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Drone: A Promising Tool In Applied Geology

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Abstract:
The rapid advancement of Unmanned Aerial Vehicle (UAV) technology has significantly altered conventional surveying and geospatial data acquisition methods. This study presents a drone-based survey that took place at the Government NPG College of Science campus in Raipur, Chhattisgarh, with the specific goal of showcasing the practical application of drones in applied geology and geospatial studies. The UAV model used for this survey was the Surveyaan, equipped with a 20 MP RGB sensor, which was employed to capture high-resolution imagery. The captured imagery was then processed into orthomosaics, Digital Surface Models (DSM), and Digital Terrain Models (DTM), providing detailed spatial data. Covering an area of 8.979 hectares with a Ground Sampling Distance (GSD) of 3.4 cm/px, the survey ensured precise spatial outputs. Furthermore, integration with GIS tools facilitated georeferencing, contour generation, and 3D modelling, enhancing the overall analysis of the collected data. The results of the survey unequivocally demonstrate the efficiency, cost-effectiveness, and accuracy of drone-based surveys for tasks such as geological mapping, boundary demarcation, and land-use assessment. This study effectively underscores the potential of UAV-based surveys in applied geology, environmental monitoring, mining, and infrastructure development, thus emphasizing drones as a contemporary and indispensable tool in geoscientific investigations.
Key Word: *Unmanned Aerial Vehicle (UAV), Digital Surface Model (DSM), Digital Terrain Model (DTM)*

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I. Introduction

A drone survey involves the utilization of an unmanned aerial vehicle (UAV) equipped with downward-facing sensors, such as RGB (Red Green Blue) or multispectral cameras, and LIDAR payloads, to capture aerial data. A drone survey was conducted in the Premises of Govt. NPG College of Science, Raipur with the instrument Surveyaan V1 Multirotor Drone. When conducting a drone survey with an RGB camera, the ground is photographed multiple times from varying angles, and each image is associated with coordinates for precise mapping.

Regarded as the pioneer of UAV (drone) technology, Karem, an Israeli-American aerospace engineer, established his legacy as the founding father of UAV technology, having graduated as an aeronautical engineer from the Technion (Israel Institute of Technology) and building his first drone during the Yom Kippur War for the Israeli Air Force before immigrating to the United States in the 1970s.

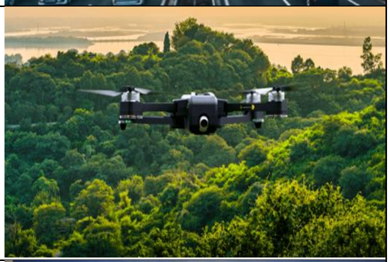
Nishant, a multi-mission Unmanned Aerial Vehicle developed by DRDO (Defence Research and Development Organization), is launched using a Mobile Hydro pneumatic Launcher and possesses Day/Night capability for battlefield surveillance, reconnaissance, target tracking & localization, and artillery fire correction.

II. What Are Drones

A drone, also referred to as an Unmanned Aerial Vehicle (UAV), is an aircraft that operates without a human pilot on board. It can be controlled remotely by an operator or programmed to fly autonomously using onboard sensors, GPS, and software. Drones are equipped with various payloads such as cameras, LiDAR, multispectral sensors, or delivery systems based on their specific application. They find extensive use in fields such as defence, agriculture, surveying, geology, disaster management, environmental monitoring, and photography. This is primarily due to their capability to access challenging terrains, capture high-resolution data, and execute tasks with great efficiency and precision. Essentially, a drone serves as a versatile aerial platform that integrates aviation, navigation, and sensing technologies to fulfil a wide array of scientific, commercial, and social functions.

III. Applications Of Drones

Drones have become widely utilized in numerous fields because of their versatility, efficiency, and capability to reach challenging terrains. The table below provides a summary of their applications in different fields:

Sector	Applications of Drones	Images
Agriculture	• Crop health monitoring with multispectral cameras • Precision spraying of fertilizers and pesticides • Soil and irrigation analysis • Yield estimation and crop mapping	
Construction & Infrastructure	• Site surveying and 3D mapping • Monitoring progress of construction projects • Inspecting bridges, towers, and pipelines • Enhancing worker safety by reducing risky manual inspections	
Transport & Roadways	• Traffic monitoring and management • Road condition assessment and maintenance planning • Assisting in smart highway projects • Delivery of goods and logistics support	
Environment & Wildlife	• Tracking deforestation and land-use change • Monitoring wildlife movements and poaching prevention • Assessing natural disasters (floods, landslides, forest fires) • Measuring pollution levels in air and water	
Urban Planning	• High-resolution aerial mapping of cities • Monitoring urban sprawl and land-use patterns • Planning smart cities and infrastructure layouts • Assessing population density and housing development	

Healthcare & Emergency Services	• Delivering medicines, vaccines, and blood supplies • Disaster relief operations in inaccessible areas • Search and rescue missions using thermal sensors • Emergency response during accidents and epidemics	
Media & Entertainment	• Aerial photography and cinematography • Live broadcasting of sports and events • Creating VR/AR immersive experiences • Drone light shows and creative advertising	
Military Operations	• Surveillance and reconnaissance in hostile areas • Target acquisition and precision strikes • Border monitoring and intelligence gathering • Supply drops in war zones and disaster-hit areas	

IV. Application Of Drones In Geology And Geography

Drones, also known as UAVs (Unmanned Aerial Vehicles), have significantly revolutionized the study and analysis of the Earth's surface in the fields of geography and geology. Their ability to capture high-resolution aerial data with precision and efficiency has established them as essential tools in the field of studies of geography and geology.

Applications of Drones in Geography

Topographic mapping and Surveying:-

- Drones have revolutionized topographic mapping and land surveying, providing efficient, cost-effective, and highly accurate spatial data collection methods. Equipped with high-definition cameras and sensors, drones capture aerial imagery at sub-meter resolution, facilitating the creation of high-resolution topographic maps.
- The captured images undergo processing using photogrammetry software to produce digital elevation models (DEMs), digital terrain models (DTMs), digital surface models (DSMs), and orthomosaic maps (georeferenced stitched images).
- Drones play a crucial role in generating contour lines at precise intervals, essential for activities such as site grading, drainage planning, cut-and-fill estimation, and construction planning.
- They are particularly valuable for surveying inaccessible or hazardous areas, like steep slopes, forested terrain, mountainous regions, and disaster-hit zones, eliminating the need for extensive ground control in risky locations.
- Accurate 3D surface models from drone surveys are utilized for volume calculations of stockpiles, earthworks, or quarry extractions, crucial for mining, construction, and landfill management.
- Drones support urban planners and civil engineers in infrastructure planning and land development by providing rapid data acquisition for large areas, making them ideal for master plans or regional development.
- They also enable frequent repeat surveys to monitor changes in landforms over time, which is beneficial in tracking erosion, landslide movement, flood extent, or construction progress.
- The data from drone surveys can be directly imported into GIS, AutoCAD, Civil 3D, and other design platforms, enhancing decision-making with accurate terrain data integrated into planning tools.
- One significant advantage of drone surveying methods is the faster data collection over large or rugged areas, requiring less manpower compared to traditional surveying techniques. Modern surveying methods, when

appropriate ground control points (GCPs) are used, offer higher accuracy and enable real-time or near-real-time updates for dynamic sites.

1. **Environmental Monitoring:** Drones are used for environmental monitoring to track changes in vegetation cover, wetlands, glacier retreat, desertification, coastal erosion, floodplains, and river dynamics.
2. **Disaster Management:** In disaster management, drones are crucial for quick aerial assessment of floods, earthquakes, landslides, and for conducting search and rescue operations as well as planning relief logistics.
3. **Agricultural Geography:** Within agricultural geography, drones play a significant role in precision farming by assessing crop health through NDVI imagery and monitoring soil erosion, irrigation, and land management practices.

Please see the table below for the applications of drones in geography:

Application Area	Description	Key Benefits
Topographic Mapping	Generation of high-resolution maps, DEMs, and 3D terrain models	Accurate and fast mapping, even in remote areas
Land Use & Land Cover (LULC)	Monitoring urban sprawl, deforestation, agriculture, etc.	Real-time data for planners and policymakers
Disaster Management	Rapid assessment after floods, earthquakes, landslides, etc.	Speeds up emergency response and damage assessment
Environmental Monitoring	Tracking ecosystem changes, wetlands, forests, and biodiversity	Helps in conservation planning and early warning systems
Coastal Zone Monitoring	Monitoring erosion, shoreline change, and tidal impacts	Protects infrastructure and aids in sustainable development
River Morphology	Studying changes in river course, sedimentation, and floodplains	Supports hydrological modelling and flood risk mapping
Agricultural Geography	Crop health assessment, irrigation monitoring using NDVI and other indices	Enhances productivity and supports precision agriculture
Urban Planning	3D modelling of buildings, infrastructure mapping, traffic flow analysis	Informs sustainable and efficient urban design
Tourism & Cultural Geography	Mapping of heritage sites and tourism hotspots	Assists in management, promotion, and preservation
Climate Studies	Monitoring glacier retreat, desertification, and vegetation changes	Supports climate change research with localized data

Applications of Drones in Geology

1. **Geological Mapping:** Drones are extensively used in geology for geological mapping, capturing detailed images of various geological features such as outcrops, faults, folds, and mineralized zones. They are particularly valuable for mapping inaccessible or hazardous terrains like cliffs, mines, and volcanic areas where traditional methods may have limitations.
2. **Landslide and Slope Stability Analysis:** Another significant application of drones in geology is providing pre- and post-event imagery for landslide and slope stability analysis, aiding in assessing slope failure mechanisms and monitoring phenomena like creep, cracks, and mass movements over time.
3. **Volcanology:** In the field of volcanology, drones play a crucial role in monitoring active volcanoes, lava flows, gas emissions, thermal anomalies, and crater morphology, providing essential data for research and hazard assessment while minimizing risk to human life.
4. **Mining and Exploration:**

- Drones play a significant role in the mining and exploration sector by conducting surveys, monitoring mine sites, and assessing environmental impacts to ensure safe and efficient operations.
- Their manoeuvrability and imaging capabilities make drones particularly advantageous for prospecting minerals in remote or challenging terrains.
- The use of drones extends to both pre-operative and post-mining activities, where they aid in exploration, reconnaissance, and detailed surveys.
- In detailed exploration surveys, drones are instrumental in demarcating high-precision contour levels and delineating areas of interest. By supplementing surficial contouring with borehole data or ore body thickness, drones can assist in estimating the reserve of the ore body.
- During mining operations, drone surveys are utilized for tasks such as delineating bench alignments, planning excavation and water management systems, and road planning. In post-mining operations, drone surveys are crucial for preparing Progressive Mine Closure Plans or Final Mine Closure Plans, highlighting their vital importance in the industry.

5. **3D Modelling of Geological Features:** Additionally, drones are utilized in the creation of 3D models of geological features through photogrammetry, offering valuable tools for educational and research purposes in the field of geology.

The field of geology has undergone a significant evolution in terms of field excursions, transitioning from the use of basic tools like a clinometer compass to advanced equipment such as drones and DGPS surveys. As time and technology have progressed, these field excursions have become more efficient and time-saving, but they have also presented new challenges. The invention and integration of drone technology has brought about a vital transformation in geology, as drones offer a wide range of applications and are of crucial importance in various geological endeavours.

The following table discusses the applications of drones in Geology in short:

Application Area	Description	Key Benefits
Geological Mapping	Detailed imaging of outcrops, faults, folds, and mineralized zones	Improves mapping accuracy in difficult terrain
Landslide and Slope Stability Analysis	Monitoring of slope movements, cracks, and landslide-prone zones	Enhances early warning and risk mitigation
Volcanology	Tracking active volcanoes, lava flows, and gas emissions	Safe, remote monitoring of volcanic hazards
Mining and Exploration	Surveying mine sites, tailings dams, and exploration zones	Improves efficiency in exploration and environmental management
3D Modelling of Geological Features	Photogrammetric models of geological features for analysis	Creates accurate, scalable visualizations for study
Seismic Hazard Assessment	Surface fault mapping and geomorphic assessment for seismic risk	Supports planning in seismically active regions
Hydrogeological Studies	Mapping aquifers, recharge zones, and terrain analysis	Aids in groundwater resource management
Paleontological Site Documentation	Capturing aerial imagery of fossil-bearing formations	Preserves data from fragile and inaccessible sites
Structural Geology	Analysing rock deformation, fractures, and stress fields	Supports tectonic and structural analysis
Remote Area Surveying	Accessing and mapping remote or hazardous geological areas	Reduces field time and increases safety

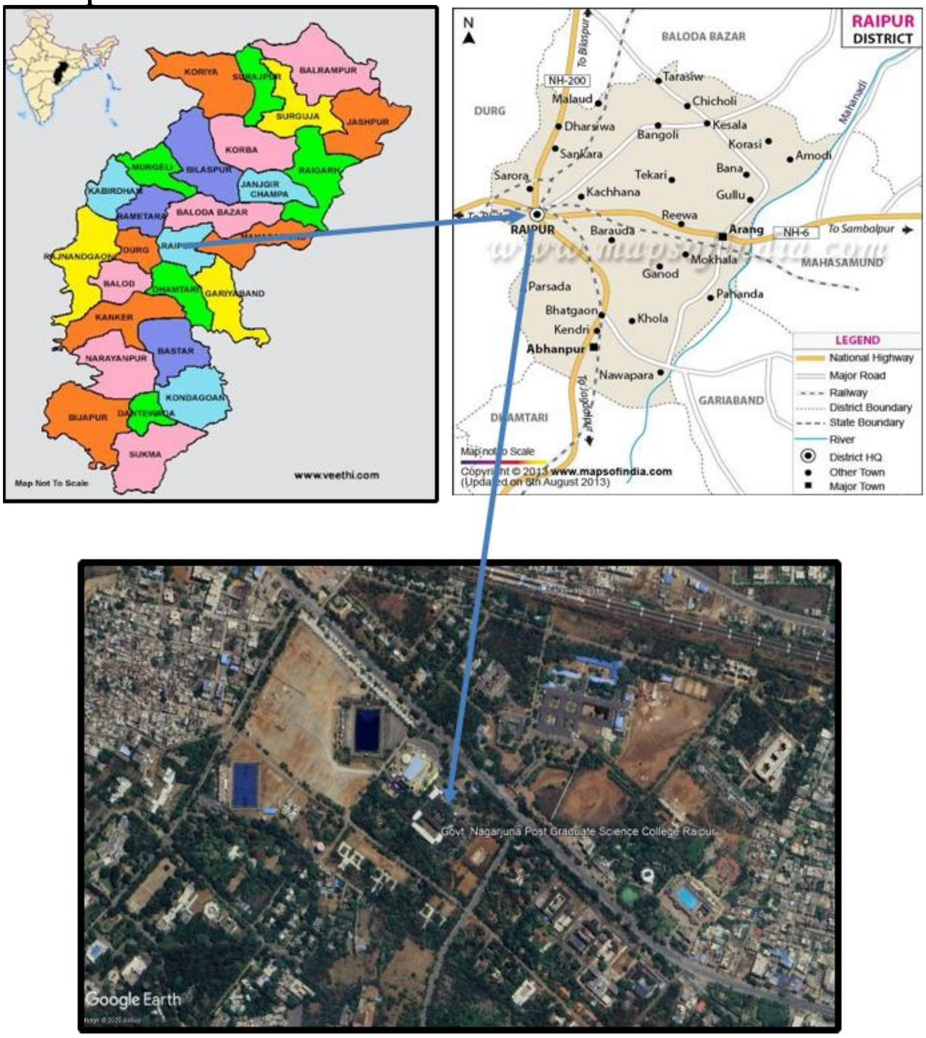
V. A Case Study Of Survey Conducted In Premises Of Govt. NPG College Of Science Raipur, Chhattisgarh

A drone survey and training initiative was carried out at the Government Nagarjuna Science College in Raipur. The survey location is positioned adjacent to G.E. Road, opposite NIT Raipur, and was chosen to create a practical setting for comprehending drone-based data collection. The training was designed to furnish geology students with practical skills in UAV operation, flight planning, aerial mapping, and data post-processing.

Objective:

- To familiarize students with drone technology and its applications in geospatial data collection.
- To conduct a detailed aerial mapping of the boundary area of Science College, Raipur.
- To capture high-resolution imagery and process it into useful geospatial outputs such as orthomosaics and DSMs.
- To develop an understanding of flight mission planning, ground control setup, and UAV operations.
- To interpret and utilize drone-derived data in geological and mining contexts.
- To learn about Sub-rule (5) of Rule 34A of MCDR, 2017 concerning mandatory drone surveys and data submission to the Indian Bureau of Mines (IBM).

Survey Area Description:



The Drone survey was done at Govt. N.P.G. Science College situated near G.E. Road, in front of NIT Raipur of Tehsil- Raipur, District- Raipur, Chhattisgarh. The surveyed area is bounded by Longitudes 81° 36' 07.64012" E to 81° 36' 10.48624"E & Latitudes 21° 14' 51.21149"N to 21° 14' 54.31897"N. The surveyed area comes under Toposheet number 64G/11 and 64G/12.

Instrument Used
- UAV Model: SURVEYAAN V1
- Type: Multirotor
- Provider: Siddharth Geo Consultants, Raipur
- Camera: High-resolution RGB sensor (20 MP)
- Flight Altitude: ~60 meters AGL
- GPS Support: RTK enabled
- GSD Achieved: ~2 cm/pixel

Drone Specification

The drone used for this survey, **SURVEYAAN**, is a high-performance, certified UAV developed by Nibrus Technologies Pvt. Ltd. It is specifically designed for surveying applications, including mining, construction, agriculture, and GIS.

Key Specifications:
- **Maximum Weight:** 2 kg
- **Endurance (Flight Time):** 25–30 minutes
- **Range:** 1.5 km

- **Maximum Altitude:** 120 meters (Micro category)
- **Speed:** 25 km/h
- **Accuracy (with GCP):** < 5 cm (X, Y) | < 10 cm (Z)
- **Wind Resistance:** Up to 25 km/h
- **Camera Payload:** 20 MP RGB sensor (PPK payload), APS-C sensor size,
- **Weight:** 215 gm
- **GNSS Supported:** GPS, GLONASS, GALILEO, QZS, SBAS
- **GNSS Update Rate**: Up to 10 Hz
- **Dual Band:** L1 & L2
- **Connectivity:** Bluetooth / Wi-Fi
- **Battery Backup:** Up to 2 days on full charge

Methodology

The methodology for drone survey was decided on the following aspects

1) Pre survey planning
2) Data acquisition
3) Post processing

These three aspects were led to the different outputs and data formats like metadata, orthomosaic maps, digital surface model, digital terrain model, and flight path and metadata.

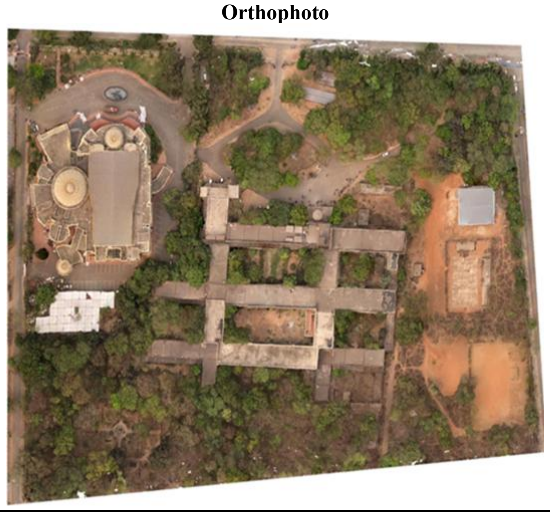
1) **Pre survey planning:** In the pre survey planning permission was sought from the Principal of Govt. NPG college of science Raipur as this demonstration was a part of curriculum of M.Sc. degree and part of project work also. The site was selected keeping in view the minimum obstacles like trees, electric lines, etc. Layout of ground control points were decided with accurate global positioning systems. The drone softwares were used to plan the drone flights.
2) **Data Acquisition:** The data acquisition was done conducting the flight mission maintaining 80% overlap.
3) **Post Processing:** After conducting successful flight plan by a pilot licensed authority Mr. Siddharth Singh, of Siddharth Geo Consultants, Raipur. The data was processed with Pix4D/ Drone Deploy. Ground control points were added for georeferencing. After these, orthomosaic maps, Digital surface model (DSM), 3D point clouds and contour maps are generated which are given below.

Metadata:

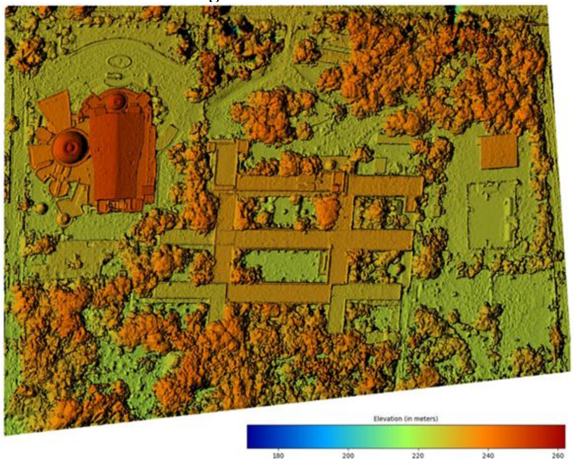
Project Name	Science College 2025
Date	18/04/2025
Total Area Processed	8.979 Hectare(s)
GSD - Orthomosaic	3.4 cm/px
GSD - DSM/DTM	10.2 cm/px
Total Photos	99
Camera Model	GoPro HERO10 Black
Photo Resolution	5568 x 4176 px
Position Reference	GPS
Photogrammetry Engine	Surveyaan Proprietary
Flight Start Date & Time	10:15:41 AM, 03/04/2025
Flight End Date & Time	10:21:47 AM, 03/04/2025

Flight Path

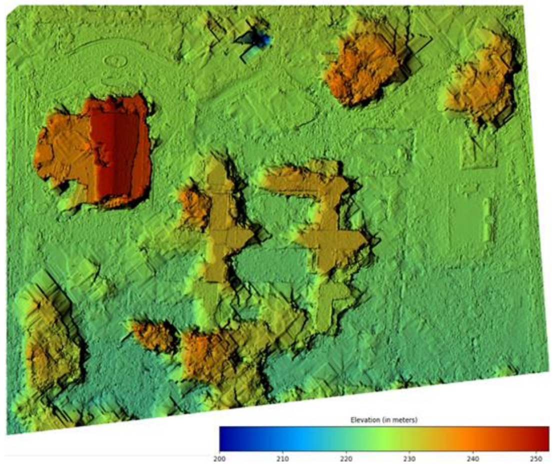
Orthophoto



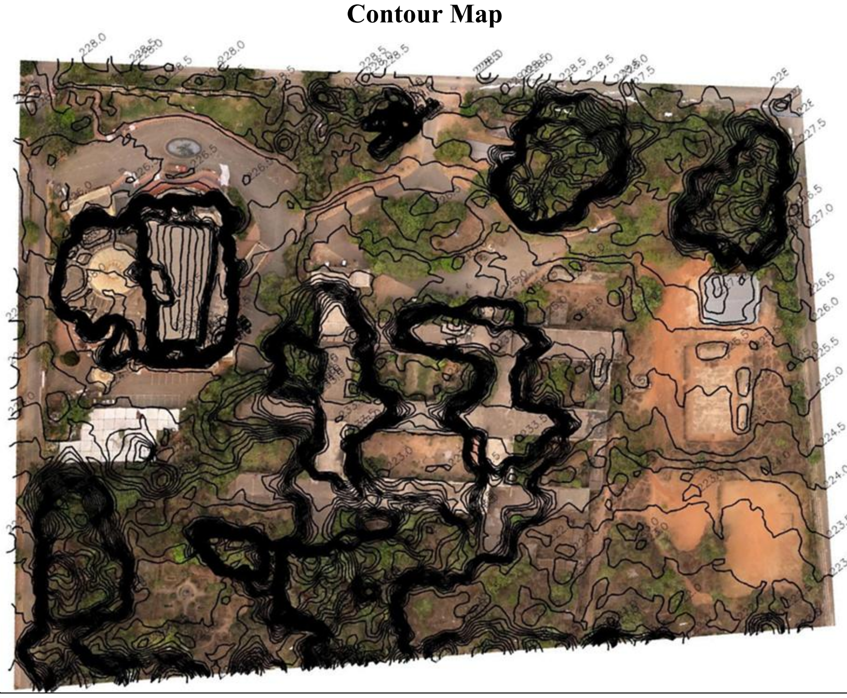
Digital Surface Model



Digital Terrain Model



Contour Map



Photographs during Survey:

VI. Discussion

The drone survey conducted at the Science College campus showcased the practical potential of UAVs in applied geology and geospatial sciences. When compared to conventional ground-based surveys, the UAV method significantly reduced field time while providing enhanced spatial resolution and accuracy. The achieved Ground Sample Distance (GSD) of 3.4 cm/px allowed for the generation of highly detailed orthophotos, Digital Surface Models (DSMs), and Digital Terrain Models (DTMs) that were subsequently integrated with Geographic Information System (GIS) platforms for visualization and analysis. This integration not only minimized positional errors but also enabled the preparation of reliable thematic maps, including contour and land classification layers. Additionally, the survey highlighted the advantages of UAVs in covering large and complex terrains, particularly where accessibility for manual surveys is limited. The capability to generate 3D models and contour maps with high accuracy makes drones particularly useful for geological studies, mining operations, urban planning, and environmental monitoring. However, there are challenges that persist, such as regulatory restrictions, weather dependency, flight time limitations, and the requirement for skilled operators. Nevertheless, the successful execution of the survey affirms drones as a promising, efficient, and versatile geospatial tool for both academic and professional applications.

VII. Conclusion

The case study conducted at Government NPG College of Science in Raipur effectively showcased the practicality of utilizing drones in applied geology and geospatial surveying. The approach of using UAVs yielded precise, reproducible, and high-resolution outputs, which would have been considerably more time-consuming and resource-intensive if traditional methods were employed. The survey not only demonstrated the effectiveness of integrating drone-derived data with GIS but also established a robust framework for accurate boundary delineation, terrain modelling, and land-use assessment. In conclusion, the research findings unequivocally validate that drones, in conjunction with advanced photogrammetry and GIS techniques, offer a contemporary, cost-efficient, and dependable solution for surveying. Moreover, they hold substantial potential for diverse applications in geology, mining, disaster management, infrastructure development, and environmental studies. It is evident that with appropriate training, supportive policies, and technological advancements, UAV-based surveys have the capability to significantly enhance the quality and efficiency of geoscientific investigations not only in India but also globally.

VIII. Acknowledgement

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