

Implementation of Drone Technology to Prepare a Contour Map of Nesave Village

S.I. Quadri^{1*}, Farhan Shaikh¹, T.R. Tirukhe², Y.Y. Shaikh²

Abstract

Nowadays modern surveying techniques or instruments like DGPS, LiDAR and Drones are widely used as they cover more area in less time for surveying. Such techniques can even be used where visiting survey areas are tough or not possible. Drones are used instead of traditional surveying in a village named Nesave. Drones are used to capture images and process them using specialized software such as Agisoft Metashape Professionals and QGIS (Quantum Geographic Information System) Desktop 3.34.3. Image acquisition orthomosaic Digital Elevation Models (DEMs) and data processing is done in Metashape. High-resolution cameras are used in drones to capture aerial images which are then processed and analyzed in Metashape and planning done in QGIS. This drone survey required less time along with manpower and also a large number of areas can be covered in the survey using a drone.

Keywords: Drone survey, Agisoft Metashape, QGIS (Quantum Geographic Information System), orthomosaic, digital elevation models (DEMs)

INTRODUCTION

Collection of aerial data can be done by using Unmanned Aerial Vehicle (UAV) commonly known as drone. Drone survey utilizes drone technology for surveying of various construction sites, villages or cities, irrigation land for construction of dams or canals, forests for expressway or highway construction, site with high altitude, mining areas, areas where there is risk to human life, areas where surveying instruments cannot be transported, areas where field survey is not possible, and many more.

In drone survey, drones are equipped with camera, sensors and LiDAR i.e. light detection and ranging. In drone survey, with the help of a drone geometrics and images of the required area and analyzing the area, data are collected to study the area carefully along with its altitude, longitude and latitude which helps in further study and research of area which is not possible such easily using traditional methods of surveying. Drone survey requires less time and effort as compared to traditional

methods and is also safer, faster and cost effective from traditional survey. There are many types of drones used in surveying; some most commonly used drones are single/multi-rotor drone, fixed-wing drone, micro drone, GPS drone, photography drone etc. In India, rules and regulations of drone survey are clearly stated by DGCA. DGCA (Directorate General of Civil Aviation) deals with the safety issues of Civil Aviation. DGCA sets the rules regarding the use of drones for the safety and privacy of other people [1–3].

Nowadays, contour maps, heat maps, etc. of various places can be prepared easily and efficiently using drones. Such a map has been prepared of a village called Nesave in Mawal Taluka of Pune

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district (MS) India. Various software are used for preparation of these maps. Software used for maps are Agisoft Metashape professionals and QGIS (Quantum Geographic Information System) [4–6].

METHODOLOGY

Procedure of Drone Survey

The case study focuses on the preparation of a contour map of Nesave village in India, situated in Mawal taluka of Pune district in the state of Maharashtra, by collecting photos from the literature of Nesave village of an actual drone survey. In this literature, following the rules and regulations given by DGCA, flew the drone over the village, took photographs of the village, and gathered all the images possible to take with the help of the drone. Altogether collected 105 images of the Nesave village and its surrounding area with the help of drone. Then using the software Agisoft Metashape an orthomosaic image was created by combining all 105 images. The orthomosaic image is shown in Figure 1 [7–9].

The heat map and the contour map of the village were created using Agisoft Metashape software. The contour map shows the contour lines showing the topography of the corresponding village showing the hills and valleys in the surrounding area of the town. The contour map of Nesave village is created by using Agisoft Metashape software and is shown in Figure 2.

The heat map of the village shows the elevation of different areas in the village and that of their corresponding area by using different colors for different elevations shown in the heat map as shown in Figure 3.

Then by using Quantum Geographic Information System (QGIS), we made the contour map combined with the map of Nesave village. The contour map aligned with village map is shown in Figure 4 [10].



Figure 1. Orthomosaic image of village.

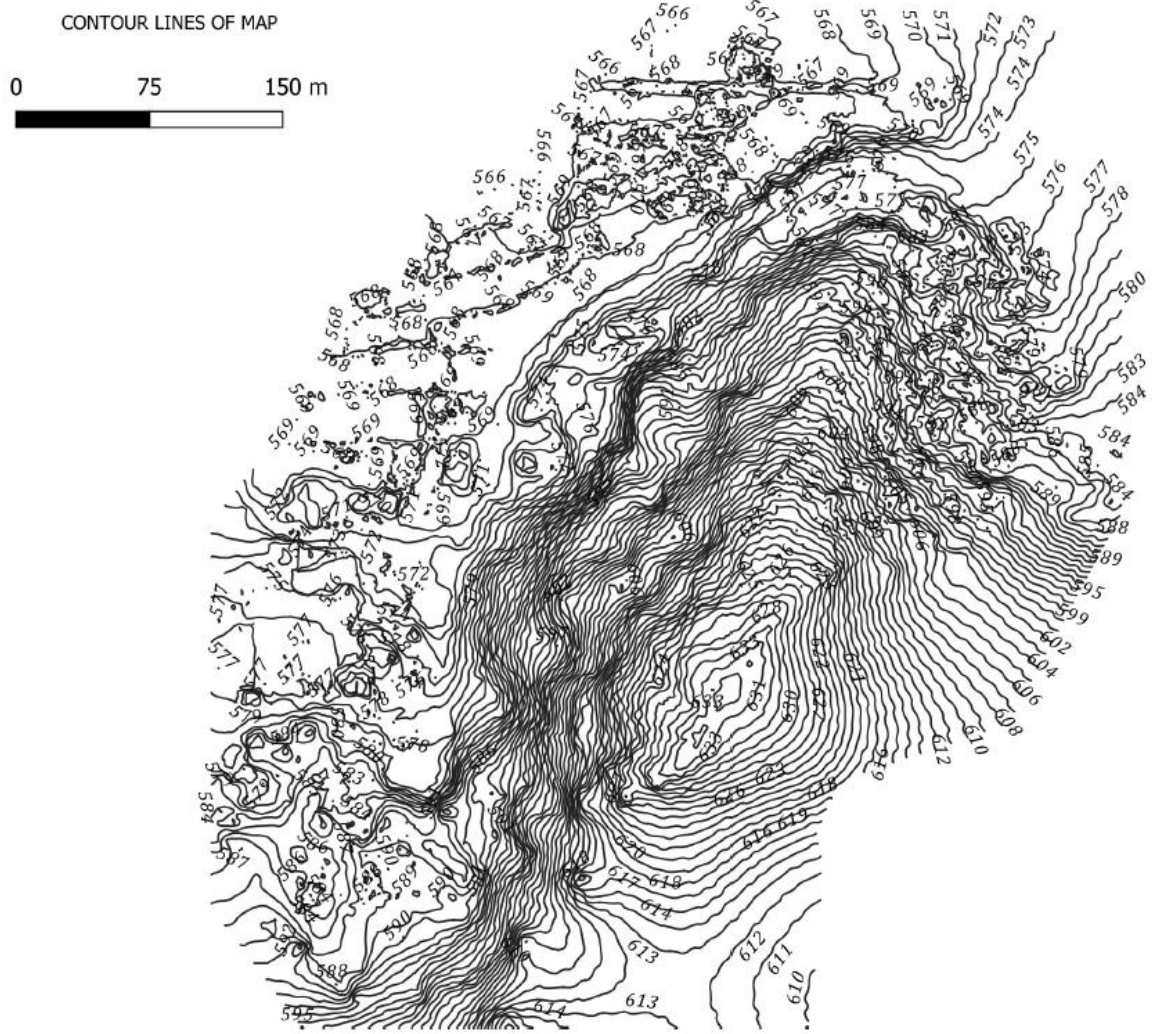


Figure 2. Contour map of the village according to contour lines.

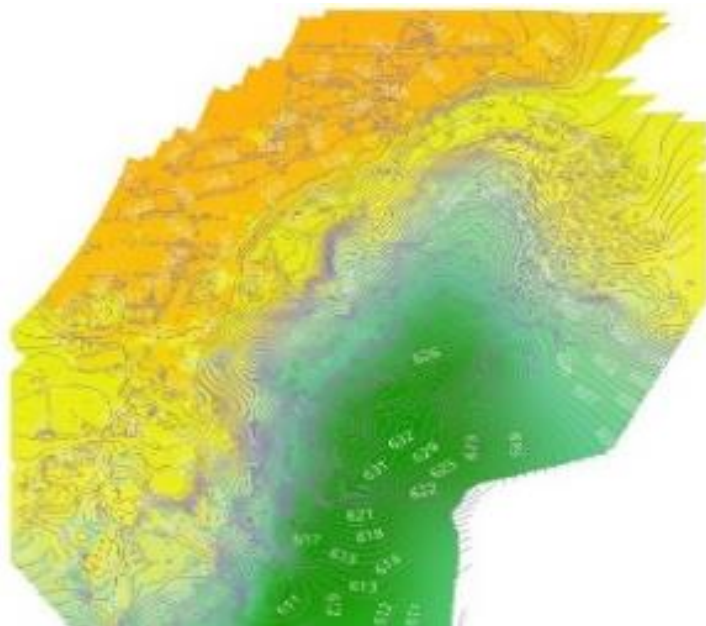


Figure 3. Heat map of the village according to its elevation.



Figure 4. Contour map aligned with village map.

This map of Nesave village is exactly accurate to the map of the village taken by satellite and can be used for various purposes like construction of road and railway lines, development of the village, etc.

Fieldwork in Drone Survey

Project Planning

- *Define the survey objectives:* For this study, preparation of a contour map.
- *Identify the survey area:* Nesave, Mawal, Pune, and Maharashtra, India.
- *Plan the flight path:* The flight path is set according to the drone's requirements and is shown in the Figure 5.

Equipment Preparation

- *Check UAV and payload:* a payload refers to the equipment or cargo the UAV carries, such as cameras, sensors, or other tools.
- *Charge batteries:* check whether the batteries are fully charged or not.
- *Calibrate equipment:*
 - a. *Yaw:* plane fuselage not parallel to the flight line:
 - Think about having to steer your car slightly into a strong cross-wind.
 - Leads to pictures not being square with the flight line.
 - b. *Pitch:* nose or tail higher than the other:
 - Leads to the principal point of not being at nadir.
 - c. *Roll:* one wing higher than the other:
 - Leads to the principal point of not being at nadir.

Survey Execution

Conduct a pre-flight check: check the various parameters regarding weather, sun time, temperature, wind, gusts, wind direction, precipitation probability, cloud cover, visibility, visible sentinel automatic triggers, KP index and sentinel automatic triggers locked. It can be checked using the UAV forecast application its images are shown in Figure 6.

Figure 6 shows the conditions for pre-flight check: (A) good to fly; (B) Not good to fly.

1. *Launch the UAV:* Launch of a UAV should be done by considering the relevant path.
2. *Ensure data capture:* Ensure the data captured by the UAV is as per requirement of the survey.
3. *Maintain communication:* Proper connection should be maintained between Rover, Satellite and base station.



Figure 5. Setting up the flight path.



Figure 6. Conditions for pre-flight check: (a) good to fly; (b) Not good to fly.

Data Processing

- *Download data:* Download the pictures captured by the drone.
- *Verify data quality:* Verify whether all the images are clear or not. If images are not clear they should be deleted from the library.
- *Process imagery:* Combine all the images and create an orthomosaic image using Agisoft Metashape software.
- *Generate reports:* Generate the survey report using Agisoft Metashape Software.

Data Analysis

- *Interpret results:* Interpret results by checking them on photographs and by observing the site.
- *Compare with existing data:* Comparing the data with existing data available on Google Earth or pre-available surveying data.
- *Identify trends or anomalies:* Identifying trends or anomalies involves recognizing consistent patterns or deviations from expected behavior in data or processes.

Reporting

- *Create a final report:* A final report using Agisoft Metashape software.
- *Include visuals:* Add visuals like color coding symbols and legends depending upon the area of study.

Share Results

Share the result in picture form, that is, orthomosaic, contour map and heat map.

DGCA RULES AND REGULATIONS

1. Register your drone: No Permission No Take-off.
2. Fly your drone at or below 200 ft.
3. Keep your drone within your line of sight.
4. Be aware of DGCA/FAA airspace restrictions.
5. Respect privacy.
6. Never fly near other aircraft, especially near airports.
7. Never fly over groups of people, public events, or stadiums full of people.
8. Never fly near emergencies such as fires or hurricane recovery efforts.
9. Never fly under the influence of drugs or alcohol.

BENEFITS OF DRONE SURVEY

1. Decreased field time and costs.
2. Fewer disruptions.
3. More accurate data and precise measurement.
4. Maps inaccessible areas.
5. Improved safety.
6. Improved data provides more options.

WORKING WITH SPECIAL INSTRUMENTS**Real Time Kinematic (RTK)**

The concept of DGNSS can be applied in one of two methods:

- a. Applied in real-time, by transmitting the correction (by radio or mobile network) from a base receiver on a known point to a rover receiver that is measuring positions.
- b. Real-time kinematic or RTK survey.

Post Processing Kinematic (PPK)

- a. Applying the corrections to the position of a rover is to do so after the survey is complete.

- b. Both the base and the rover continuously log position data and corrections from the base receiver are applied to rover positions using the time stamp information from both receivers, post-survey.
- c. This is referred to as a post-processing kinematic or PPK survey.

INTRODUCTION TO SOFTWARE AND PHOTOGRAPHIC PRODUCTS

Photographic products are derivatives of single photographs or composites of overlapping pictures. These photographic products are made by using all the images and pictures taken using drone from different angles, positions, points, heights and range. Some commonly used software used to create photographic products are Agisoft Metashape, QGIS, Pix 4D, DroneDeploy, Autodesk ReCap, Global Mapper and many more.

Software Used for Photographic Products in Drone Survey

After capturing images using drones, specialized software is used to process, analyze, and generate various photographic products like orthomosaics, 3D models, and digital elevation models (DEM). Below are some popular software tools used in drone surveying:

Pix4D

- *Type:* Photogrammetry and Mapping Software.
- *Best for:* Creating high-resolution orthomosaics, 3D models, and point clouds.

Features

- a. Processes images into accurate maps and 3D models.
- b. Generates Digital Terrain Models (DTM) and Digital Surface Models (DSM).
- c. Supports LiDAR data processing.

Common Use

Agriculture, construction, mining, and land surveying.

Agisoft Metashape

- *Type:* Photogrammetry and 3D Modeling.
- *Best for:* Generating high-quality 3D models and textured orthomosaics.

Features

- a. Produces georeferenced 3D models.
- b. Can handle multi-camera setups.
- c. Exports data for GIS (Geographic Information Systems).

Common Use

Archaeology, forestry, mapping, and environmental studies.

DroneDeploy

- *Type:* Cloud-based Mapping and Analysis.
- *Best for:* Easy-to-use platform for automated drone mapping.

Features

- a. Creates 2D maps, 3D models, and elevation maps.
- b. Supports real-time data processing.
- c. Compatible with most commercial drones.

Common Use

Construction, agriculture, and disaster management.

Autodesk ReCap

- *Type:* 3D Reality Capture and Reconstruction.
- *Best for:* Converting drone images into CAD-compatible 3D models.

Features

- a. Processes point cloud data.
- b. Works with Autodesk CAD software like AutoCAD and Revit.
- c. Creates accurate 3D models for construction and engineering.

Common Use

Architecture, engineering, and construction (AEC).

Global Mapper

- *Type:* GIS and Mapping Software.
- *Best for:* Processing large aerial datasets and terrain analysis.

Features

- a. Works with orthophotos, LiDAR, and GIS data.
- b. Exports DEM, DSM, and topographic maps.
- c. Handles large-scale mapping projects.

Common Use

Government mapping, forestry, and environmental studies.

Bentley Context Capture

- *Type:* Reality Modeling and 3D Reconstruction.
- *Best for:* High-detail 3D modeling from drone images.

Features

- a. Generates photo-realistic 3D city models.
- b. Supports large-scale infrastructure projects.
- c. Works with CAD and GIS platforms.

Common Use

Urban planning, real estate, and civil engineering.

Photographic Products in Drone Survey

Drone surveys generate a variety of photographic products that are used for mapping, analysis, and decision-making. These products are created by processing aerial images with specialized software like Pix4D, Agisoft Metashape, DroneDeploy, and QGIS.

Orthomosaic Maps

An orthomosaic is a high-resolution, geometrically corrected aerial image created by stitching together multiple drone photos. Unlike regular images, orthomosaics maintain uniform scale and accurate geolocation, allowing precise measurements.

Features

- a. High-resolution, corrected for distortion.
- b. Used for land surveying, urban planning, agriculture.
- c. Supports GIS and CAD applications.

Common Use

Land mapping, real estate, construction monitoring.

Digital Elevation Models (DEM)

A DEM is a 3D representation of terrain elevation, created from drone imagery. It includes:

- a. *Digital Surface Model (DSM)*: Represents buildings, vegetation, and ground features.
- b. *Digital Terrain Model (DTM)*: Only shows the bare earth, with structures removed.

Features

- a. Helps in flood risk assessment, terrain analysis, and contour mapping.
- b. Used for engineering, environmental monitoring, and mining.

Common Use

Urban development, topographic mapping, watershed analysis.

3D Models (Photogrammetry Models)

A 3D model is a realistic digital reconstruction of a site using drone images and photogrammetry techniques. It provides a fully interactive view of the landscape.

Features

- a. Allows accurate volume calculations (stockpiles, buildings, excavation sites).
- b. Used in construction, mining, archaeology, and heritage conservation.
- c. Enables virtual inspections and site visualization.

Common Use

Architecture, infrastructure planning, archaeological research.

Point Cloud Data

A point cloud is a collection of 3D data points generated from drone images or LiDAR sensors. Each point represents a precise location in space.

Features

- a. Used for 3D mapping, terrain analysis, and building inspections.
- b. Supports CAD and BIM software for engineering projects.
- c. Helps in forest mapping and canopy analysis.

Common Use

3D reconstruction, civil engineering, forestry analysis.

NDVI (Normalized Difference Vegetation Index) Maps

An NDVI map is used in agriculture and forestry to assess plant health. It is created using multispectral or near-infrared (NIR) cameras on drones.

Features

- a. Helps detect unhealthy crops, drought stress, and soil conditions.
- b. Used for precision agriculture and irrigation planning.
- c. Supports early pest and disease detection.

Common Use

Precision farming, environmental conservation, forestry.

Thermal Maps

A thermal map is generated using a thermal imaging camera on a drone. It detects temperature variations across an area.

Features

- a. Used for infrastructure inspections (power lines, solar panels, pipelines).
- b. Helps in wildfire detection and search-and-rescue operations.
- c. Identifies heat loss in buildings for energy efficiency.

Common Use

Industrial inspections, disaster response, renewable energy monitoring.

APPLICATIONS AND ADVANCEMENTS IN DRONE SURVEY

Drone surveys have revolutionized various industries by making mapping, monitoring, and data collection more efficient, accurate, and cost-effective. With continuous advancements in drone technology, their applications are expanding rapidly.

Applications of Drone Survey

Land Surveying and Mapping

- a. Generates high-resolution orthomosaics and 3D topographic maps.
- b. Creates Digital Elevation Models (DEM) and Digital Terrain Models (DTM).
- c. Improves property boundary mapping and land-use planning.

Industries: Real estate, urban planning, government land records.

Construction and Infrastructure Monitoring

- a. Tracks construction progress with aerial time-lapse images.
- b. Measures earthwork volumes and site elevations.
- c. Helps in structural inspections of bridges, roads, and railways.

Industries: Civil engineering, road construction, infrastructure development.

Agriculture and Precision Farming

- a. NDVI maps help assess crop health and detect diseases.
- b. Monitors soil moisture levels and irrigation needs.
- c. Identifies pest infestations and nutrient deficiencies.

Industries: Farming, agribusiness, forestry.

Mining and Quarrying

- a. Conducts stockpile volume calculations.
- b. Maps open-pit mines and excavation sites.
- c. Improves worker safety by inspecting hazardous areas.

Industries: Mining, geospatial surveying.

Environmental Monitoring and Disaster Management

- a. Maps areas affected by deforestation, erosion, and climate change.
- b. Assists in flood modeling and coastal erosion studies.
- c. Helps in wildfire monitoring, search and rescue operations.

Industries: Disaster relief, environmental research, forestry.

Advancements in Drone Survey Technology

AI and Machine Learning in Drone Surveys

- a. Drones can automatically analyze data and detect changes in terrain.

- b. AI helps in predictive maintenance of structures.
- c. Machine learning enhances crop monitoring and disease detection.

Example: AI-powered drones in agriculture provide real-time insights on crop health.

LiDAR Technology Integration

- a. Provides high-precision 3D terrain mapping.
- b. Works in dense forests and low-light conditions.
- c. Enhances flood modeling, archaeology, and infrastructure planning.

Example: LiDAR drones are used for forest canopy analysis and archaeological discoveries.

BVLOS (Beyond Visual Line of Sight) Drones

- a. Increases survey coverage over longer distances.
- b. Reduces the need for on-site drone operators.
- c. Used in pipeline inspections, railway monitoring, and disaster response.

Example: BVLOS drones help monitor remote oil pipelines without human intervention.

Real-Time Data Processing and Cloud Integration

- a. Drones upload survey data to the cloud instantly.
- b. Enables faster decision-making and collaboration.
- c. Used in real-time mapping of disaster zones and construction sites.

Example: DroneDeploy and Pix4D allow cloud-based mapping and analysis.

Autonomous and Swarm Drones

- a. Multiple drones work together for large-scale mapping.
- b. Reduces survey time and improves data accuracy.
- c. Used in agriculture, military, and environmental monitoring.

Example: Swarm drones are used for reforestation projects and large-area surveys.

CHALLENGES AND FUTURE DEVELOPMENTS

Challenges

- Regulatory Challenges: Governments will need better drone laws for BVLOS operations.
- Battery Limitations: Future drones will need longer flight times and solar-powered innovations.
- Data Security and Privacy: Drone data needs better encryption and cyber security measures.

Future Solutions

- Hydrogen-powered drones for longer endurance.
- Stronger AI regulations for ethical drone use.
- Improved geofencing to prevent drone accidents.

OBSERVATIONS

1. All the points are accurately matched with the map shown on Google Earth.
2. Elevations taken out with the help of drones are the same as shown on Google Earth.
3. To use drones for surveying it is necessary to check weather conditions.
4. The velocity of wind or wind pressure should be less to use drones efficiently.
5. Radio communications should be in the range of the drone to get the proper latitude, longitude and altitude.

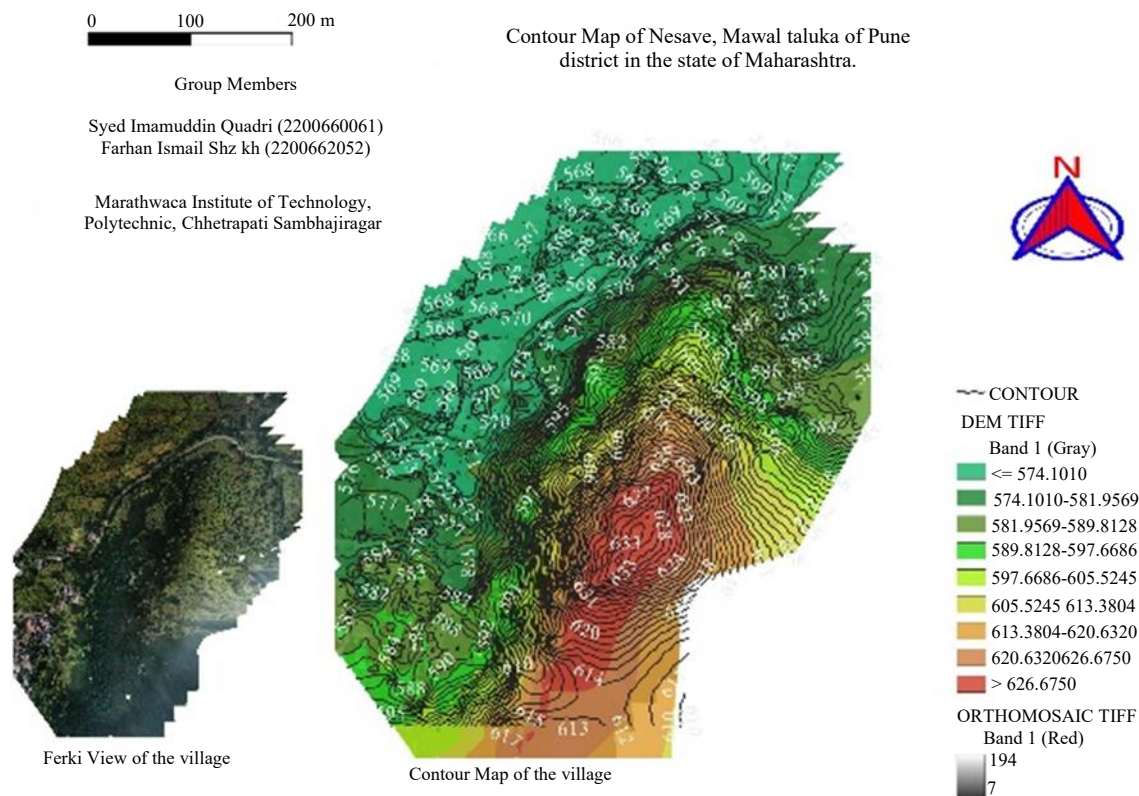


Figure 7. Contour map of Nesave village represented with color coding (red: highest elevated point, and green: lowest elevation point).

RESULTS AND DISCUSSION

With the help of drone surveys various types of maps have been made such as heat map and contour map. An orthomosaic image of the surveyed village has been prepared using Metashape software. The image of the village made by the software with the help of a drone is the same when compared with the one of Google Earth. The contour map with all the details including elevation in meters, color grading showing green as lowest elevation point and red as highest elevation point is shown in Figure 7.

CONCLUSION

1. The drone is used to provide a satisfactory means to perform the required survey in some circumstances like large-scale projects and projects where access is difficult.
2. Utilizing drones for surveying reduces the work available for the survey.
3. A good option for large paddock-like sites and sites where survey access is difficult.
4. Less suitable for smaller sites with hardstand areas.
5. In addition to the digital model and plans a complete relatively close-range set of photographs was available.
6. Aerial image underlay is a very valuable resource for future planning.
7. Drone surveys are transforming industries by improving efficiency, accuracy, and safety.
8. Advancements like AI, LiDAR, 5G, and autonomous drones are making surveys even more powerful.
9. Future innovations will focus on faster processing, improved automation, and extended flight ranges.

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