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Geospatial Survey and Mapping Using DGPS and Drone Technology

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Abstract: *This study integrated Differential Global Positioning System (DGPS) and drone-based photogrammetry to conduct a high-precision geospatial survey of the 32-acre Christu Jyothi Institute of Technology & Science (CJITS) campus in Jangaon, Telangana. Using G30 GINTEC DGPS and a DJI Mavic 3 Enterprise drone, the project mapped terrain, infrastructure, and natural features with centimeter-level accuracy. Aerial imagery, captured at 60 meters with 70% overlap, was processed in Agisoft Metashape to produce orthomosaics, Digital Surface Models (DSMs), Digital Terrain Models (DTMs), contour maps, and watershed visualizations. AutoCAD Civil 3D and ArcMap analyses generated spatial datasets, including elevation (361.147–365.607 m), slope (0.01–871.39%), and a detailed building inventory (e.g., Administrative Main Block: 3,707.08 m²). The results demonstrate the efficacy of combined geospatial technologies for institutional mapping, offering scalable solutions for campus management, infrastructure planning ,urban planning, and environmental sustainability. Geospatial survey and mapping have evolved significantly with the integration of advanced technologies such as Differential Global Positioning System (DGPS) and Unmanned Aerial Vehicles (UAVs), commonly known as drones. These technologies offer a highly efficient, accurate, and cost-effective approach for collecting and analyzing spatial data over large and inaccessible areas.*

DGPS enhances the accuracy of conventional GPS by using a network of fixed ground-based reference stations, providing centimeter-level precision, which is crucial for detailed topographic and cadastral mapping. When integrated with drone technology, the capabilities of geospatial surveys are vastly improved. Drones equipped with high-resolution cameras, LiDAR, and thermal sensors can capture real-time aerial imagery and data, which is processed using photogrammetry and GIS software to create detailed 2D maps, 3D models, Digital Elevation Models (DEMs), and orthomosaics.

This combination is particularly beneficial for applications in civil engineering, urban planning, agriculture, disaster management, and environmental monitoring. The use of DGPS ensures the positional accuracy of drone-captured data, making it suitable for precise engineering and planning tasks. Overall, the synergy between DGPS and drone technology is transforming traditional surveying methods,.

Keywords: CJITS College

I. INTRODUCTION

Geospatial technologies have revolutionized spatial data acquisition, providing accurate, cost-effective, and scalable solutions for mapping and analysis. Differential Global Positioning System (DGPS) offers centimeter-level precision for ground control points (GCPs), while drone-based photogrammetry enables rapid, high-resolution data collection. Together, these technologies produce detailed 2D and 3D models, supporting applications in urban planning, infrastructure development, and environmental management.The 32-acre CJITS campus in Jangaon, Telangana, spans diverse infrastructure, including academic buildings, hostels, and natural features like wells and vegetation. This project aimed to create a comprehensive geospatial dataset to support campus planning, topographic analysis, and resource management. Outputs include orthomosaics, DSMs, DTMs, contour maps, watershed visualizations, elevation/slope analyses, and a detailed building inventory. This report details the methodology, results, and applications, highlighting

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the benefits of integrated geospatial approaches.DGPS is an enhancement to the standard GPS system that provides improved location accuracy, often up to a few centimeters, by correcting signal errors using reference stations. When paired with drones— autonomous or semi-autonomous aerial vehicles equipped with advanced sensors and cameras—the result is a highly effective system capable of capturing high-resolution geospatial data over large and difficult-to-access areas in a fraction of the time required by conventional methods.

II. OBJECTIVES

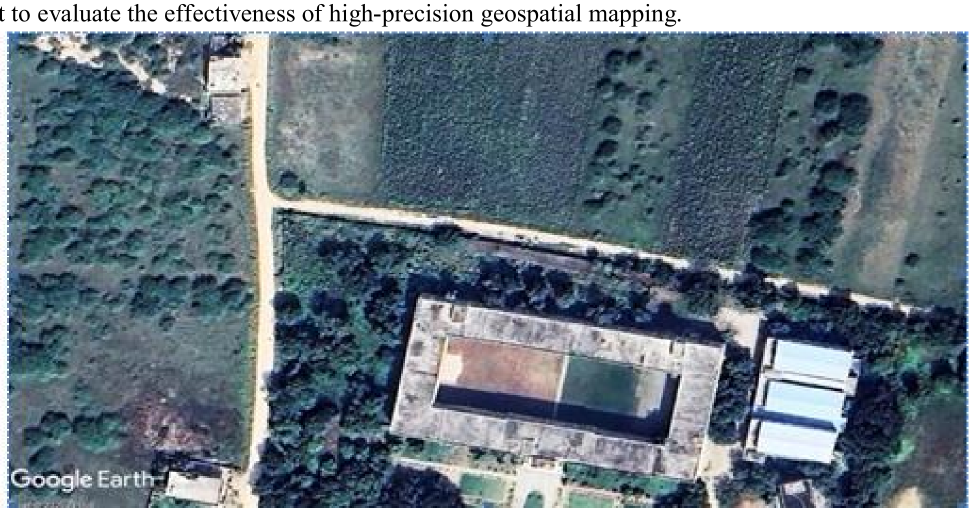
The main objectives of the project are as follows:

- Establish precise Ground Control Points (GCPs) using G30 GINTEC DGPS for georeferencing.
- Conduct an aerial survey of the CJITS campus using a DJI Mavic 3 Enterprise drone at 60 meters.
- Process DGPS and drone data using CHC Geomatics Office 2 and Agisoft Metashape to generate high-resolution outputs.
- Produce orthomosaics, DSMs, DTMs, contour maps, watershed visualizations, and elevation/slope analyses for planning.
- Derive terrain characteristics, detailed building inventories, and spatial data layers for campus management.
- To enhance the accuracy of spatial data collection.
- To improve efficiency and reduce time in surveying operations.
- To generate high-resolution imagery and 3D models.
- To support multi-disciplinary applications with precise geospatial outputs.

III. STUDY AREA

The 32-acre CJITS campus in Jangaon, Telangana (506167, India), is a semi-urban site with academic, residential, and utility infrastructure, plus natural features like wells and vegetation. The campus is divided into three zones:

- Zone 1 (First Boundary): Academic and administrative facilities (e.g., Administrative Main Block, laboratories).
- Zone 2 (Second Boundary): Residential and support facilities (e.g., Boys' Hostel, staff quarters).
- Zone 3 (Third Boundary): Girls' Hostel and related infrastructure.
- Varied topography (361.147–365.607 m elevation) influences drainage and infrastructure placement, necessitating detailed mapping.
- The chosen site may cover open fields, roads, buildings, water bodies, and uneven topography—offering a realistic environment to evaluate the effectiveness of high-precision geospatial mapping.



IV. LITERATURE REVIEW

1. Advancements in satellite positioning, aerial imaging, and computational processing have driven geospatial technology evolution. DGPS, developed in the 1990s, corrects GPS errors for centimeter- level accuracy (Smith & Brown, 2021). Drone-based photogrammetry, popularized in the 2010s, reduces survey costs and time (Pix4D, 2022). Studies like Johnson et al. (2020) demonstrate DGPS-drone integration for campus mapping, achieving 2 cm accuracy. Gupta and Sharma (2022) highlight their use in Indian urban planning, emphasizing DGCA compliance. Agisoft Metashape is a standard for photogrammetric processing, producing high-precision outputs (Agisoft, 2023). Challenges include regulatory compliance, data processing demands, and environmental factors (Esri, 2023). This study applies these technologies to CJITS, addressing local constraints.
2. According to El-Rabbany (2002), DGPS significantly improves the positional accuracy of standard GPS by using ground-based reference stations to correct satellite signal errors. This has proven critical for precision applications such as cadastral surveys and infrastructure planning. Research by Leick et al. (2015) further emphasizes DGPS's ability to deliver sub-meter to centimeter-level accuracy, making it suitable for high-precision geospatial tasks
3. Colomina and Molina (2014) discuss the role of UAVs in photogrammetry, highlighting their efficiency in capturing high-resolution aerial images for 2D and 3D mapping. Their work illustrates that drones can drastically reduce survey time and labor, especially in inaccessible or hazardous areas.

V. INSTRUMENT AND SOFTWARE USED

The G30 GINTEC DGPS: Base and rover units for centimeter-level GCP accuracy. DJI Mavic 3 Enterprise Drone: 48-megapixel camera for aerial imagery.

1. Drone (UAV – Unmanned Aerial Vehicle):
Multirotor or fixed-wing drones equipped with high-resolution cameras or LiDAR sensors for aerial data capture.
2. Differential Global Positioning System (DGPS):
A base station and rover setup used to correct GPS signals and enhance positional accuracy, providing centimeter-level precision.
3. High-Resolution Camera:
Mounted on the drone for capturing geo-tagged aerial images suitable for photogrammetry and mapping.
4. LIDAR Sensor (optional):
Used in advanced surveys for detailed 3D point cloud generation, especially in vegetated or complex terrain.
5. Ground Control Points (GCPs) and Markers:
Physical markers placed on the ground and surveyed using DGPS to georeference and improve the accuracy of aerial maps.
6. Battery Packs and Charging Units:
For powering drones and DGPS systems during field operations.
7. Tablet/Remote Controller with GPS Connectivity:
Used to operate the drone, plan flight paths, and monitor real-time image capture.

SOFTWARE:

Agisoft Metashape: Photogrammetric processing for orthomosaics, DSMs, DTMs, point cloud and 3D models.
AutoCAD Civil 3D: Vector drafting and topographic analysis.
ArcMap: GIS-based spatial visualization and analysis.

1. Drone Flight Planning Software (e.g., DJI GS Pro, Pix4Dcapture, or Mission Planner):Used to define flight paths, altitude, image overlap, and automate drone flights.
2. Photogrammetry Software (e.g., Pix4Dmapper, Agisoft Metashape, DroneDeploy)
3. GIS Software (e.g., ArcGIS, QGIS):
4. DGPS Post-Processing Software (e.g., Trimble Business Center, Leica Geo Office)
5. AutoCAD or Civil 3D:

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VI. METHODOLOGY

DGPS SURVEY:

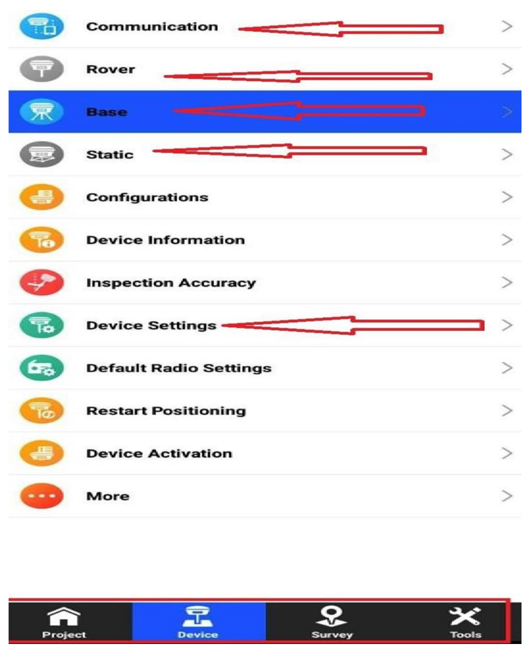
STATIC SURVEY PROCEDURE:

Three GCPs were established in a triangular arrangement using the G30 GINTEC DGPS system. GCPs were placed in open areas with clear satellite visibility.

FIGURE NO: 1 GROUND CONTROL POINTS OF CJITS

GCP 2 GCP 3

Tripod Setup and Instrument Mounting



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DGPS SETUP PROCESS

The tripod was set up at each static point, and the DGPS base and rover units were mounted securely. The SurPad 4.3 software was opened on the controller device.

In the software, the Communication tab was accessed to connect the base and rover units using their respective device codes. (G912BC148613315 for base),(G912C3148624732 for rover)

Static Survey Setup:

The Static Survey option was selected.

Instrument height was entered, along with the method of measurement (from antenna phase center). Each static point was named accordingly: GCP1, GCP2, and GCP3.

Data was recorded continuously at each point for duration of 3 hours. After recording, the instrument was connected to a computer via Wi-Fi.

The device's IP address (192.168.10.1) was entered in a browser to access the Gentic DGPS interface. The recorded .sth file was downloaded for further processing.

Static observations (3-hours sessions) were post-processed in CHC Geomatics Office 2, achieving horizontal and vertical ±11mm accuracy.

• First Convert the .sth file to RINEX format using Static to RINEX software

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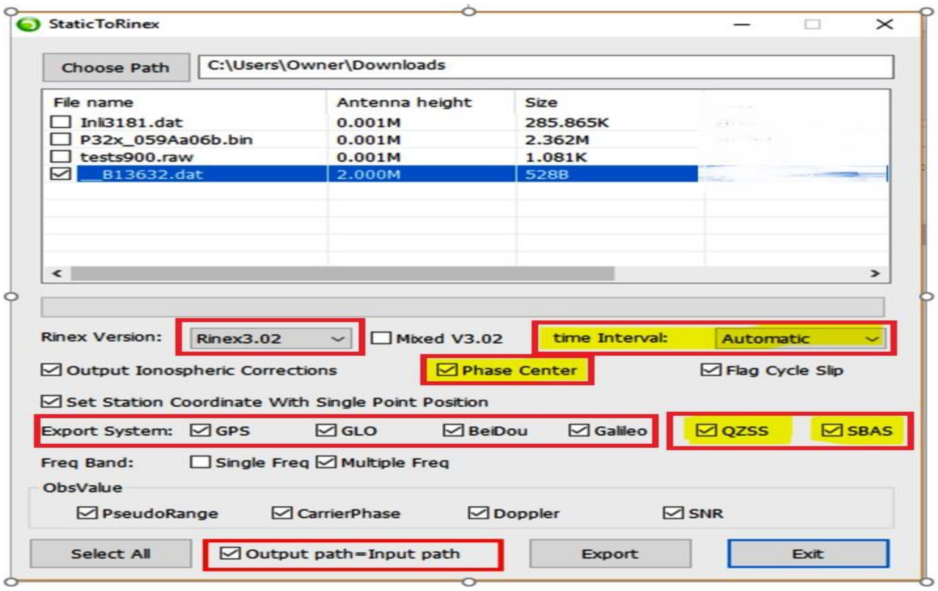
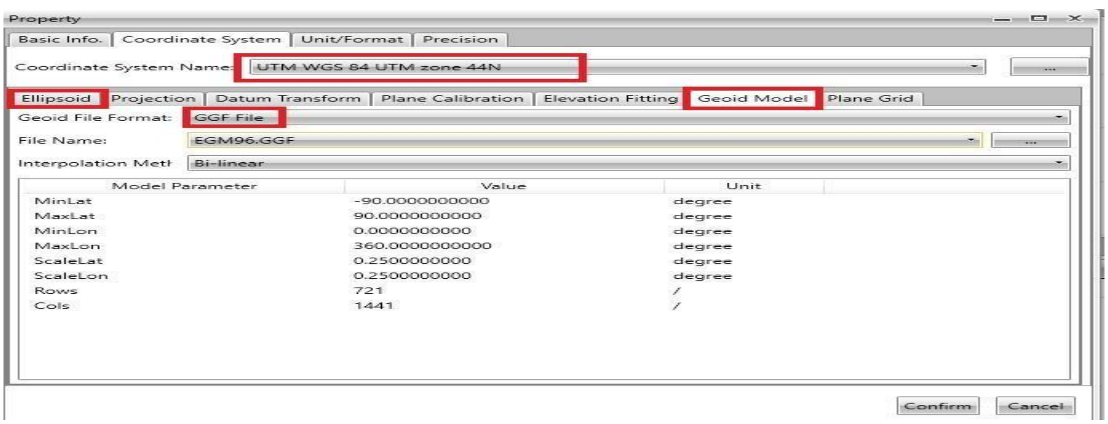
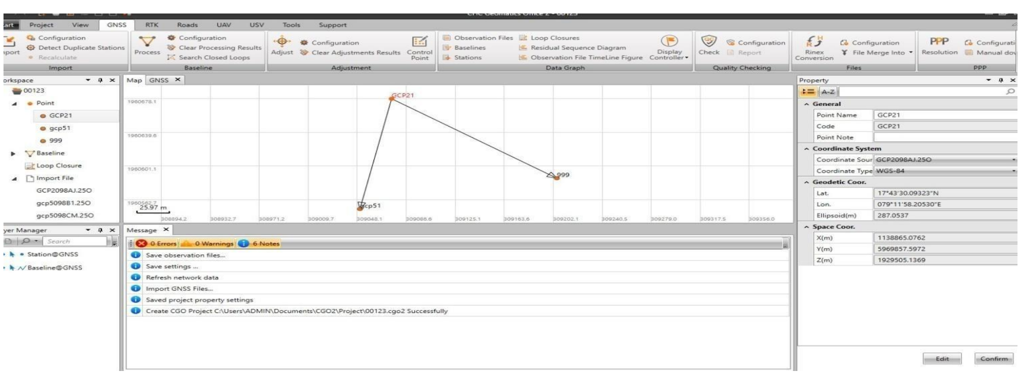


Open CHC Geomatics Office 2 software and Set coordinate parameters first

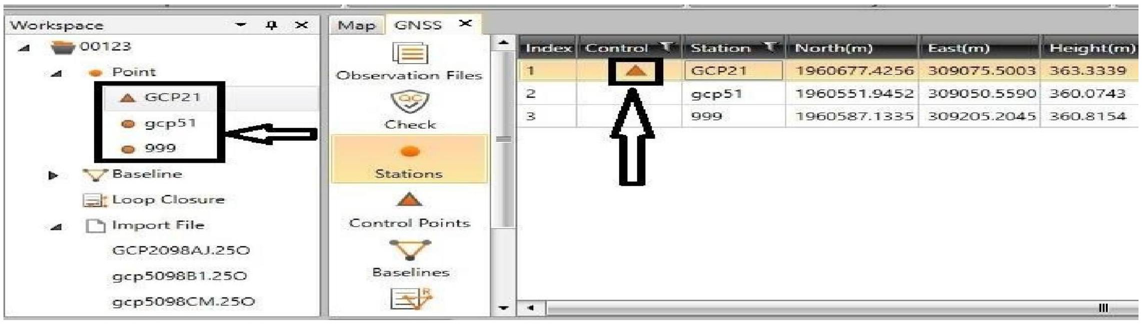
- Ellipsoid: WGS 84
- Zone: 44N
- Geoid file: GGF



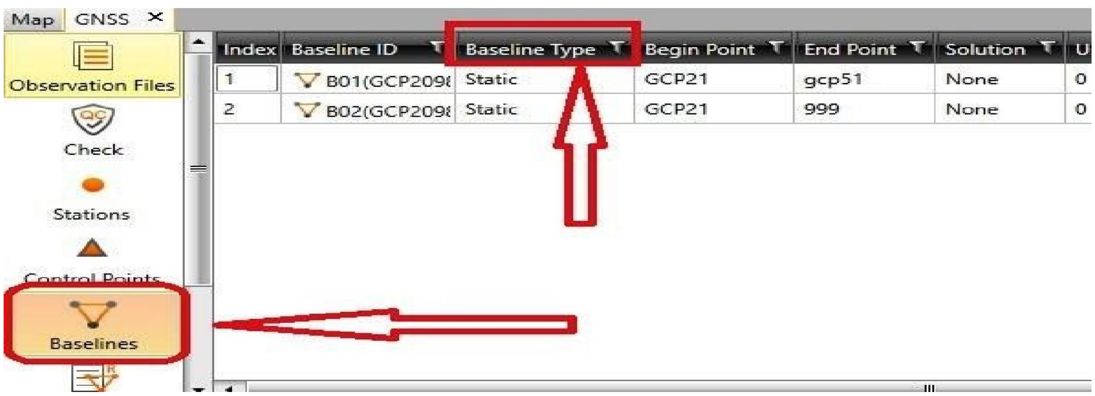
- Load all three static points used for triangulation
- Load the converted ((.o)) (observation) file into CHC Geomatics Office 2.))



• Mark a known reference point as a Control Point.



• Perform Baseline Processing using the marked control point as the reference.



Generate the Final Report with computed final coordinates.

Table 1: GCP Final Coordinates

GCP	Easting	Northing	Geoid Height
GCP1	309204.1836	1960586.1884	362.5044 m
GCP2	309048.4290	1960552.8785	363.2558 m

VII. SURVEY EXECUTION PROCEDURE

Initial Setup

The DGPS instrument was set up by positioning the tripod and adjusting the foot screws to ensure proper leveling.

The base station was then securely attached to the tripod.

The rover unit was mounted on a range pole (recovery pole) for mobility during data collection. Opened the SurPad application and navigated to the project section to create a new project.

Under the communication settings, the base and rover were connected using their respective codes. Coordinate settings were configured, ensuring appropriate parameters were selected for the survey area.

In the advanced settings, all available satellite constellations (GPS, GLONASS, Galileo, etc.) were enabled to enhance positional accuracy.

Accessed the Survey module to begin data collection.

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COLLECTING THE POINT BY DGPS (ROVER)

Ensured optimal signal quality by monitoring the number of satellites being tracked and the status of the fix (Fixed/Float). Data collection was only started when the horizontal and vertical accuracy was within acceptable limits (typically less than 0.02 to 0.01 meters).

Structure points were recorded with high precision across the survey site

Antenna Height	Northing	Easting	Elevation	Solution Status	Used satellites	Tracked satellites	PDOP	HRMS	VRMS
1.6	1960679	309073.4	363.561	FIXED	33	35	1.3	0.018	0.021
1.6	1960675	309069.3	363.481	FIXED	31	34	1.3	0.018	0.021
1.6	1960675	309066.3	363.409	FIXED	31	34	1.3	0.018	0.021
1.6	1960676	309060.9	363.473	FIXED	31	33	1.2	0.018	0.021
1.6	1960677	309056.8	363.424	FIXED	32	34	1.2	0.018	0.021
1.6	1960677	309052.3	363.565	FIXED	32	34	1.2	0.017	0.019
1.6	1960679	309048.2	363.5	FIXED	32	34	1.2	0.017	0.019
1.6	1960683	309046	363.47	FIXED	32	34	1.3	0.017	0.02
1.6	1960688	309044.8	363.453	FIXED	32	34	1.3	0.018	0.021
1.6	1960690	309043.6	363.462	FIXED	33	35	1.2	0.018	0.021
1.6	1960694	309043	363.51	FIXED	33	35	1.7	0.018	0.02
1.6	1960696	309045.7	363.589	FIXED	31	34	1.5	0.019	0.021
1.6	1960695	309050	363.583	FIXED	31	34	1.4	0.019	0.021
1.6	1960691	309052.2	363.548	FIXED	29	31	1.4	0.017	0.019
1.6	1960689	309054.3	363.512	FIXED	27	29	1.3	0.017	0.02
1.6	1960685	309056.7	363.458	FIXED	30	32	1.3	0.017	0.02
1.6	1960684	309059.8	363.459	FIXED	30	32	1.3	0.018	0.022
1.6	1960685	309063.8	363.43	FIXED	32	34	1.2	0.018	0.021
1.6	1960687	309067.4	363.496	FIXED	32	34	1.3	0.017	0.02
1.6	1960689	309071	363.451	FIXED	32	34	1.2	0.018	0.02
1.6	1960691	309075.8	363.495	FIXED	29	32	1.4	0.018	0.02
1.6	1960689	309080.1	363.464	FIXED	25	29	1.4	0.019	0.021

After recording ground coordinates using DGPS, these points are utilized in multiple stages of the drone data processing workflow

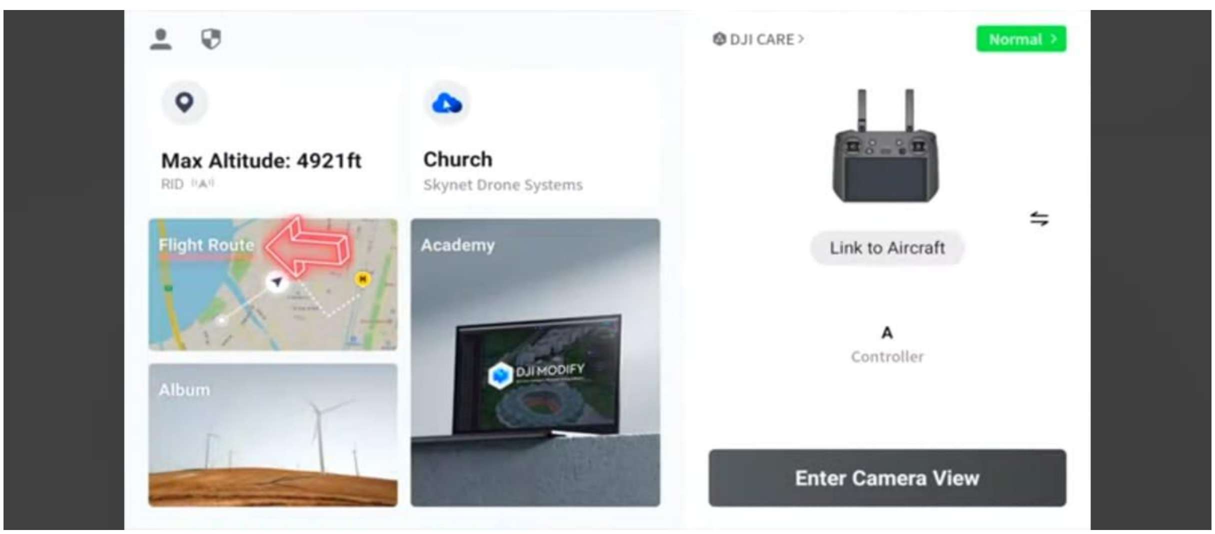
• Geo referencing drone imagery
• Comparing drone data with DGPS measurements
• Importing into Civil 3D for generating:
  o Contours
  o 15m x 15m grid levels
  o Slope maps
  o Elevation maps
  o Knowing boundary areas of plots and buildings

VIII. DRONE SURVYING

Directorate General of Civil Aviation (DGCA). (DIGITAL SKY) This regulatory body ensures that drone operations adhere to national aviation safety standards and that the intended flight does not interfere with restricted airspace or pose any security risks.

Setup & Preparation
• Insert battery until it clicks securely on both sides.
• Attach propellers:
  o Match black/gray markings on props and motors.
  o Push down and twist to lock.
• Inspect drone for damage; clean camera and unlock gimbal.
• Ensure SD card is inserted (if needed).

Power On & Connection
• Power on drone and RC:
  o Tap once, then hold the power button.
• DJI Pilot 2 app auto-launches on RC Pro.
• Wait for:
  o Aircraft connected status.
  o GPS lock & Home Point confirmation.



Pre-Flight Checks
• Check firmware updates.
• Calibrate compass, IMU, and gimbal if prompted.
• Set Return-to-Home (RTH) altitude.
• Confirm area is clear off

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o No-fly zones
o People, power lines, obstacles

• Check weather and wind conditions.

Flight Plan Setup (Mission Mode)

• Open DJI Pilot 2 and Tap Flight Route.
• Choose mission type

• Mapping (2D/3D), Waypoint, Linear, Corridor, etc.
• Draw flight area or import KML file.

Configure settings:

• 60 meters altitude
• Speed: 10 m/s.
• Image Overlap: 70% (front and side).
• Ground Sampling Distance (GSD): 2.5 cm/pixel.
• Total Images: 450.
• Drone battery: 100%.
• GPS/RTK signal: 48 satellites.
• Camera : 48 MP,
• Save and Upload to Aircraft.

Execute the Flight

• Tap Go and confirm pre-flight checklist.
• Use Auto Takeoff or start motors manually (sticks down/in).
• Monitor:
• Pause/resume mission as needed.
• Adjust camera/gimbal during flight if necessary.

Landing & Post-Flight

• Tap Return-to-Home (RTH) or land manually.
• Wait for landing and motor shutoff.
• Power off drone and RC (tap once, then hold).
• Remove battery and props.
• Transfer image/data from SD card or RC storage.

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IX. PHOTOGRAMMETRIC PROCESSING – AGISOFT METASHAPE

Data processing using Agisoft Metashape, a professional photogrammetry software that transforms 2D images into 3D spatial data. This dataset consists of 450 high-resolution images captured for the purpose of 3D reconstruction and spatial analysis. Proper processing of this image set is essential to ensure accurate and high-quality results.

Step 1: Adding Images

1. Open Agisoft Metashape and create a new project:

o Launch the application and go to File > New Project.

o Choose a location on your computer to save the project and name it.

2. Add images to the project:

o Go to Workflow > Add Photos (or right-click in the Workspace pane and choose Add Photos).

o Browse your folders, select the images you want to process (usually in JPEG, TIFF, or PNG format), and click Open.

o The images will be added to the Photos pane.

Step 2: Aligning the Images

1. Align the images to create a sparse point cloud:

o Go to Workflow > Align Photos.

o In the dialog box, you can adjust settings:

 Accuracy: Set this to High or Ultra High for better precision.

 Key point limit: Set this to a value like 40,000 (depending on your computer's processing capability).

 Tie point limit: Set this to 4,000 (you can adjust this according to the dataset).

o After configuring, click OK to start the image alignment.

o The program will process the images, find tie points, and create an initial sparse 3D model.

2. Inspect alignment:

o Once completed, you can see the sparse point cloud in the 3D View.

o You can check for errors by visualizing the camera positions and the distribution of tie points.

Step 3: Building Tie Points (if necessary)

• Agisoft automatically generates tie points during alignment. However, if you need to build more, or if alignment results in poor tie points:

o Use the "Add Tie Point" tool in the Photo pane or Tools menu to manually select features on images.

o This is typically needed only in cases of poor alignment or minimal overlap.

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Step 4: Setting Reprojection Error
1. Check the reprojection error:
o Go to the Tools > Camera Calibration.
o Here, you can view the reprojection error for each camera. The value should ideally be under 1 pixel for a good alignment.
o If the error is too high, you might want to manually adjust the camera positions or improve the photo alignment.
2. Optimize alignment (optional):
o After reviewing the reprojection error, you can run the "Optimize Cameras" tool to improve the alignment further:
 Go to Tools > Optimize Cameras.
 In the Optimization Parameters, check options like Optimize lens distortion and Optimize camera positions.
 Click OK to start the optimization.
Step 5: Setting Reconstruction Uncertainty
1. Set reconstruction uncertainty:
o This can be done in the Workflow > Build Dense Cloud step by choosing the Quality and Depth Filtering settings.
o You can select Low, Medium, or High for quality, but if you want to ensure better reconstruction, go with High.
o The Depth Filtering can also be adjusted to Aggressive (if you want fewer noise points) or Moderate for general use.
2. Preview and adjust if necessary:
o If reconstruction uncertainty seems high, you might need to refine image quality, camera calibration, or alignment.
Step 6: Setting Projection Accuracy
1. Adjust projection accuracy for the 3D model:
o After building the dense cloud, ensure your settings for the Projection Accuracy are correctly set.
o You can define the accuracy in Tools > Preferences > Projection and adjust it based on the desired output quality.
Step 7: Calibrating the Camera
1. Camera Calibration:
o Go to Tools > Camera Calibration.
o If you are working with known camera settings, you can use a camera calibration file. If not, you may need to manually adjust focal length or sensor size.
o For best results, you can also use the "Refine Calibration" option to fine-tune intrinsic parameters based on the alignment.
Step 8: Building the Model (Dense Cloud, Mesh, Texture)
1. Build Dense Cloud:
o Go to Workflow > Build Dense Cloud.
o Set the Quality (High or Ultra High) and Depth Filtering (Aggressive or Moderate).
o Click OK to generate the dense point cloud.
2. Build Mesh:
o Once the dense cloud is generated, proceed to Workflow > Build Mesh.
o Set the Face Count for the mesh (low, medium, or high), depending on the required resolution.
o Choose Surface Type: Arbitrary (default) or Height Field if working with terrain.
o Click OK to generate the 3D mesh.
3. Build Texture:
o After creating the mesh, go to Workflow > Build Texture.
o Set the Mapping Mode to Generic or Orthophoto, depending on your model's nature.
o Click OK to generate the texture for the mesh.

OUTPUTS:
1. Export 3D Model and Point Cloud:
o To export your final 3D model and point cloud (in formats like OBJ, PLY,LAS points or FBX), go to File > Export > Export Model.

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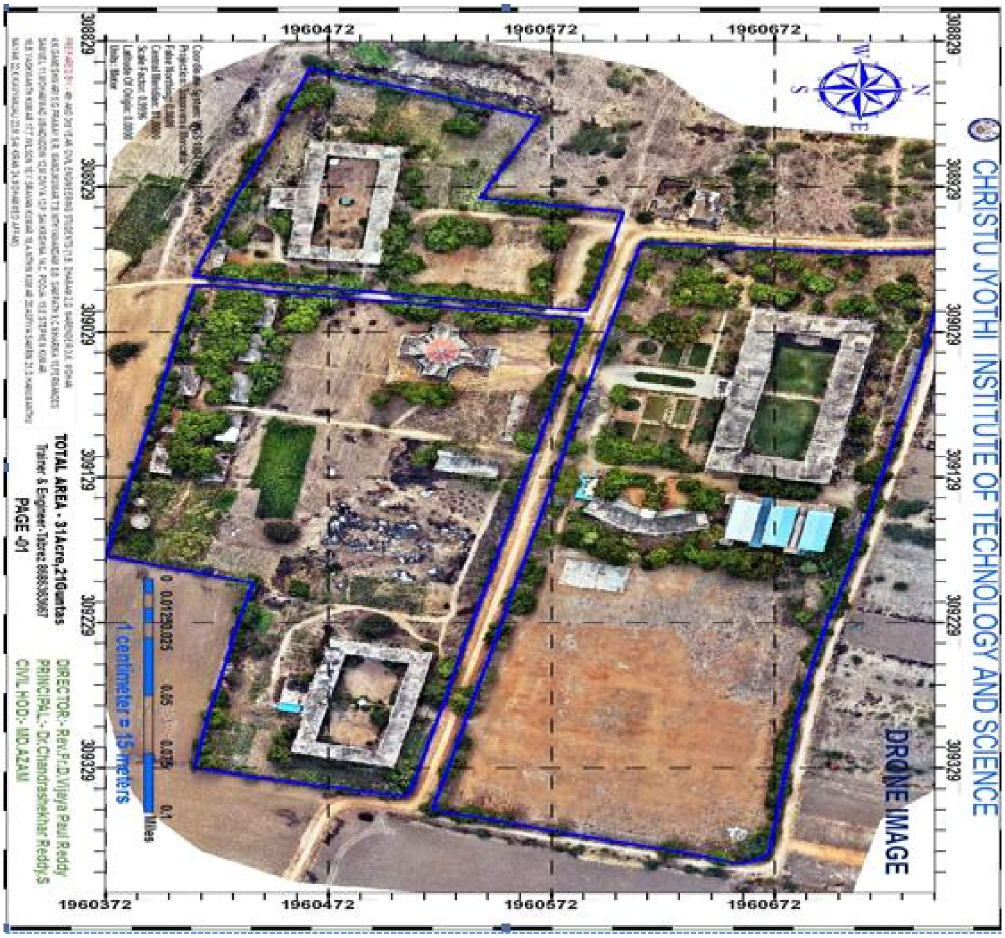
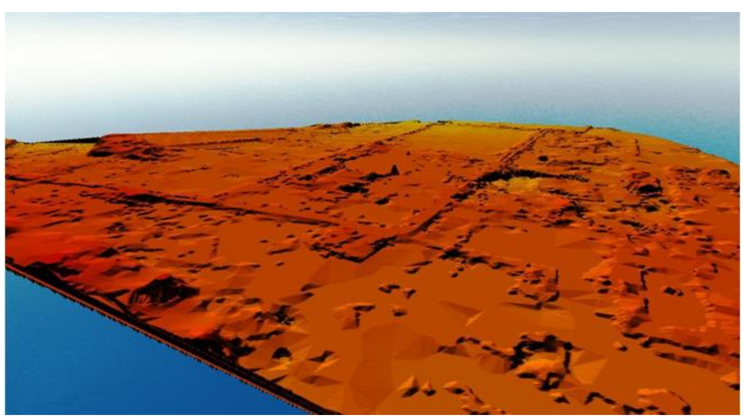
o Choose the desired file format (e.g., .obj, .ply,las), and export



EXPORT ORTHOPHOTO

1. Export DEM:

o To export a Digital Elevation Model (DEM), go to Workflow > Build DEM, then export via File > Export > Export DEM.



EXPORT DEM

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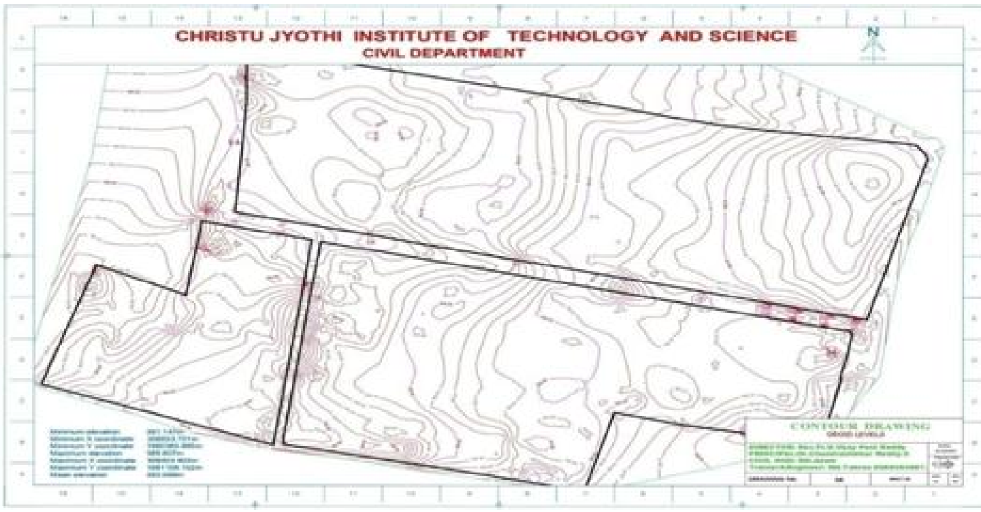
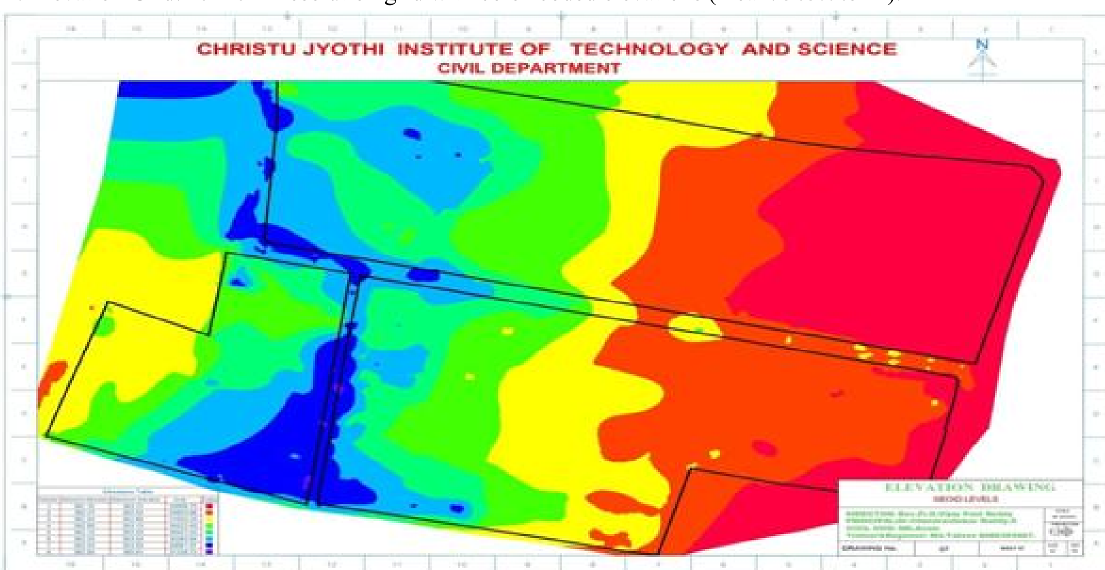
X. AUTOCAD CIVIL 3D AND ARCMAP ANALYSIS DRAWINGS

Map 1: Contour Map: 0.1-meter minor interval and 0.5 meters major interval contours with elevation labels (361.147–365.607 m).



Map 2: Elevation Grid: 15x15 m resolution grid with color-coded elevations (mean: 363.069 m).



Map 3: Slope Map: Color-coded slope distribution (0.01–871.39%), highlighting steep areas for drainage planning.

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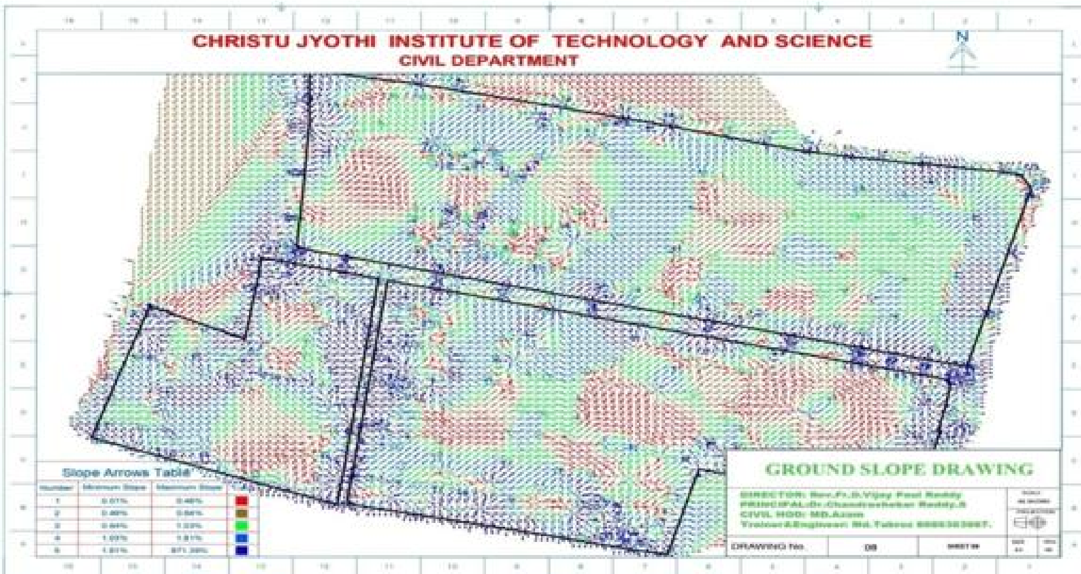

Map 4: Building Inventory Map: Spatial distribution of buildings (e.g., B1–B22) with area and perimeter annotations.

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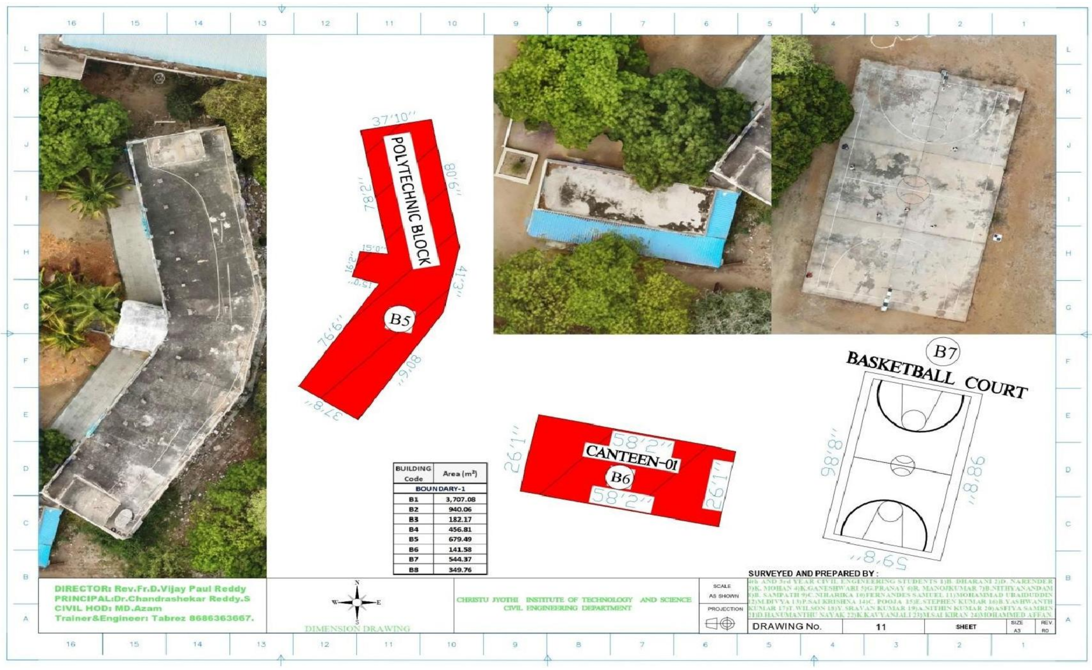

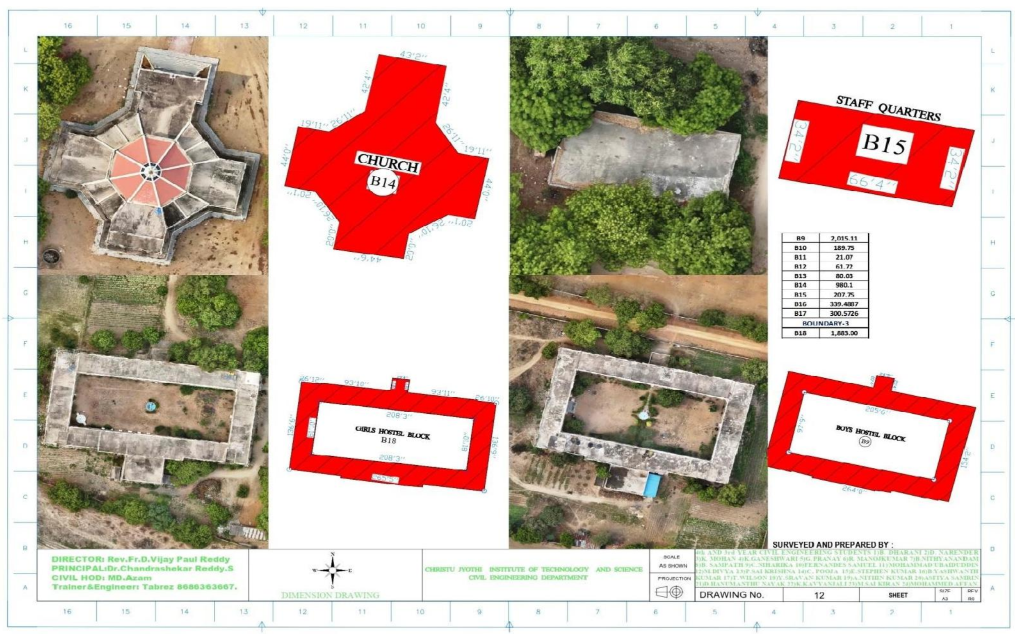

XI. RESULTS AND OUTPUTS

Elevation Range:

Minimum Elevation	Maximum Elevation
361.15	362.21
362.21	362.54
362.54	362.89
362.89	363.13

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363.13	363.33
363.33	363.54
363.54	363.93
363.93	365.61

Slope Range: 0.01% to 871.39%, indicating varied terrain for drainage and stability assessments.

Minimum Slope	Maximum Slope
0.01%	0.46%
0.46%	0.64%
0.64%	1.03%
1.03%	1.81%
1.81%	871.39%

BUILDING Code	Boundary Type	Building Name	Inner Perimeter (m)	Outer Perimeter (m)	Area (m²)
B1	Boundary -01	Administrative Main Block	232.21	346.61	3,707.08
B2	Boundary -01	Laboratory 1 (RCC Structure)	0	126.5	940.06
B3	Boundary -01	Laboratory 2 (Temporary Shed)	0	79.02	182.17
B4	Boundary -01	Laboratory 3 (RCC Structure)	0	102.74	456.81
B5	Boundary -01	Polytechnic Block	0	145.83	679.49
B6	Boundary -01	CANTEEN-01	0	51.29	141.58
B7	Boundary -01	Basketball Court	0	96.34	544.37
B8	Boundary -01	Storage Sheds (Rear of Administrative Block)	0	156	349.76
B9	Boundary -02	Boys' Hostel – Main Block	184.18	269.71	2,015.11
B10	Boundary -02	Boys' Hostel Kitchen (RCC Structure)	0	55.99	189.75
B11	Boundary -02	Boys' Hostel Utility Room (RCC Structure)	0	18.84	21.07
B12	Boundary -02	Boys' Hostel Storage Shed (Attached to Kitchen)	0	33.38	61.72
B13	Boundary -02	Boys' Hostel Cattle Shed	0	39.76	80.03
B14	Boundary -02	CHURCH	0	147.49	980.1
B15	Boundary -02	Staff Quarter – Single Unit	0	60.88	207.75
B16	Boundary -02	CANTEEN-02	0	84.9798	339.4887
B17	Boundary -02	Power Room	0	88.4652	300.5726
B18	Boundary -03	Girls' Hostel – Main Block	176.64	240.27	1,883.00
B19	Boundary -03	Girls' Hostel Kitchen (RCC Structure)	0	52.49	168.18
B20	Boundary -03	Girls' Hostel Utility Room (RCC Structure)	0	18.78	21.11
B21	Boundary -03	Girls' Hostel Storage Shed (Attached to Kitchen)	0	20.21	25.12
B22	Boundary -03	Girls' Hostel Cattle Shed	0	41.34	70.98

Table 2: Building Inventory

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Table 3: Elevation and Slope Summary

Minimum elevation	361.147m
Minimum X coordinate	308833.701m
Minimum Y coordinate	1960365.895m
Maximum elevation	365.607m
Maximum X coordinate	309404.903m
Maximum Y coordinate	1961109.102m
Mean elevation	363.069m

XII. CONCLUSION

The CJITS campus survey demonstrated the power of integrating DGPS, drone-based photogrammetry, and detailed building inventories (22 structures) with elevation (361.147–365.607 m) and slope (0.01– 871.39%) data. The outputs provide a robust foundation for campus planning, environmental management, and asset inventory. The methodology is efficient, cost-effective, and scalable, applicable to educational institutions and urban planning. Future enhancements like LiDAR and machine learning could further improve data quality, ensuring sustainable development. This innovative combination allows for rapid data acquisition, even in remote or difficult terrains, while ensuring high positional precision critical for engineering, planning, and environmental applications.

By reducing manual effort and increasing data quality, these technologies not only streamline survey workflows but also enhance decision-making processes across multiple sectors. As the demand for real- time, high-resolution spatial data continues to grow, the adoption of DGPS-enabled drone systems is expected to expand, playing a crucial role in shaping the future of geospatial science and smart infrastructure development.

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