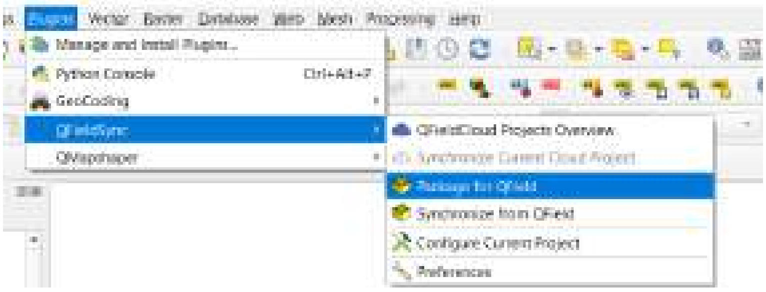
Properties>>Select Q-field (LHS Last Option)

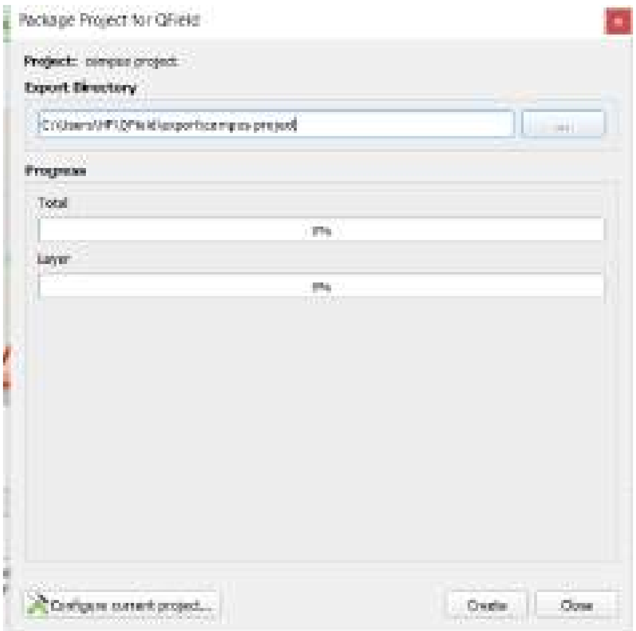
In Cable Layer Action select from drop down menu Keep existent (copy if missing)

Click Apply> OK



Go To plugins in the main menu>>Q-Field sync >> package for Q-Field



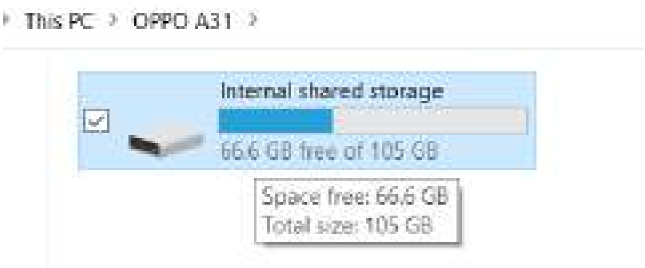


Click on Create

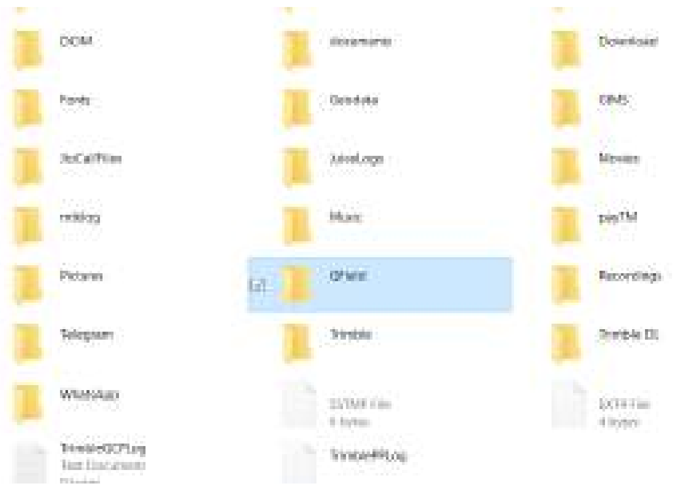
- All the data is exported to the following file with default path
- C:\Users\HP\QField\export\Naksha_Batch3\Naksha_Batch3_qfield.qgs
- Now it's ready to copy in field device (FDC/TAB/MOBILE)

4.9 Copying the Project Folder to a Mobile/Field Device

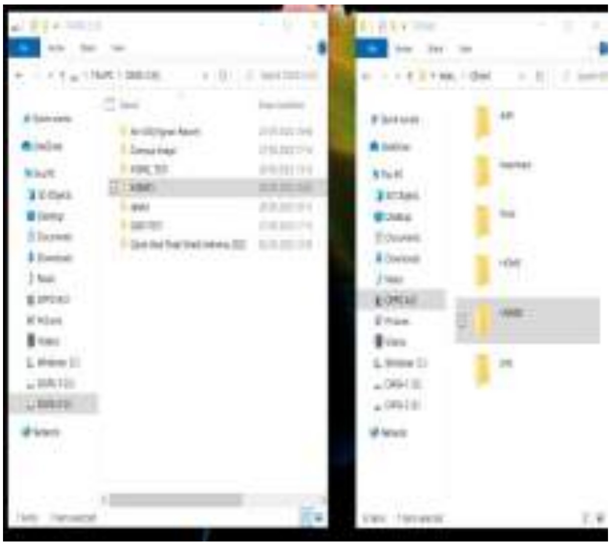
Connect the mobile phone or field device (Tablet) to the computer using a USB cable.



Navigate to the exported project folder on the desktop



- Copy the entire project folder.
- Open the mobile phones file manager and locate or create a Q-Field folder.
- Paste the copied project folder into the Q-Field folder on the mobile device.



Safely disconnect the mobile phone from the computer.

5. Collection of land Parcel Boundaries using Q-field.

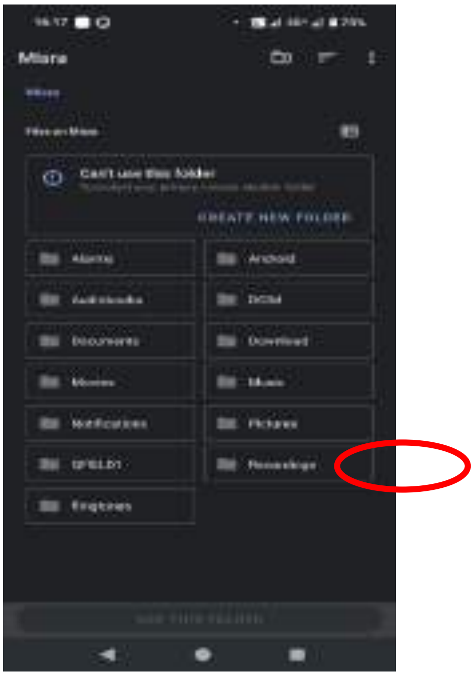
By the above steps, the ORI (as MB tiles), the vector layer (MAP-1) deliverables provided by SOI has been loaded into the Mobile device.

Also a vector point layer 'land parcel vertex' has been created to collect the co-ordinates in the field. This has been enabled for off-line editing. The co-ordinates so collected in the field will be recorded in this vector layer along with this attributes. The following steps will illustrate the procedure for collection of the Parcel vertex using the Q-field application.

Open Q-field App in the mobile device.

Tap on open local file option and Tap on Internal storage

Go to Q-Field folder in the internal memory of the mobile device.



All the listed folder will be available for selection.

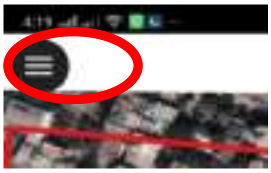
Select the desired folder (naksha_batch3).

All the items inside the folder that will be displayed.

Click on ‘Use this folder’ option at the bottom. It will open your project which was created in Desktop

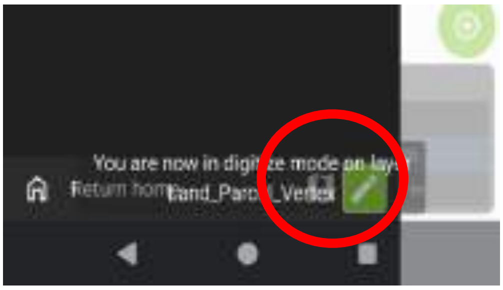
The project will open in Q-Field app as shown below

From the above steps the Vector data and raster data (ORI) has been fed into the mobile device.
To collect features follow the following steps:
If you need to capture a point under the Land Parcel Vertex
Tap on Menu.



Tap on Land parcel Vertex (Point Feature) which is to be surveyed

Tap on pen icon



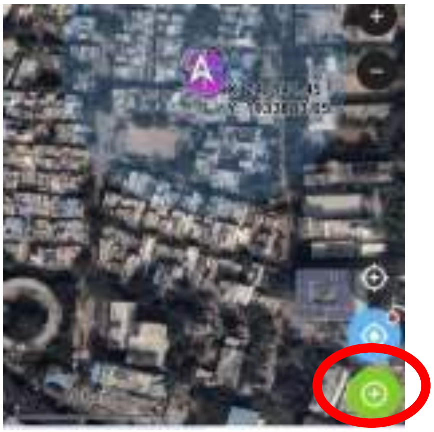
It will display ‘**You are now in digitize mode on layer Land_Parcel_Vertex’**

Note: Connect the Mobile Device/ Tab to the GNSS receiver via Trimble Mobile Manager App. The detailed SOP of TMM Application is provided at Annexure-I.

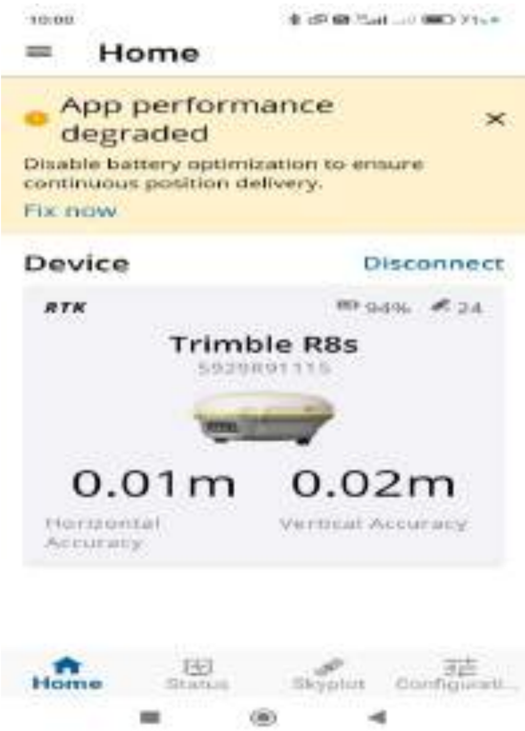
Place the GNSS rover precisely at the vertex of the land parcel.

Tap on GNSS positioning (second) button at lower right corner

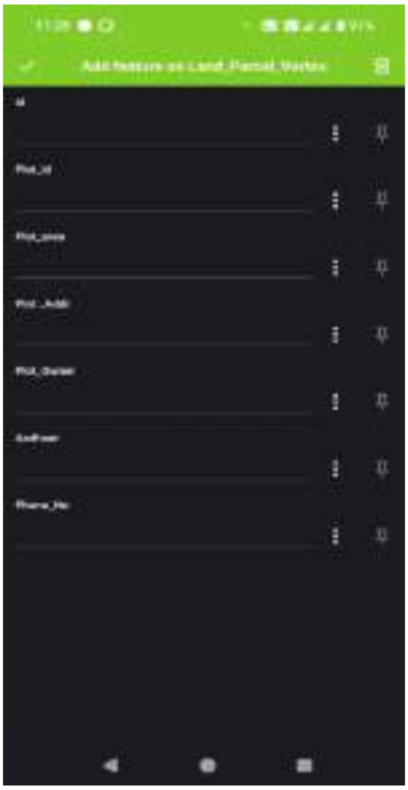
Now click on green button to add data point at the GNSS rover location.



Before inputting the data point, check the accuracy in the TMM application



A popup menu of the created attribute table will open. Fill in the required details.



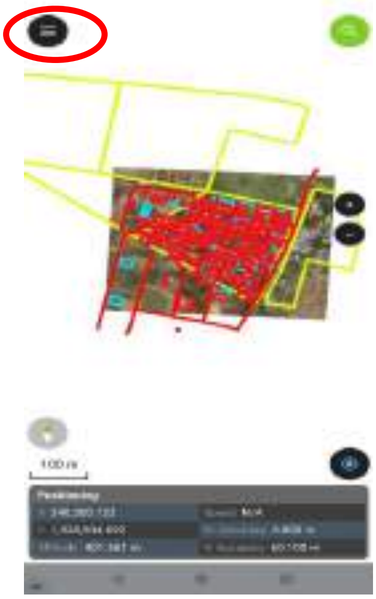
Tap tick mark (upper right corner).

The details captured along with entered attributes will be stored.

Similarly capture the other details.

6. Synchronization of Field data.

Once the field data capturing has been completed then the data can be exported to the desktop from the mobile device. The land parcel vertex layer that has been collected in the field will be exported in the GeoPackage format. This GeoPackage format can be directly opened in the Q-GIS Desktop application for further processing and editing.



Click on the menu button the Top left corner of the mobile.

Click project folder as shown in the figure below.

The project folder will open and long press or the click the three dots on the right side the ‘data.gpkg’ item.

Click on the ‘send to’ option, by this the data created in the field can be shared with any individual through Whatsapp/email etc. or you can copy the same to the internal folder.

By the above steps the data collected (Land Parcel Vertex) in the field has been exported or shared for further processing and editing in the Desktop Q-GIS application.

7. Conclusion:

The land Parcel vertex points have been collected in field using Q-field Application coupled with the use of GNSS Rover with high accuracy using the CORS.

Useful reference links for Q-field and TMM:

1. QField Documentation: https://qfield.org
2. QGIS Documentation: https://qgis.org

ANNEXURE-IV

STANDARD OPERATING PROCEDURE

for

Creation of Land parcel using QGIS

TABLE OF CONTENTS

1. Objective and Scope:

To create Land Parcel polygon layer using field observed Co-ordinates of Land parcel vertices.

2. Hardware and Software Requirement:

Hardware Requirements

Desktop System shall have the following specifications

a) Processor – multi-core processor (Intel i5/i7 or AMD equivalent) for smooth performance.

b) RAM – Minimum 8GB (recommended 16GB or more for large datasets).

c) Storage – SSD (256GB minimum, 512GB+ recommended) for faster data access.

d) Monitor – High-resolution display (Full HD or higher) for better map rendering.

Software Requirements

a) Operating System – Windows 10/11, Windows/Linux/macOS (for QGIS).

b) GIS Software –QGIS (3.28 LTR version).**"To download QGIS, visit "**https://qgis.org/download/**."**

3. Prerequisites and References

The user should have a basic knowledge of geospatial data and be familiar with QGIS software.

4. Data Preparation

The following data sets needs to be collected before start of work.

a) Coordinates of Land parcel vertices collected using ETS in .csv format

b) Coordinates of Land parcel vertices observed using GNSS/Qfield (.gpkg file or csv file)

c) Ortho rectified image. (ORI)

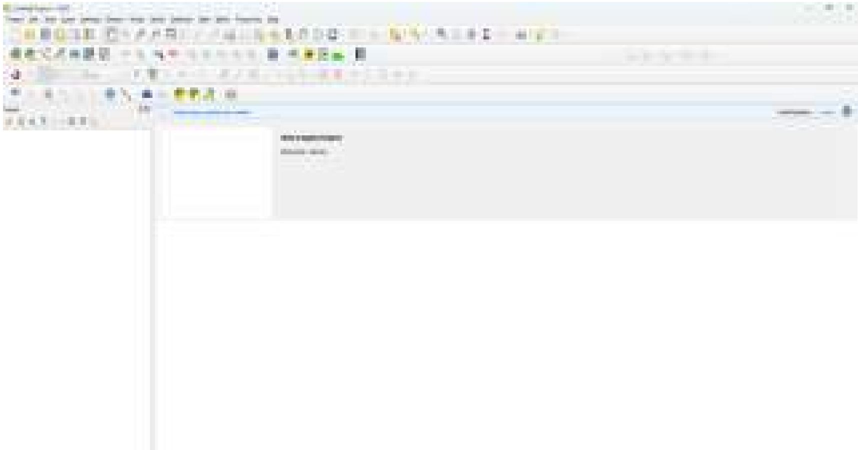
d) The feature extracted vector layer (MAP-1 deliverable provided by SOI).

e) Geo-referenced Revenue Map (if available).

5. Creation of a Q-GIS Project

a) Launch the QGIS application from the Start menu

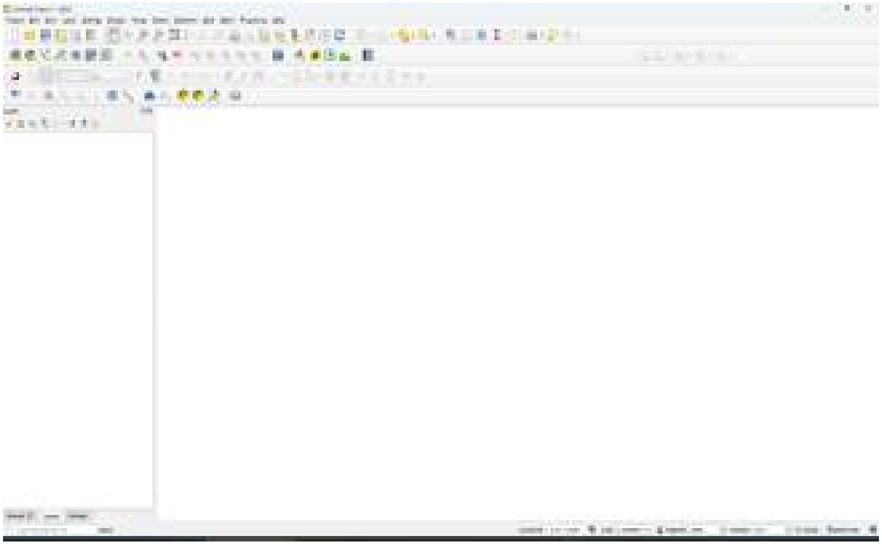
b) Once QGIS opens, the Welcome screen will appear.



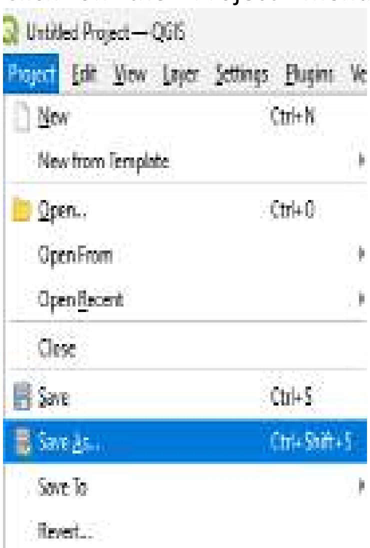
c) Click on 'New Empty Project' from the main window.

d) Alternatively, select 'Project' from the menu bar >>click 'New'.

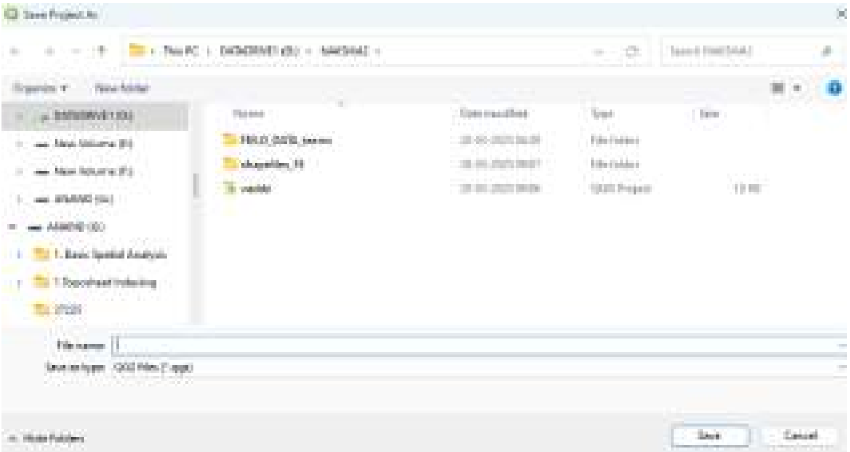
e) A new QGIS project is now ready for use.



f) Click on the 'Project' menu in the toolbar, select 'Save As...' from the dropdown menu.

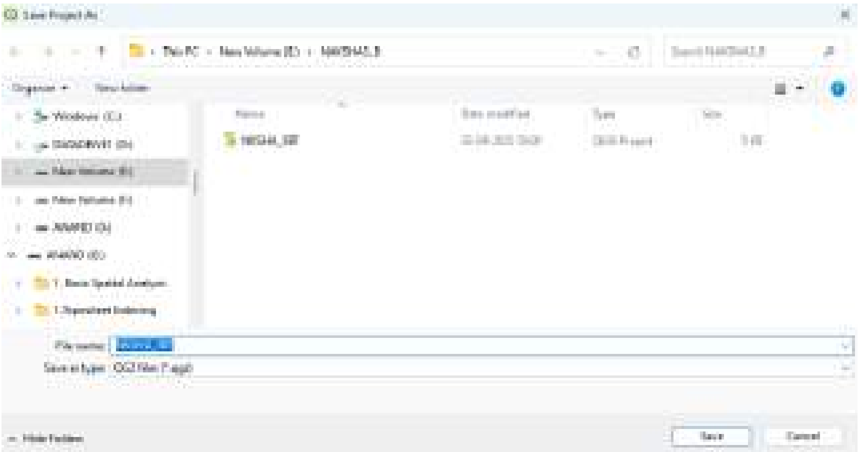


g) In the 'Save Project As' window, the desired folder shall be browsed to, and the file format should be set to 'QGIS Project Files (*.qgz)'.

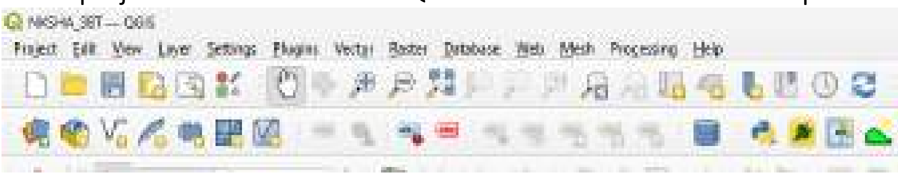


h) A project name should be entered in the 'File name' field.

i) Click on the 'Save' button to confirm. The project will now be saved as 'NAKSHA_3BT.qgz' in the selected location.



j) The project title in the QGIS title bar will be updated to 'NAKSHA_3BT'.



6. Importing field surveyed data:

The field data (land parcel vertices) collected during the survey will be received in two formats:

Land parcel vertex data collected using an Electronic Total Station (ETS) will be available to the surveyor in CSV file format.

Land parcel vertex data collected using GNSS and QField will be available in GeoPackage format.

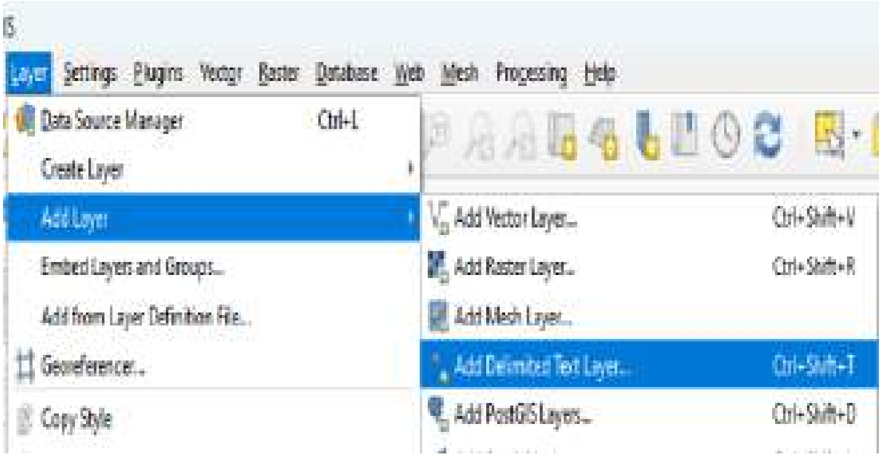
The step-by-step procedure to import these data formats and create parcel polygons is illustrated below.

6.1. Importing CSV file (Data collected using ETS)

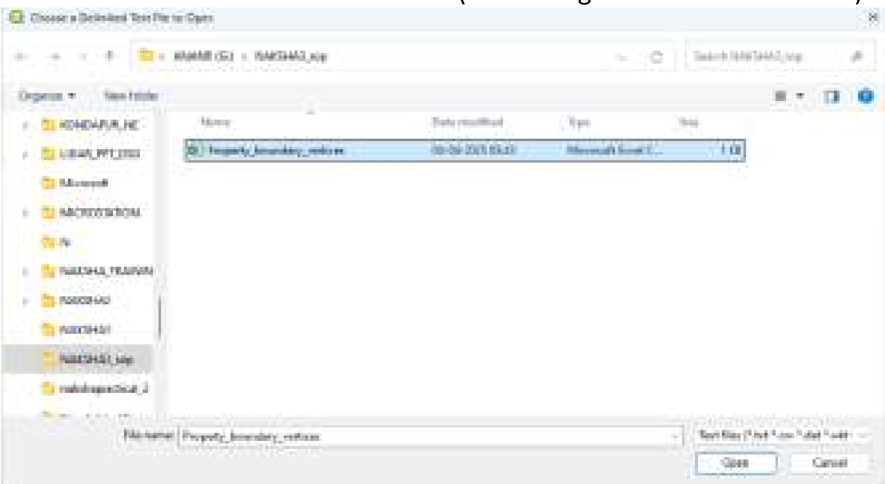
ETS (Electronic Total Station) and GNSS Rover data is typically stored in CSV format, containing coordinate points collected during field surveys. To visualize and process this spatial information, the data must be imported into QGIS. QGIS offers a straightforward method to load CSV files as point layers by mapping their coordinate fields to the appropriate spatial reference system.

Follow the steps below to import ETS data into QGIS:

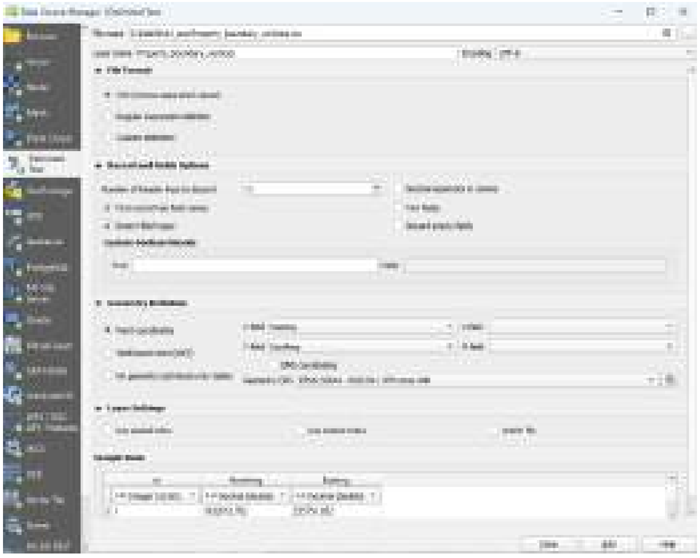
a) **Navigate to** *Layer >> Add Layer >> Add Delimited Text Layer***.**



b) The **Data Source Manager** window will appear. Navigate to the appropriate file path to locate and load the desired dataset (containing the CSV file). Then Click 'Open'



c) In the Geometry Definition section, the appropriate option shall be selected from the dropdown, ensuring that the X field is set to 'Easting' and the Y field is set to 'Northing'.

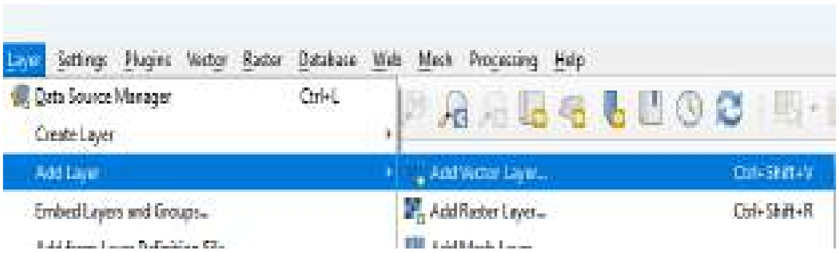


Click ‘add’ button. The layer will be added to layer panel.

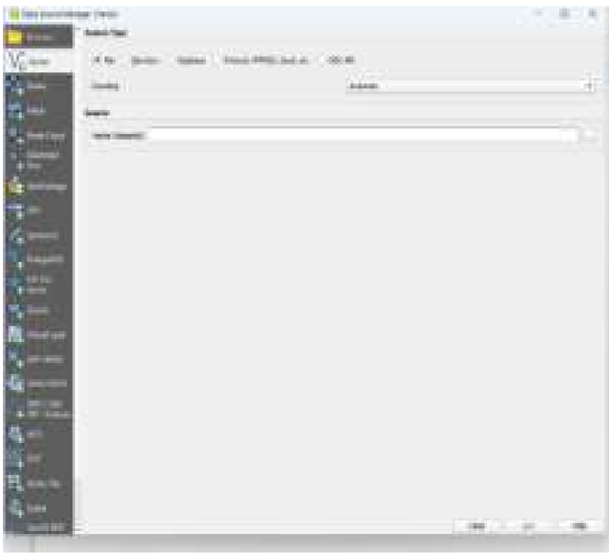
6.2. Importing Land parcel vertex data collected from GNSS (Q-field).

The land parcel vertex data collected from the field will be provided in GeoPackage format—an open, portable, and efficient spatial data format.

a) To import this into QGIS, navigate to ***Layer > Data Source Manager > Vector***, and select 'GeoPackage'.

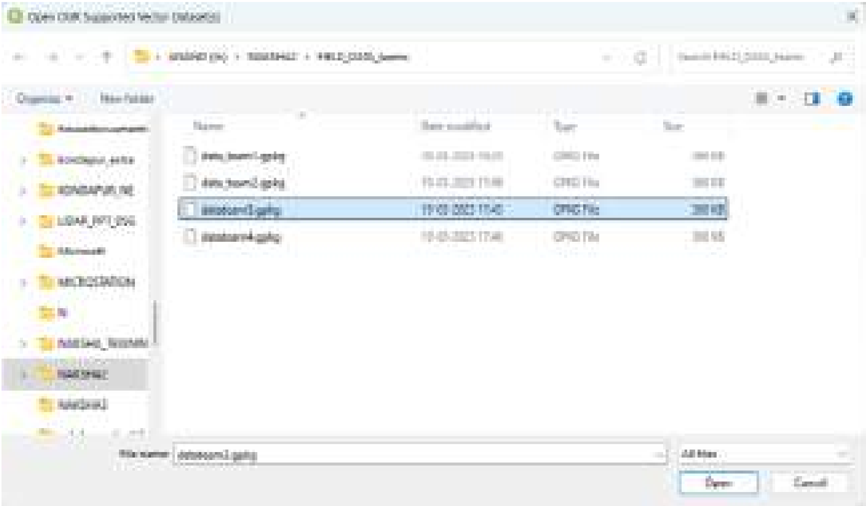


b) In the Data Source Manager – Vector window, the three dots (...)  icon next to the Source field shall be clicked.

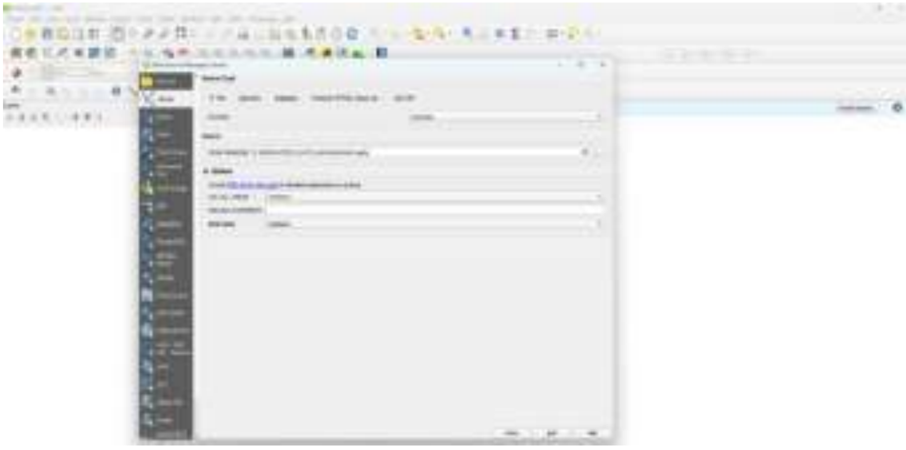


c) Navigate to the folder location where the field data (geopackage).gpkg layer is stored.

d) Select the appropriate file say 'Datateam3.gpkg'

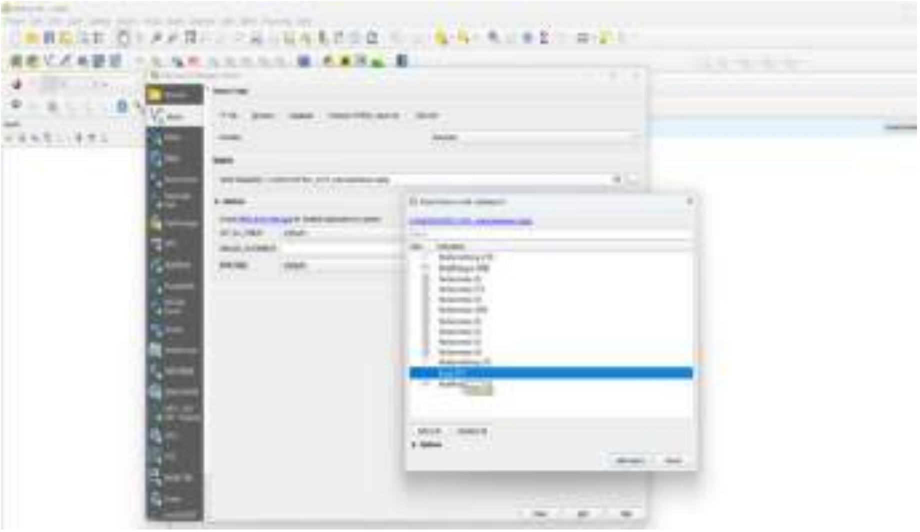


e) Click the 'Open' button. The selected file will then be displayed in the Source panel.

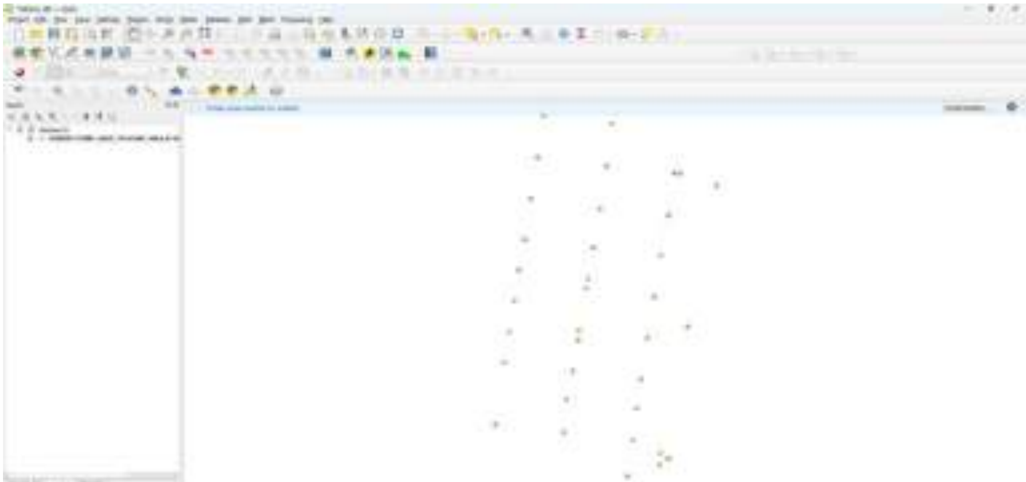


f) Click the 'Add' button. The 'Select Items to Add' window will appear.

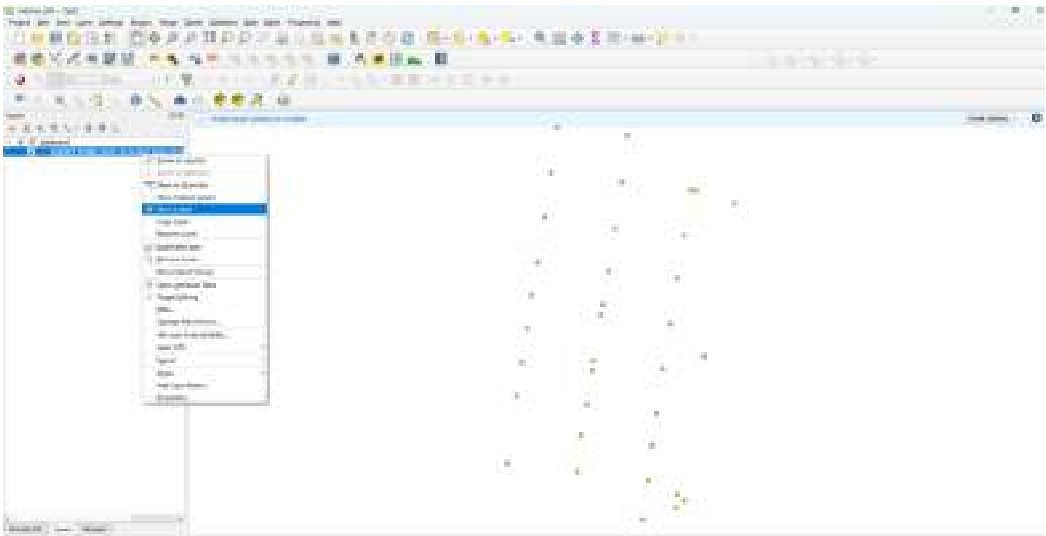
g) Select the desired layer where the land parcel vertex is stored e.g. 'Points (Land parcel Vertex)' option should be selected, followed by clicking on 'Add Layers'. The points will then be added to the Layers Panel.



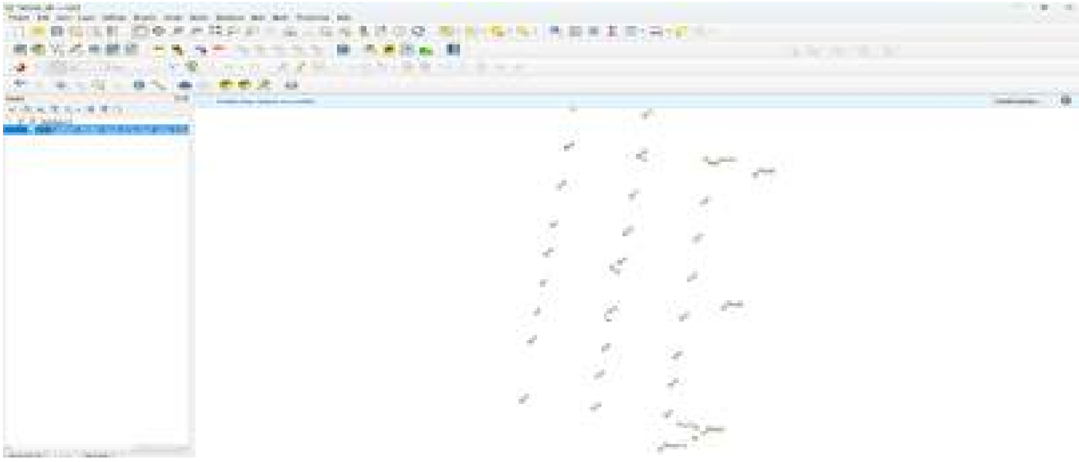
h) In the **Layer** window, the added layer will be displayed as shown below.



i) To enhance data visibility, labels can be added to the layer by following these steps: right-click on the added layer and select 'Show Labels'.

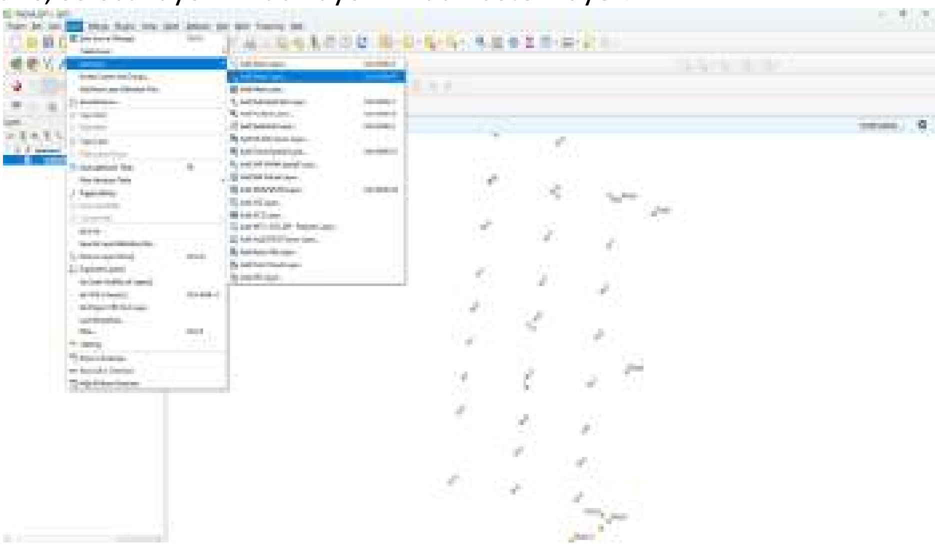


j) The labels will appear.



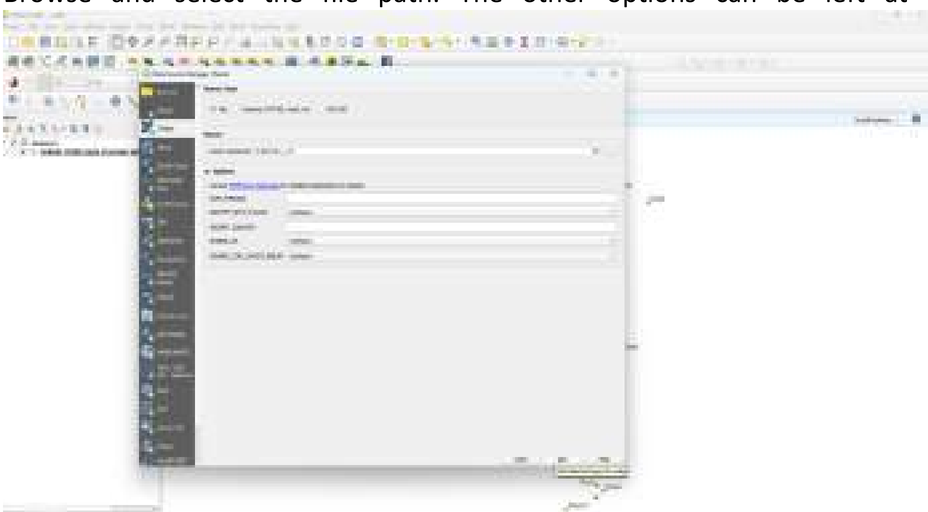
7. Adding the raster layer:

In order to view a raster, the ORI layer needs to be added to the Layers Panel. To do this, select Layer > Add Layer > Add Raster Layer.



a. The Data Source Manager window will appear. Click the three-dot (…)  icon in the Source section

b. Browse and select the file path. The other options can be left at their default settings.



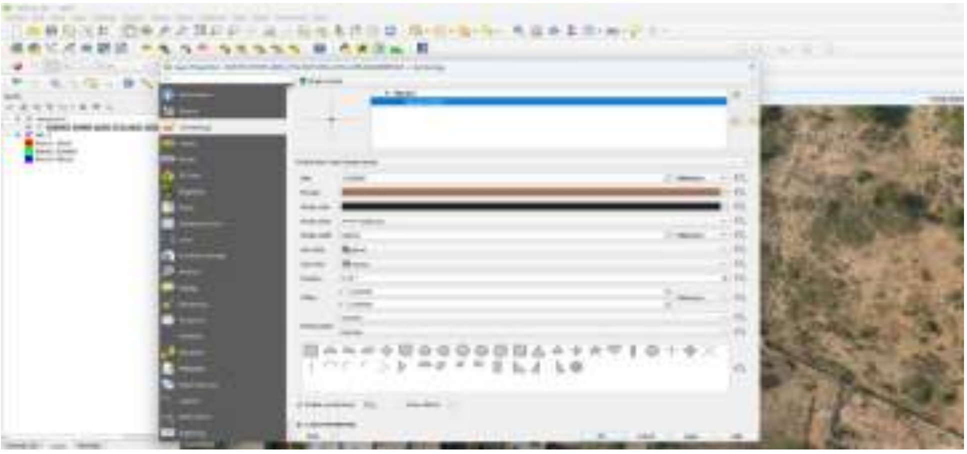
c. The ORI (raster) layer has been successfully added to the Layers Panel and will appear in the canvas

d. The previously added layers (e.g., points) may not be visible due to the recently added ORI raster layer. To make them visible, the layer order in the Layers Panel should be adjusted by dragging and rearranging the layers as required.

e. The added land parcel vertex (vector points) may appear small in size. To enhance visibility during land parcel digitization, their size, style, and colour shall be adjusted.

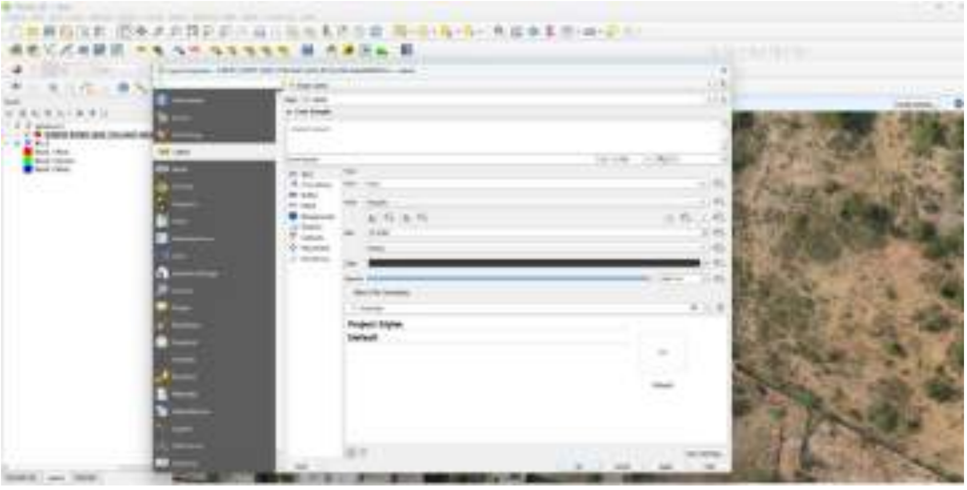
f. This can be done by right-clicking on the layer, select 'Properties >> symbology>> Layer Properties window will appear.

g. Simple Marker' shall be selected under the Symbology tab to customize the layer's appearance. The size should be adjusted to modify the marker's dimensions.



h. A colour shall be chosen to enhance visibility. The fill colour should be changed to modify the marker's appearance.

i. Similarly, the label size can be increased by navigating to the **Labels tab** in **Layer Properties** and adjusting the size under the Text settings.



j. Finally, the labels will be displayed according to the selected size and style.

k. In the above steps the land parcel vertices (observed using GNSS and Q-Field) and the raster layer have been added to the canvas. For visualization purposes, the symbology and labels have been modified. Now, the land parcel polygon layer can to be created using the land parcel vertices.

8. Create Land parcel polygon layer from the land parcel vertex

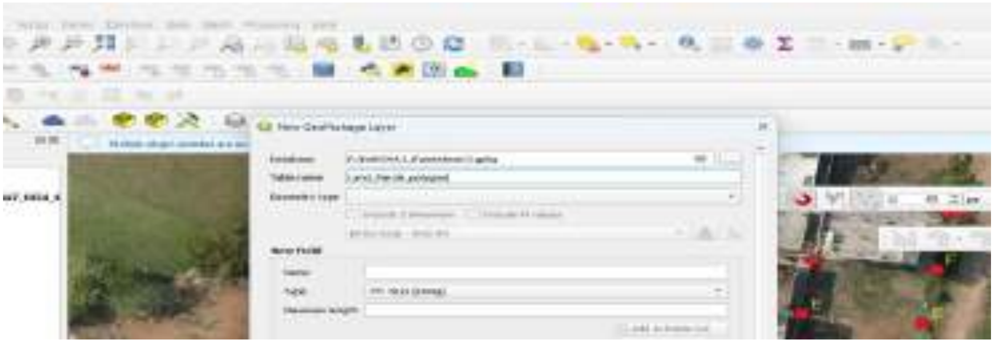
As per the schema, no land parcel polygon layer currently exists; therefore, a new layer shall be created and digitized using the land parcel vertices.

To create a land parcel polygon layer, the following steps should be followed: In the main menu select Layer menu >> select ***Create Layer >> New GeoPackage Layer***.

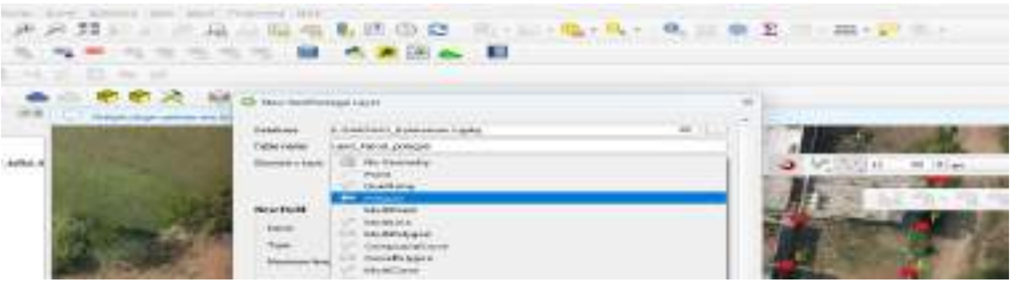
A 'New GeoPackage Layer' window will appear. Choose the desired file path—for e.g., *E:\NAKSHA_3B\datateam3.gpkg*—shall be selected in the Database field

Then, click the 'Save' button.

Enter the Table name as '**Land_parcel_polygon'.**



In the Geometry Type section, 'Polygon' shall be selected.



The correct Coordinate Reference System (CRS) should be chosen from the CRS section by clicking on the three dots (…) icon.

The required zone (e.g., EPSG: 32644 – WGS 84 / UTM Zone 44N) should be selected.

To include additional attribute information from UrPro (Property Card), new fields should be created using the field names specified in UrPro.

In the 'New Field' section, the required fields should be entered. For example, fields from Urban Property Pro (UrPro) may include:

Municipal ID, Property Type, Owner's Name, Area

Enter '**Name**' in the **Field Name** section.
E.g. Enter '**MunicipalID**' in the **Field Name** section and
select '**Integer (32-bit)**' as the **Type**.

The maximum length may be set to '32'. The 'Type' defines the data type to be stored (e.g., TEXT, INTEGER, REAL), while the 'Length' specifies the number of characters or digits the data can hold (e.g., 32, 64).

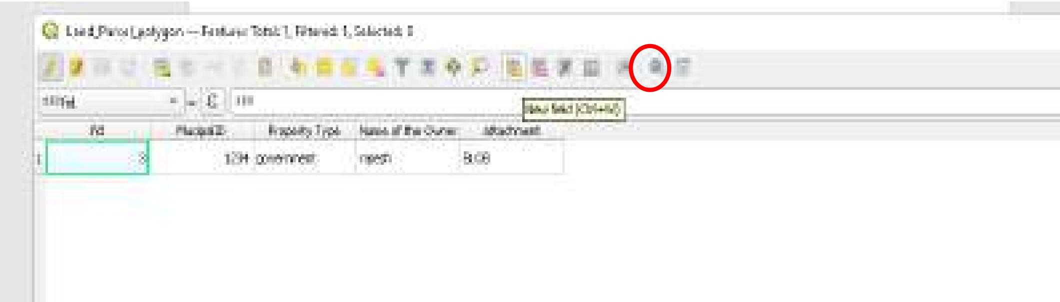
After the details have been entered, the click on 'Add to Fields List' button. The entered fields will then appear as shown below.

Similarly, any number of fields, along with their respective data types and lengths, can be added to the dataset.

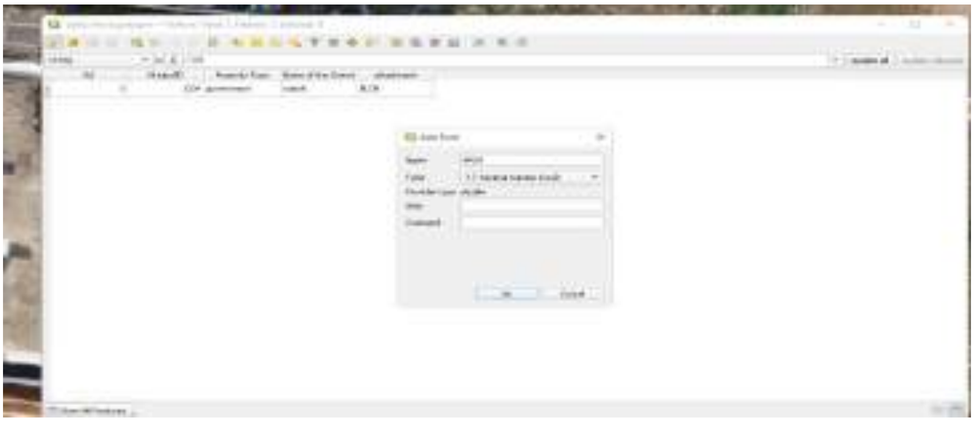
Click the 'OK' button. The layer will then be added to the Layers Panel.

Add an area field and update it with the area of each feature.

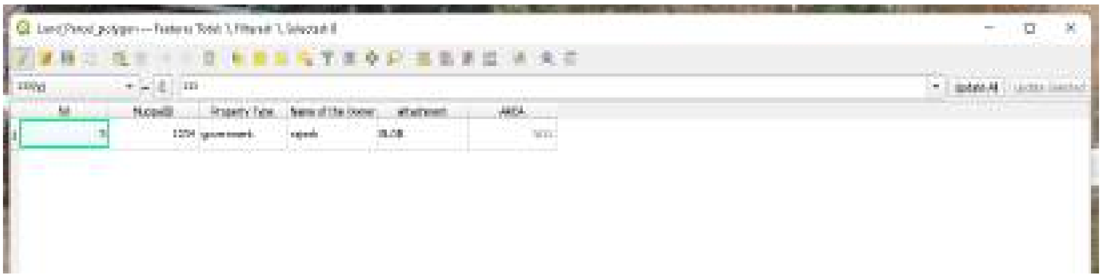
Click on 'New Field'. The 'Add Field' window will appear



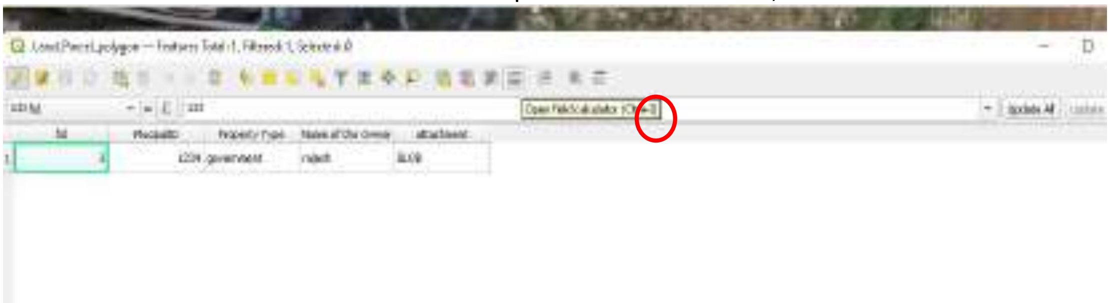
In the 'Field Name', enter 'AREA'. Set the 'Type' to 'Decimal', and click 'OK



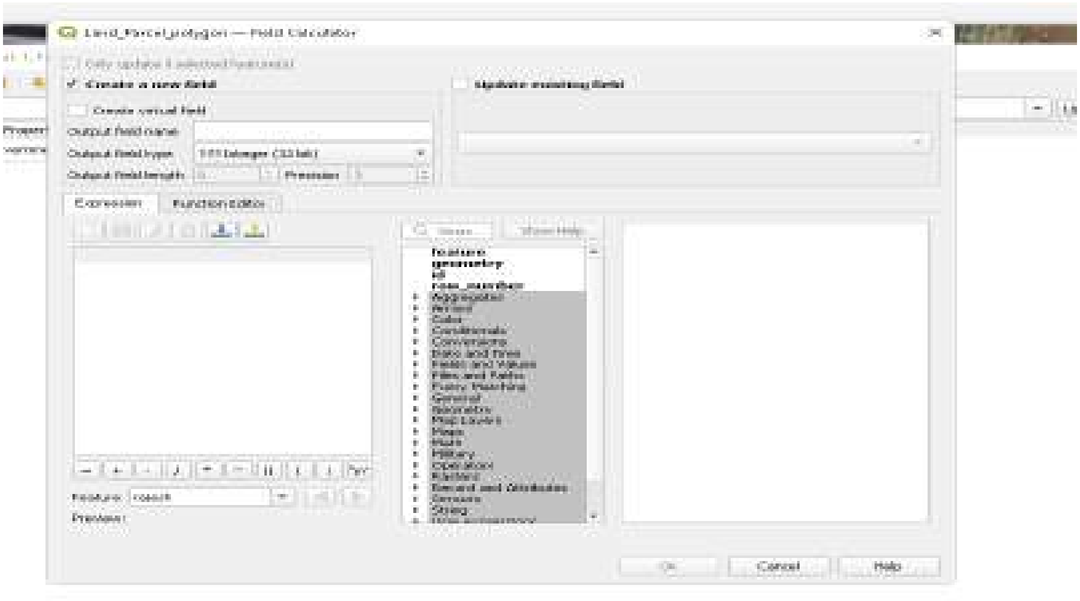
The 'AREA' field is now created and added to the attribute table



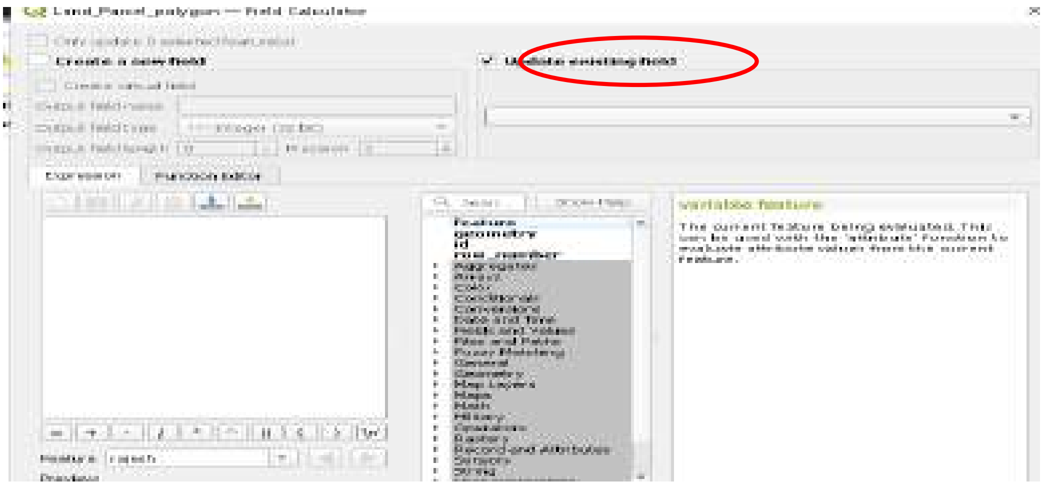
To calculate the area of each feature and update the 'AREA' field, click on the 'Field Calculator



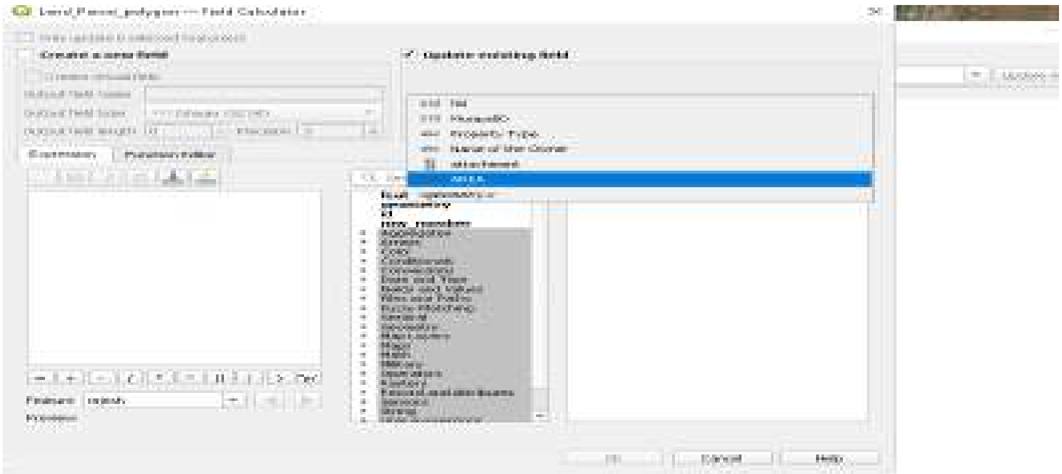
The 'Field Calculator' window will appear



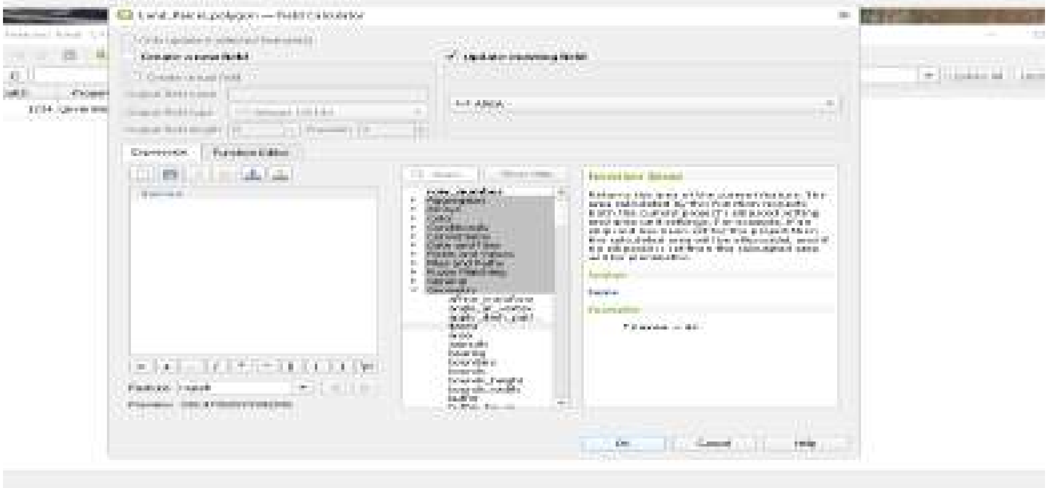
In the Field Calculator window, select the option 'Update existing field' to update the values in the existing 'AREA' field.



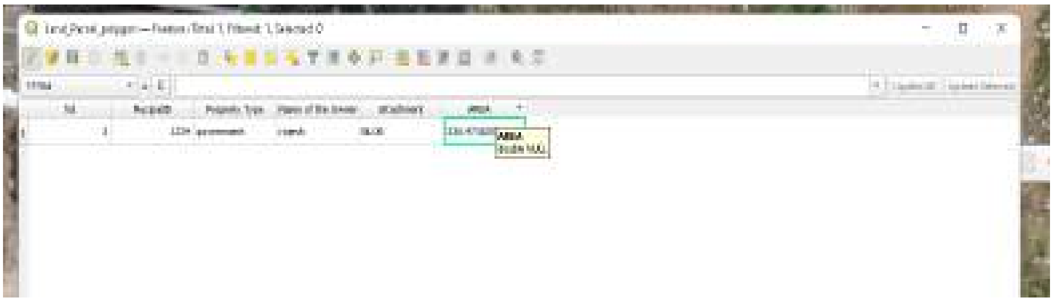
From the 'Fields and Values' panel, select the 'AREA' field to update its values.



Click the drop-down arrow next to 'Geometry', double-click on **“$area”** to add the expression to the calculator, and then click '**OK**' to apply.

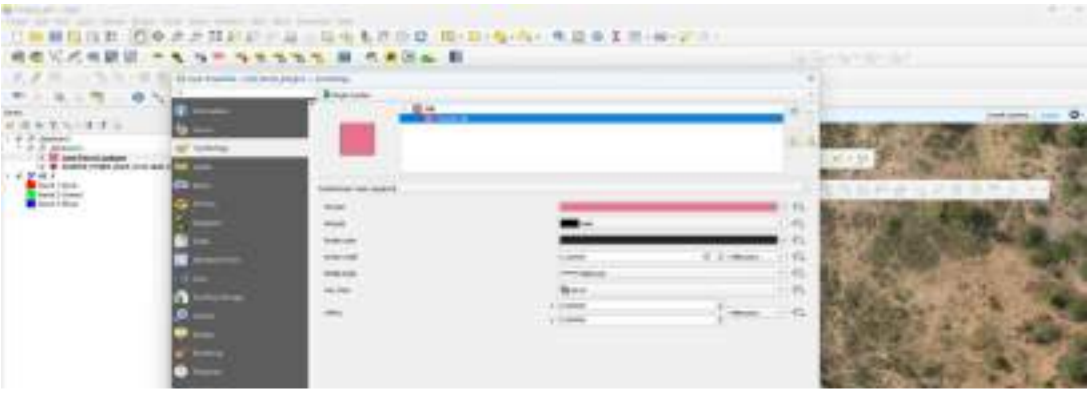


The area of each feature will be automatically calculated and updated in the 'AREA' field

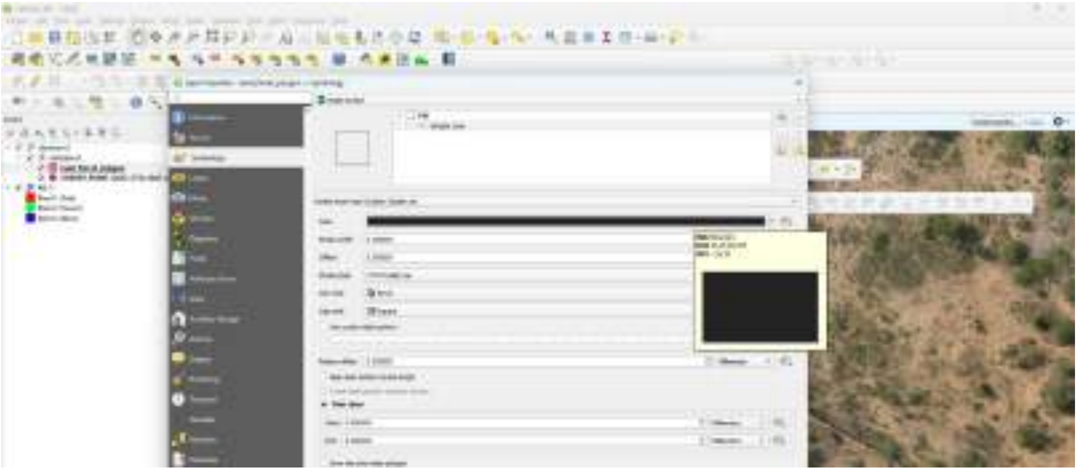


For visualization purposes, if the polygon is to be displayed as hollow, its symbology shsll be adjusted by right-clicking on the '**Land_parcel_polygon**' layer and selecting **Properties > Symbology.**

The Layer Properties window will appear as shown below. Click the 'Symbology' option.

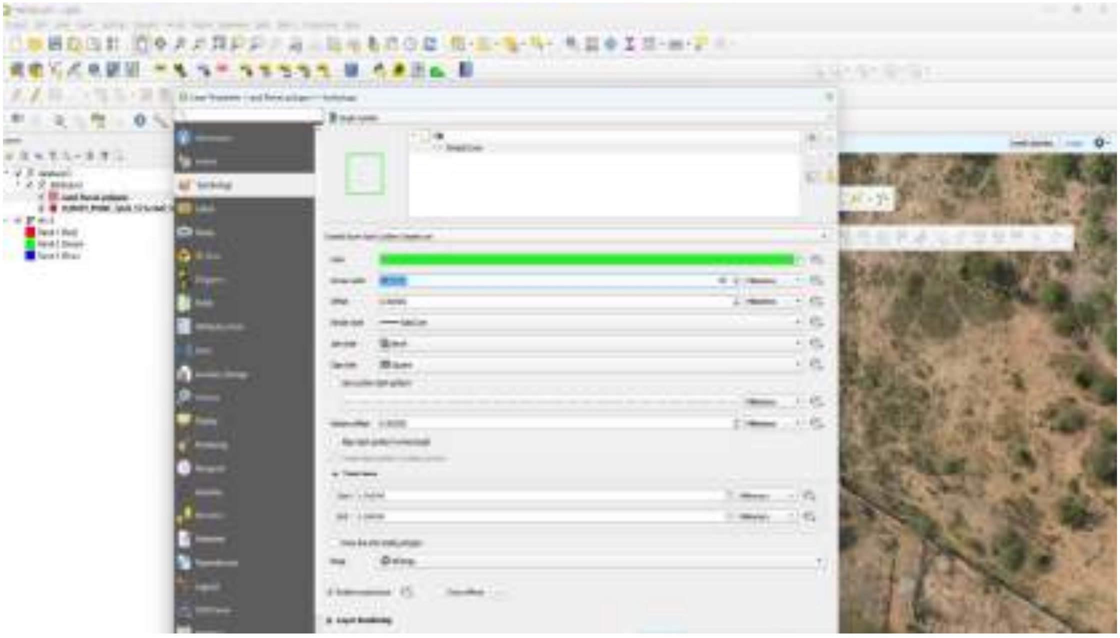


To make the polygon hollow, select 'Simple Fill', then click again to open its properties.
In the drop-down list for Symbol Layer Type, 'Outline: Simple Line' should be chosen, and the Fill Color should be set to 'Transparent'.



The desired colour shall be chosen, and then click 'OK' button

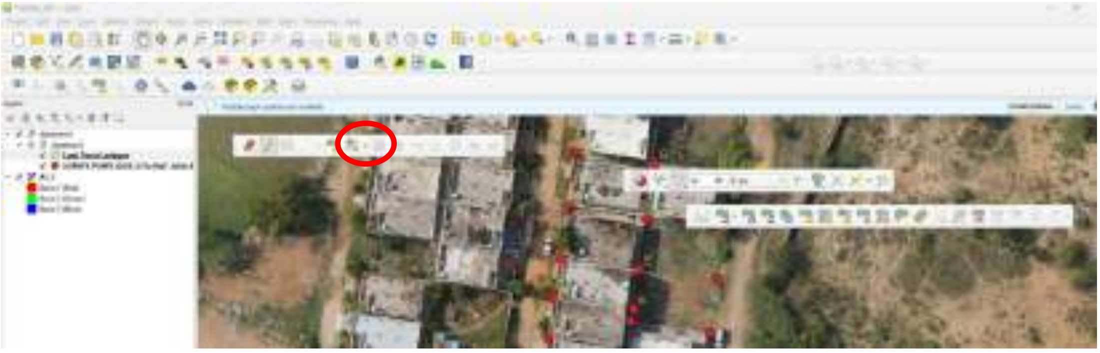
Similarly, the stroke width can be increased to make the boundary more prominent.



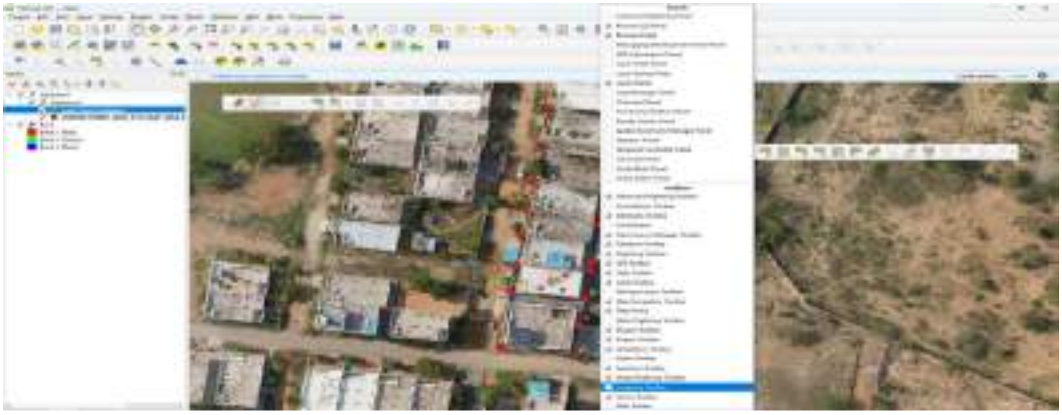
The land parcel layer has been made hollow to allow background imagery can be viewed, and polygons can now be created.

To create the *Land_Parcel_Polygons*, the following steps should be followed:
right-click on the layer **,** and select ***'Toggle Editing'*** to enable editing.

By clicking on '**Toggle Editing',** the **pencil icon** will be highlighted, indicating that the editing mode has been enabled.

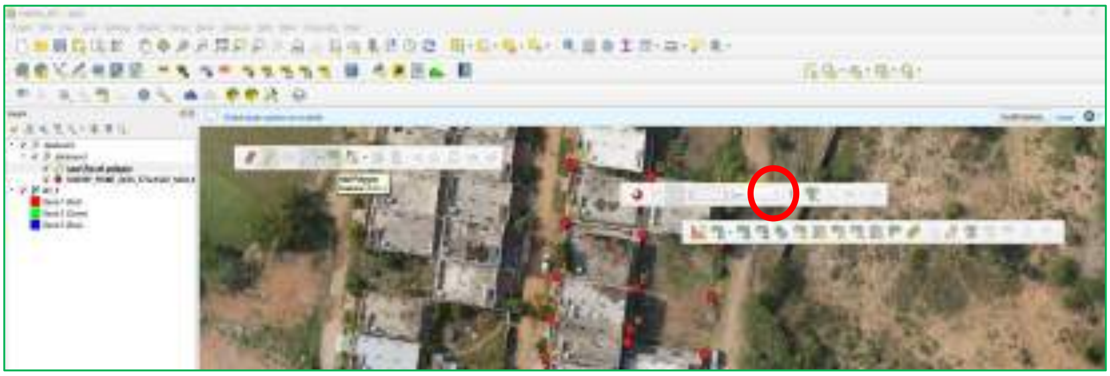


To ensure accurate polygon creation, **snapping** must be enabled to snap to vertices. Right click on the empty area of the **toolbar** and the '**Snapping Toolbar'** shall be enabled. This ensures that the vertices of the polygons are captured precisely over the existing land parcel vertices layer during digitization.

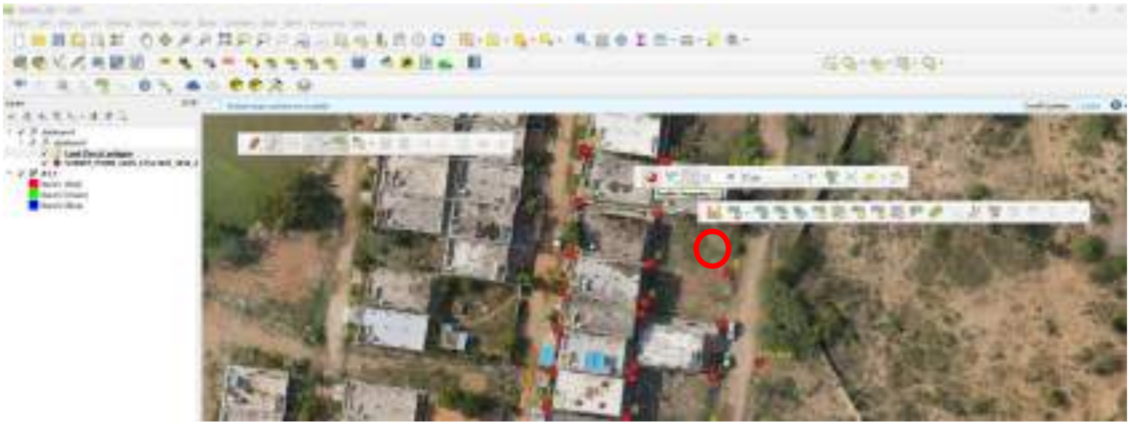


Click the 'Snapping Toolbar', and the toolbar will appear as shown below.

To create a polygon using measured boundary points in QGIS, the '**Add Polygon Feature'** tool should be clicked from the **Digitizing toolbar**, and points should then be added at the desired locations.



Click on **'Enable Snapping'** in the **Snapping Toolbar** to ensure correct placement of polygon vertices during digitization in QGIS.



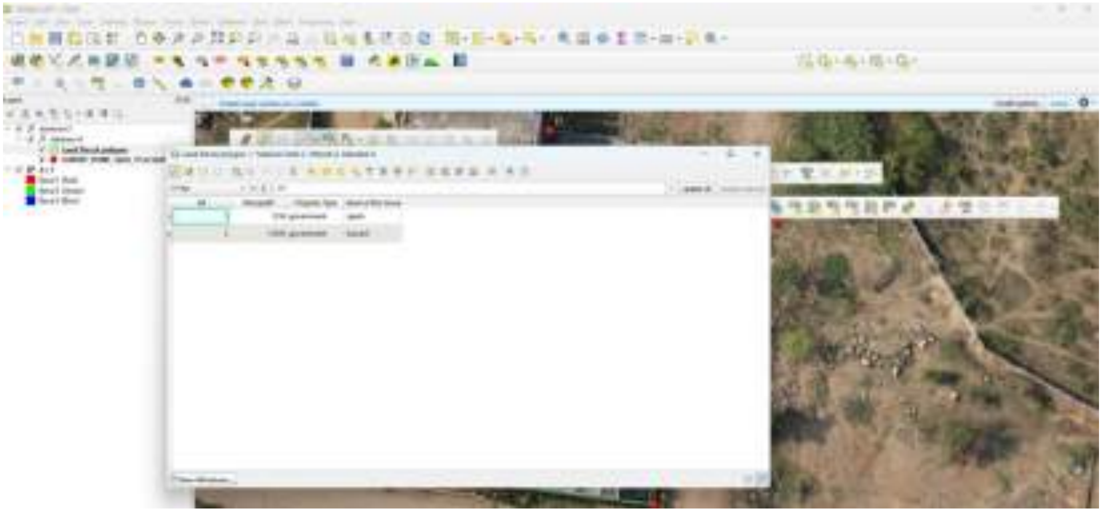
To digitize a polygon in QGIS, the cursor should be moved near the field-collected vertex points—snapping will assist in capturing the exact vertex.
Each point should be added sequentially by clicking, forming the polygon shape, and the feature shall be completed by right-clicking.

After the polygon has been digitized, by right clicking **'Attributes'** window will appear, this will allow the attribute information to be entered before the feature is saved. Click on '**Save Edits'** to save the work.

After the saving is completed, the window will be displayed as shown.

Similarly, all polygons can be created.
If additional fields are required, they can be added in the ***Land_parcel_polygon*** attribute table.
To do this, the right click on ***'Land_parcel_polygon'*** layer, and select '**Open Attribute Table'** option

The ' Attribute Table' window will be displayed as shown below.



A new field can be added. Now, 'New Field' should be clicked.

The 'New Field' window will be displayed as shown below.

All the required details, such as Field name, type, and other necessary information, shall be entered, and click 'OK' button.

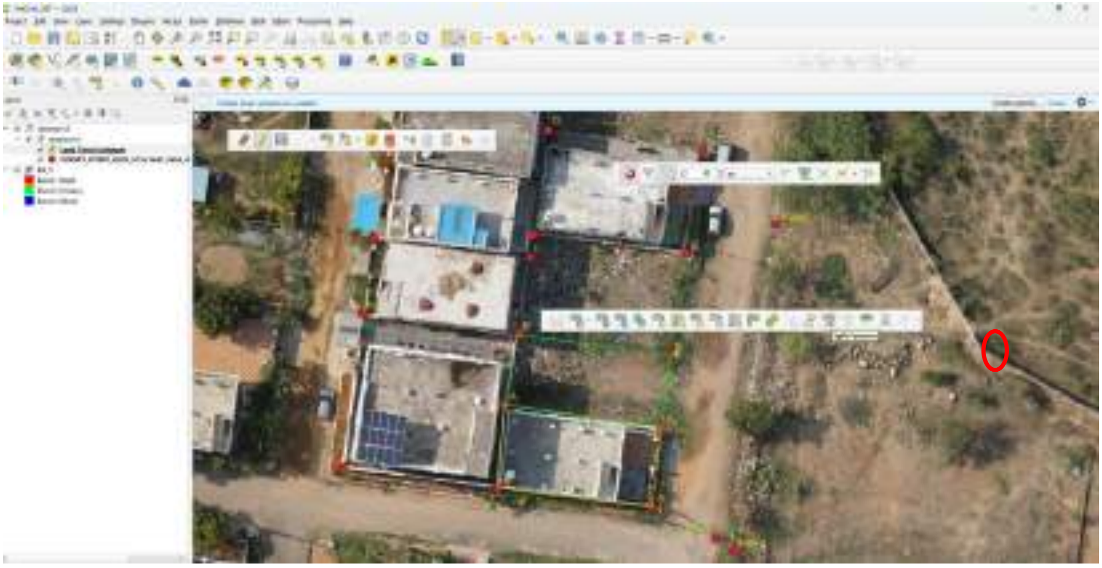
9. Splitting the polygon:

To split the polygon, the Advanced Digitizing toolbar is required.
To enable it, right click in the empty area of the menu bar, and the corresponding radio button shall be clicked to activate the toolbar.

The Advanced Digitizing toolbar window will be displayed as shown.

Now, click on 'Split Features' tool to split the polygon.
First, the feature to be split shall be selected

Once it has been selected, click on ‘Split Features' tool in the Advanced Digitizing toolbar.



Now, enter the data button/click on the feature to be split, followed by another clicking to define the split line.

The operation should be completed by right-clicking. The feature will be displayed as shown after being split.

The difference can be observed more clearly when each feature is selected individually.

The Selection Toolbar should be used to select a feature, and the individually split polygon will be displayed as shown below.

10. Merging the polygon:

The Merge Polygons feature icon can be used to merge two polygons. To perform the merge, the polygons should be selected first using the Select Features icon. Alternatively, the selection tool can be used by dragging over the polygon features. Once selected, the polygons will be highlighted.

The Merge icon will be highlighted only after the features have been selected.

Now, click the **'Merge Selected Features' icon** . The '**Merge Features'** window will appear, click the ‘OK’ button.

Then, the polygons will be merged and displayed as shown below.

11. Conclusion:

Thus, by following the above steps the Land parcel polygons has been created by using the field collected land parcel vertices and the desired attributes as per the UrPRo have been added to the polygon layer.

ANNEXURE-V

STANDARD OPERATING PROCEDURE

for

Electronic Total Station

TABLE OF CONTENTS

1. Objective

To collect the Land parcel vertices using the ETS where GNSS rover observation is not feasible.

2. Hardware & Software

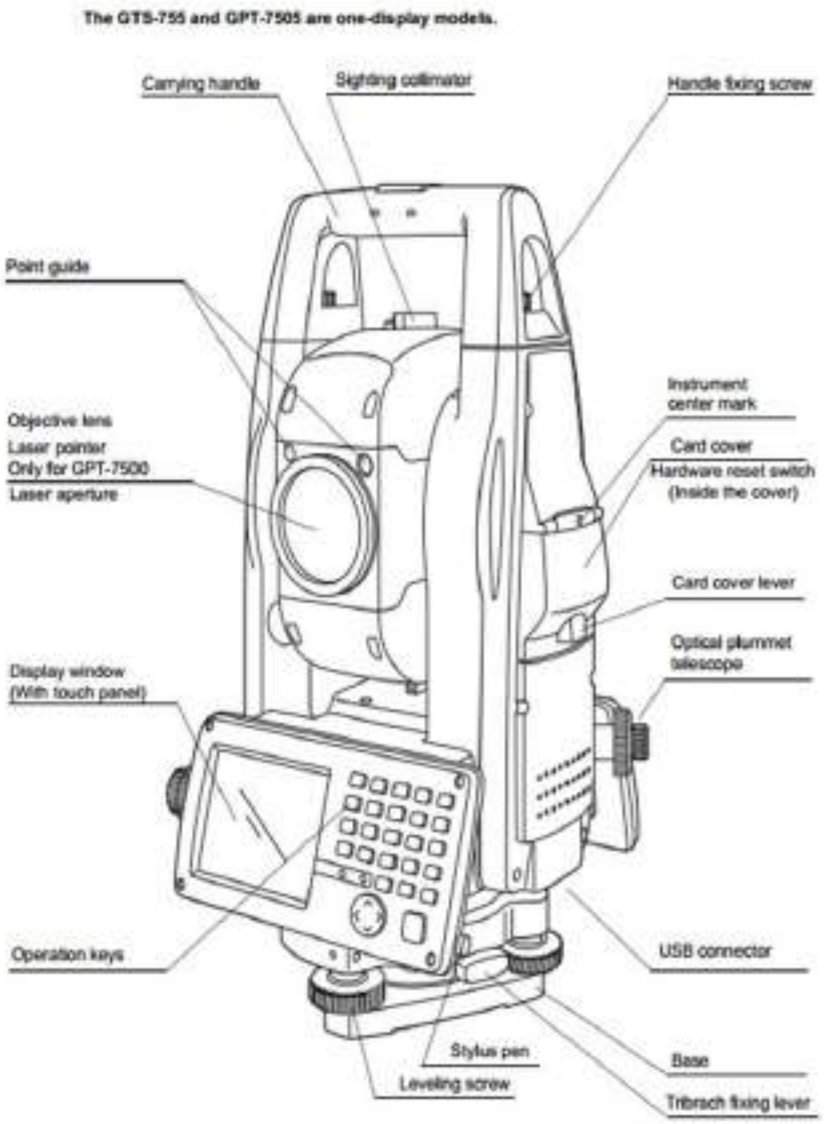
2.1. Hardware:

- 01 no. Electronic Total Station (ETS)
- 02 nos. Tripod Stands
- 01 Tribrach Prism
- 01 No. Rod with Prism.

2.2. Software:

- ETS native/Inbuilt software. (Topsurv for Topcon)

Diagram of Topcon Total Station



Note: This SoP is prepared based on Topcon ETS model no. 7501.

3. Pre-requisites

The following are required before commencing the ETS Survey.

- The surveyor should know how to operate ETS.
- 02 inter visible known control points near the Survey location.
- If the control points are not available, then the Surveyor should establish control points near the location using GNSS NRTK method.

4. Roles & Responsibilities

The surveyor will have the following roles and responsibilities.

- The surveyor will identify the land parcel vertices based on the records and documents available with him.
- Once the land parcel vertices have been identified on the ground, conduct ETS survey to pick the co-ordinates of land parcel vertices.

5. Setting up the ETS Instrument

5.1. Setting up of the Tripod

- Extend the tripod legs to a stable position.
- Adjust the tripod height so that the instrument is at a comfortable working level.
- Firmly place the tripod on the ground and ensure it is stable. It should be placed vertically above the control point marked on the ground using paint.

5.2. Mounting the ETS

- Carefully place the Electronic Total Station onto the tripod.
- Secure it using the central fixing screw.

5.3. Leveling the ETS

- Use the circular bubble level to roughly level the instrument.
- Adjust the tripod legs if necessary.
- Use the three leveling screws to fine-tune the level until the bubble is centered in the circular vial.
- Turn each screw in opposite directions in pairs to maintain an even balance and prevent unnecessary tilting.
- Make gradual adjustments to avoid overshooting the correct level position.
- Check the electronic level (if available) in the Total Station's settings and make further adjustments as needed.
- Reconfirm the level status after all adjustments to ensure accuracy before proceeding.

5.4. Centering over the Control Point

- Use the optical plummet or laser plummet to align the instrument over the control point.
- Adjust the tripod legs slightly to position the instrument correctly.
- Recheck the leveling after final adjustments.

5.5. Setting up of Tripod Prism

- Assemble the Prism Pole
- Attach the prism to the prism pole securely.
- Ensure the prism is clean and free of obstructions.

- Place the prism pole precisely over the designated survey point.
- Use the built-in bubble level on the prism pole to ensure it is upright.
- If using a tripod-mounted prism, securely attach the pole to the tripod.
- Adjust the height of the prism according to the required specifications.
- Align the prism pole with the Total Station's line of sight.
- Double-check the height settings and ensure accurate placement before proceeding with measurements.

6. Create Job and set parameters.

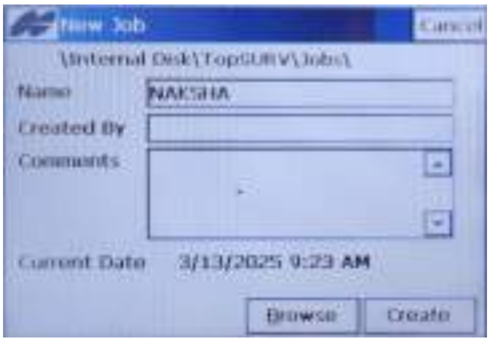
The following procedures in adopted to create and set the parameters.

6.1. Create Job

- Place battery in the ETS, Switch on the ETS.
- Double-Click on the Topsurv Icon  visible on the screen.
- The Topsurv application will open. (Note: previous job will open by default)

- Click Job >>New

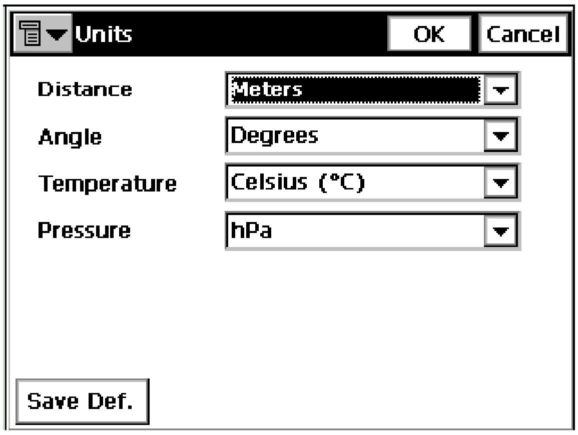
- Enter the new job name. (A valid job name consists of alpha/numeric).
- Enter the job description, surveyor name, and comments. (Optional).
- Press >> Create



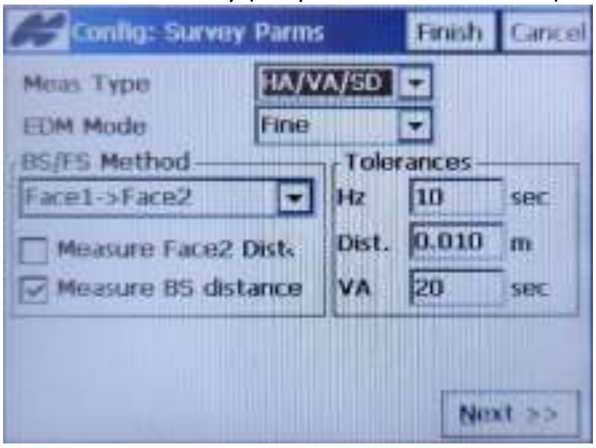
6.2. Setting of Job Parameters

a) Press: Job >> Config

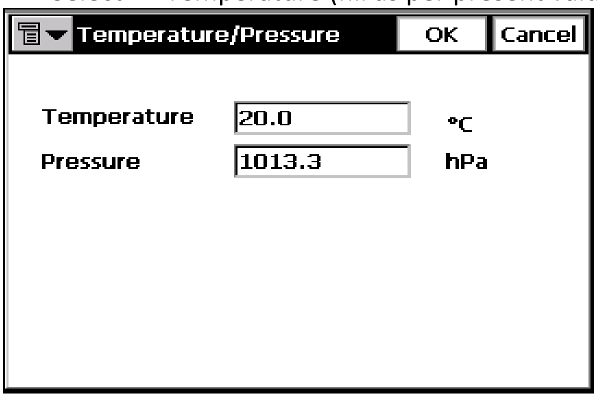
➢ Select>> Units (Enter as shown) >> OK



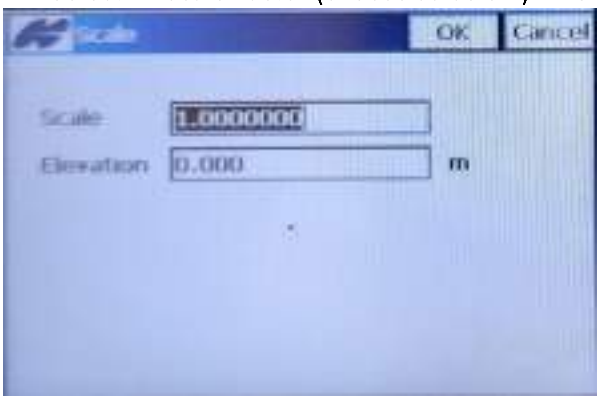
➢ Select>> Survey (set parameters as shown)>>Next>>Finish



➢ Select >> Temperature (fill as per present values) >> OK

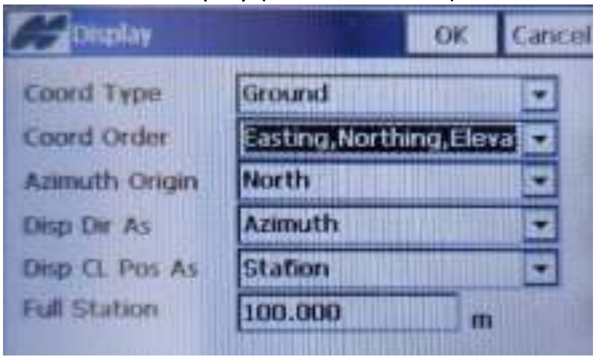


➢ Select >> Scale Factor (choose as below) >> OK



➢ The Scale Factor converts the ground distances to the grid distances and scales the average mapping factor.

- Scale: the value of projection scale. Range from 0.9 to 1.1.for Everest ellipsoid, and for UTM Grid it is 1.0004 for Hyderabad
- Select >> Display (Enter as shown) >> OK



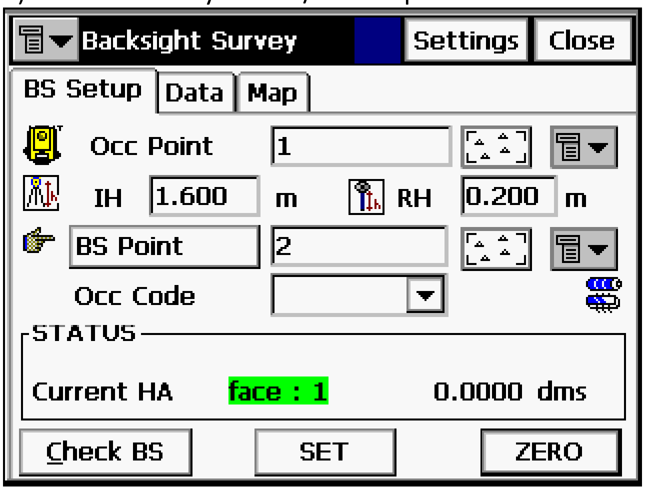
6.3. Adding Coordinates of Known Control Points

a) Menu: Edit >> Point >> Add

- Enter the Easting, Northing and Elevation of both the known points. Control Point A to be saved as Point 1, Control Point B to be saved as Point 2
- Check on the box for Control point.

7. Orientation of ETS

a) Menu: Survey >> Occ/BS Setup



- Sight and focus the ETS to the prism placed at Control point B
- Measure the Height of the ETS (IH) and Prism (RH) using a measuring tape
- Enter the Occupation point No. as 1 , In this case it is (Control Point A)from List
- Select Back sight point, in this case point no 2 (Control Point B) from list
- Instrument Height (IH) and Reflector Height (RH) are to be entered.
- Sight the Back sight prism after proper intersection (Cross hair) on Face 1-Set

- A beep sound will come. Press check BS. The error in Easting, Northing and Elevation will be displayed. This error should be within permissible limit (preferably in mm).

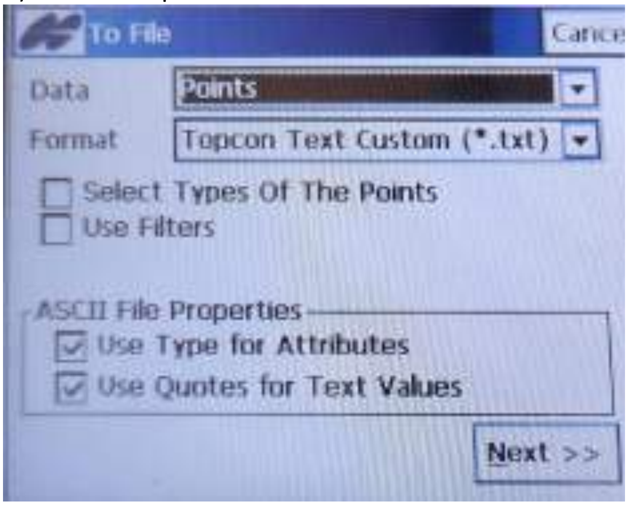
8. Measurement of Property Parcel Vertices

a) Menu>> Survey >> Observations

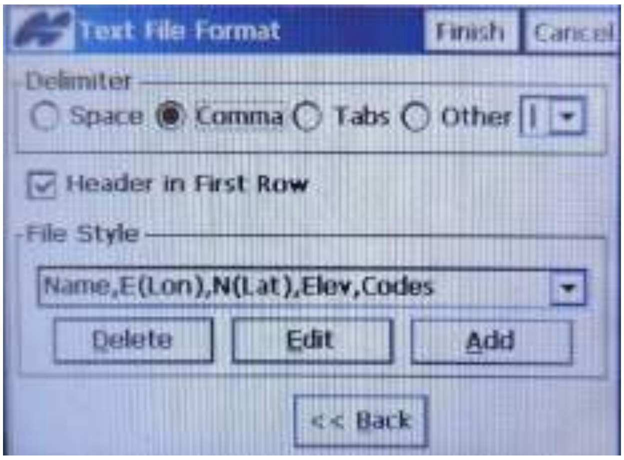
- Send the reflector Prism to the vertex you want to measure. Centre and Level the rod prism as near as possible to the vertex.
- Key in Point number, Code and Reflector Height
- Sight the Prism (Reflector)
- Press MEAS. The point is recorded in the file.
- Repeat the point 5.6 for measuring other unknown parcel points.

9. Downloading of Data

b) Job >> Export>>to file



- Next
- Select the folder
- Enter a file name



- Finish – Close
- Copy above file to Pen drive.

10. Conclusion:

Thus, the coordinates of land parcel vertices which could not be surveyed by GNSS rover has been surveyed by ETS to complete survey for land parcel vertices.

Note: All presentations/SOP/User Manual related to this content material are provided in the drive: https://drive.google.com/drive/folders/17tnCf1JezkD7o64s5P-KIaNnO10diVlD?usp=drive_link