

Topographical Survey Using High-End Technologies of DGPS and UAV of Khadka Village, Nagpur

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Abstract — From above, a detailed look at Khadika Village near Nagpur comes into view - covering 354 hectares under the southern part of NMRDA. Flying in precise grid patterns, ten meters above ground level, the CD Space drone captured overlapping images from multiple angles instead of relying on single passes. At the same time, fixed points were marked across the area using a Trimble DGPS device so that every aerial detail lines up exactly with real-world positions. Afterward, these inputs merged inside ArcGIS to form a sharp bird's-eye image showing paths between homes, streams cutting through fields, edges of settlements, patches of crops, wires strung on poles, and property divisions alike. Because both systems worked together, measurements landed closer to true location, gaps disappeared from the record, days got shaved off how long it took versus older tools like total stations. Plans drawn later - for handling runoff water, laying new roads, organizing public services - can now pull straight from this data without guesswork holding things back.

Index Terms — Topographical Survey, DGPS, UAV, Topographical , Ground Control Points (GCP), ArcGIS, Khadka Village Nagpur, NMRDA, Drone Mapping, Digital Terrain Model.

I. INTRODUCTION

Clear maps showing land shape matter for building roads, cities, layouts, property lines. Long ago, people measured hills and slopes with tools like theodolites, plane tables, total stations - steady gear, yet slow, heavy on workers, narrow in reach. One person records just scattered spots, gaps filled by guesswork between them [1].

Out near the edge of modern survey work, precision takes shape differently now. Instead of relying only on old-school methods, tools like DGPS have stepped into the spotlight - correcting location data down to mere fractions of a centimeter by syncing mobile receivers with steady base points through GPS and GLONASS frequencies. Picture this: one stationary hub sends refined signal tweaks while another moves across terrain, locking exact spots without guesswork. Flying above it all, drones carry sharp-eyed cameras that snap hundreds upon hundreds of pictures during each run, tiles slightly shifted so overlap covers every angle. These snapshots feed into software smart enough to reconstruct space itself, building detailed depth maps just from image patterns. From those, models rise - surface shapes, elevation layers, flat-top views - all stitched tight, showing detail as fine as a few centimetres per pixel. Ground truth meets airborne clarity where math stitches vision into form.

Out here in Khadka Village - part of the NMRDA South-A zone in Maharashtra, India - land covers about 354 hectares. Fields stretch across much of it, alongside homes clustered together, dry streambeds that flow only during rains, roads cutting through uneven terrain, and patches of unused ground. Yet detailed maps at a usable scale?

They're missing.

Because of that, people designing infrastructure under programs like PMGSY or SVAMITVA face real hurdles. Even work on the planned Outer Ring Road runs into trouble without reliable elevation and layout details. To help fix this, a full survey was done using DGPS tools combined with drone flights covering every part of the village. From start to finish, the process captured precise ground levels, boundaries, slopes, and surface features. What came out isn't just raw numbers - it's practical information ready for actual engineering plans. The way it was built matters too: methods used blend field measurements with aerial imaging, checked point by point. Results show how modern techniques can fill old data gaps when applied carefully. For places like Khadka, having accurate base maps changes what's possible down the line. No guesswork needed anymore where contours once blurred into assumptions. This kind of detail supports better decisions - from drainage routes to road grades - without overstating what it does. It simply gives planners something solid instead of estimates pulled from outdated sources.

II. STUDY AREA DESCRIPTION

Down near Khadka Village - set in Nagpur district, Maharashtra, India - you'll find it around 21°03'N and 78°56'E. Sitting inside the NMRDA South-A zone, its edges touch two big roads: one running southwest, that's NH-44; farther south lies the Samruddhi Mahamarg stretch. Close by are smaller places like Sukali, Mondha, Panjari, along with Shivmadka tagging nearby. Spread across the map, the land checked here adds up to exactly 354 hectares, broken into:

Farms growing seasonal crops cover about two-thirds of the region. Most fields sit on level ground or soft rolling hills. These areas include both summer and winter harvests. Roughly sixty-five percent of the landscape supports such farming. The terrain changes slowly, staying mostly even across stretches

Some homes sit inside the habitation core, alongside patchy dirt paths mixing with stronger paved ones. About fifteen percent of the area holds these living spots together with shared spaces where people gather. Structures range from temporary setups to solid builds, linked by routes that connect daily life. This section forms a small slice of the whole layout, yet supports most routines. Community features appear throughout, stitched between houses and pathways

Away from the main ridge, two temporary streams cut across the land heading southwest. These watercourses emerge only during certain times of year. Their paths shape narrow lowlands along the flow direction. Flood-prone zones run alongside these channels. The terrain slopes gently downward following their course

Out here, flat empty land mixes with tough low plants - about twelve percent of the area looks like this

Alongside expressway paths, power line routes stretch through areas marked by NMRDA for future development. Where highways clear space, utility corridors quietly follow. Right-of-way zones double as pathways for grid expansion. Near planned layouts, high-voltage lines trace across open land. Through these strips, both transport and energy networks grow in step

On Google Maps, Khadka Village appears in Figure 1. The area studied is marked by a red outline. Nearby towns sit close around it. Connected to the Samruddhi Highway, an off-ramp sits nearby. This shows how the village fits within the local layout.

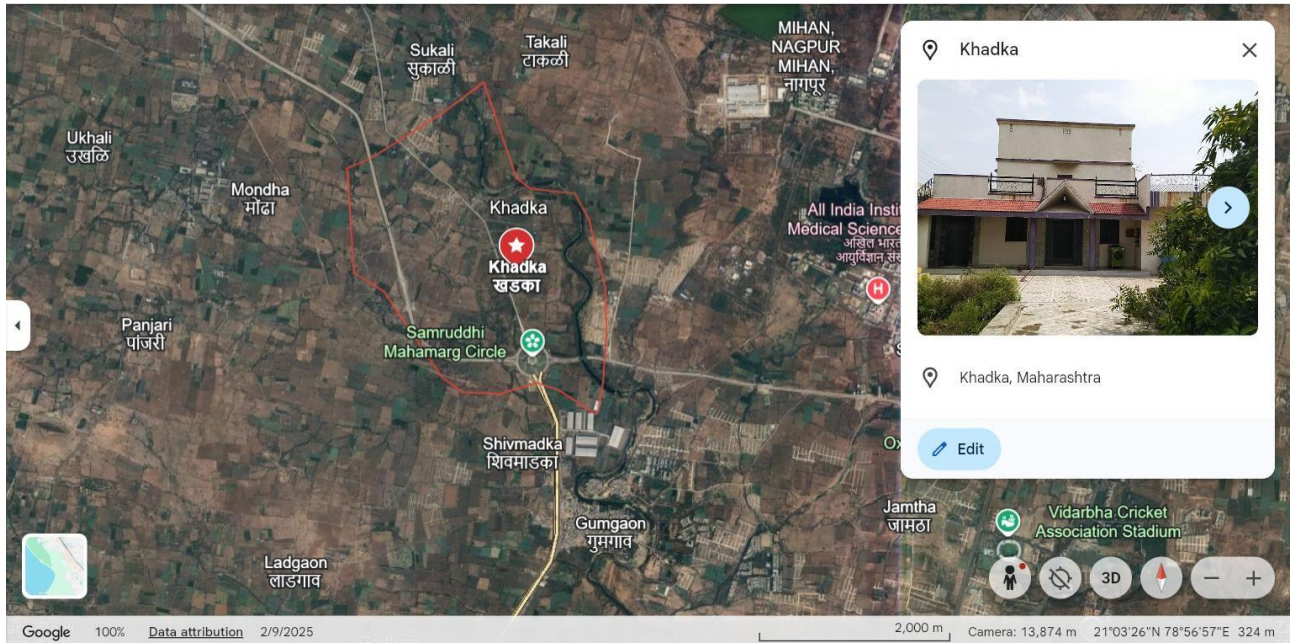


Fig. 1: Near the edge of Nagpur sits Khadka Village, shown clearly in Figure 1. This map comes from Google Maps data collected in early 2025

Figure 2 presents the NMRDA sectoral plan on Google Earth Pro, showing Khadka Village (grey sector, centre) within the South-A planning zone, surrounded by adjacent sectors including Sukali (green), Takali (purple), Sumthana (mauve), and Dahegaon (dark blue).

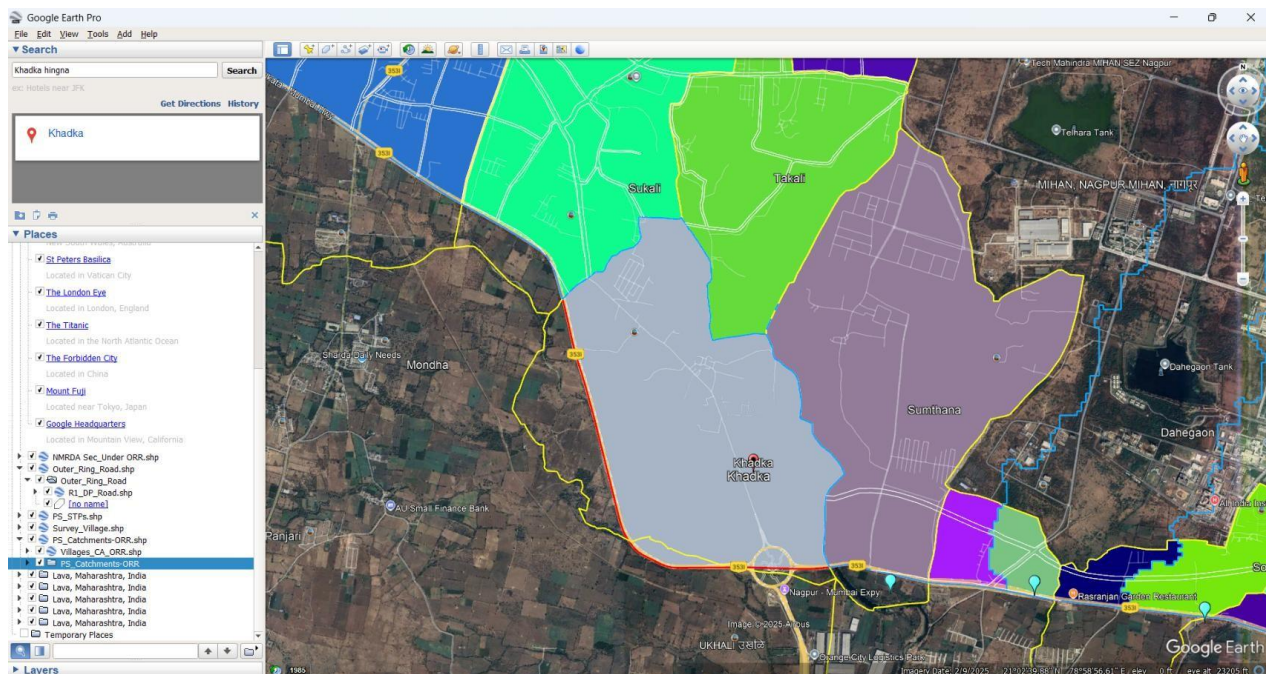


Fig. 2: NMRDA South-A Sector Plan showing Khadka Village boundary (Source: Google Earth Pro, October 2024)

III. EQUIPMENT AND SOFTWARE

3.1 UAV Platform — CD Space Drone

Above the treetops, the CD Space Drone zipped through its route, a multi-rotor craft carrying a sharp imaging camera along with integrated GNSS hardware. Flight patterns were laid out ahead of time via specialized software, enabling hands-free operation across structured grids. Among the standout traits: built-in precision tools, stable hovering ability, strong battery life, consistent image output, and seamless ground tracking

Table 1: CD Space Drone Specifications

Parameter	Specification
Platform Type	Multi-rotor UAV (Quadcopter)
Camera Resolution	20 MP (1-inch CMOS sensor)
Shutter Type	Mechanical global shutter
GNSS	Multi-constellation
Max Flight Endurance	~28 minutes per battery
Operating Wind Speed	< 8 m/s
Survey Altitude (this project)	100 m AGL
Side Overlap (this project)	70%
Front Overlap (this project)	80%

3.2 DGPS System — Trimble GNSS Receiver

A Trimble Differential GPS setup handled Ground Control Point creation, working in static mode alongside real-time kinematic methods. With signals from both GPS and GLONASS satellites, it captured L1 and L2 phase measurements for extreme precision. Positioning details reached under-one-centimetre correctness across horizontal and vertical planes once corrected later. Collected field information moved into Trimble Business Center for processing tasks after collection finished.

Table 2: Trimble DGPS System Specifications

Parameter	Specification
GNSS Constellations	GPS L1 L2 G.L.O.N.A.S.S
Static Horizontal Accuracy	3 mm plus 0.1 ppm
Static Vertical Accuracy	3.5 mm plus 0.4 ppm
RTK Horizontal Accuracy	8 mm plus 0.5 ppm

3.3 Software

Later on, different tools handled the editing and mapping tasks. First up, ArcGIS Pro took care of turning photos into precise images, pulling out features, shaping maps with elevation details, plus building clean layers for output. Then came Trimble Business Center - this one pulled GPS records from devices, adjusted positions using reference signals, while also calculating exact ground points used as anchors. Another part involved Google Earth Pro, which gave an overview of locations before work started, helped outline edges of study zones, along with showing how sectors fit inside NMRDA boundaries.

IV. METHODOLOGY

4.1 Pre-Survey Planning

From above, the layout of Khadka Village took shape through Google Earth Pro snapshots paired with official land records called 7/12 extracts. Spreading across 493.3621 hectares, the area matched boundaries defined by NMRDA's southern zone plan. Before drones flew, permission came through for air use under India's 2021 drone regulations managed by DGCA. Paths in the sky got mapped out digitally via flight software, holding flights steady at 100 meters high off ground level while overlapping images - eighty percent ahead, seventy to the sides - for strong photo links needed later on.

4.2 DGPS GCP Survey

From a fixed point, measurements spread out over the landscape using mobile gear. Through time adjustments, positions sharpened down to each centimeter's place. With those points set, drone pictures found their true spot on earth.

4.3 UAV Data Acquisition

A bird's-eye view of the entire 493.3621 Ha site began with a first pass flying east-west lanes. Following that, a second run sliced north-south to fill in gaps. Together, these overlapping sweeps covered every corner. Two distinct paths made sure nothing slipped through. The sky scans moved like meshing gears - each turn adding clarity

Running top to bottom, the yellow paths cover every part of the zone, forming the main line of shots. These north-south tracks lay down the backbone of the imaging run, stretching through without gaps.

Running east to west, green flight paths slice across north-south lanes, building a crisscross layout that hits 70% overlap from every angle. With two rounds of flying, gaps shrink while the depth detail sharpens in the final model.

North-south passes appear in yellow across Khadka Village, part of a twin-grid drone run captured in Figure 3. Green marks trace east-west paths woven through the area. Where these routes cross, red dots pinpoint DGPS ground control spots. The layout reveals how flight lines overlap at exact reference points.

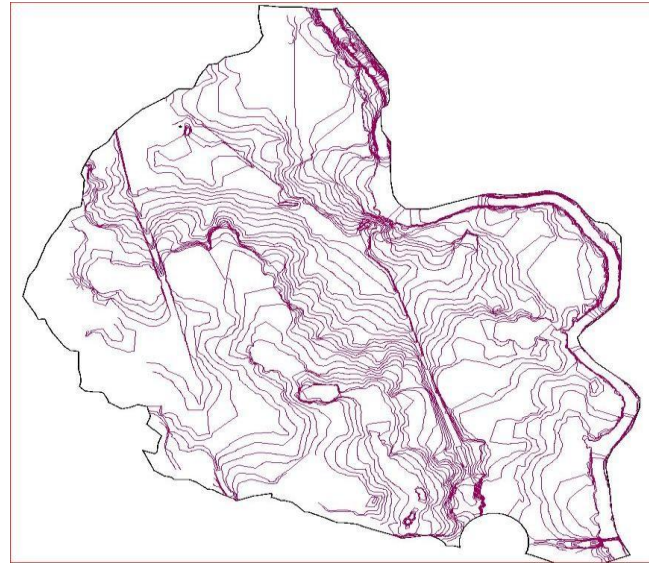


Fig. 3: A contour map appears based on UAV scans - elevation shifts twist across the landscape.

A narrow zigzag path, like mowing a lawn, helped capture fine detail in tighter zones. This approach ran one strip at a time, seen clearly in Figure 4. Ground markers tied to DGPS showed up every so often around the edge of each pass.

Figure 4 shows the CD Space drone on the ground at the survey site prior to a flight mission, demonstrating the compact, field-deployable nature of the platform.



Fig. 4: CD Space Drone at Khadka Village Survey Site

Table 3: UAV Mission Parameters

Parameter	Value
Total Survey Area	354 Ha
Flight Altitude	100 m AGL
Front Overlap	80%
Side Overlap	70%
Flight Pattern	Double Grid (N-S + E-W)
No. of Flights	Multiple sorties
GCPs Established	Well-distributed
Processing Software	ArcGIS Pro

4.4 Photogrammetric Processing and Feature Mapping

From UAV shots, visuals moved into ArcGIS through step-by-step photogrammetry work. First up, photos lined up, building a loose set of 3D points. Then came ground control points added to fix location accuracy across the model. After that, a tighter cluster of points formed, giving depth and detail. A clear map appeared next, matching the camera's original resolution on the ground. Shapes like paths, water channels, community edges, homes, power supports, plus future plots emerged by hand atop this base view. One after another, these layers took shape above the photo map. Each wore unique visual styles. Info collected outside filled their properties. Done.

V. RESULTS AND DISCUSSION

5.1 Topographic and Feature Map

A detailed aerial image of the entire 493.3621-hectare zone was built using drone data corrected by DGPS. This map lines up precisely with real-world coordinates, showing every surface detail clearly. Instead of rough estimates, it reveals fine structures on the ground down to less than ten centimetres. On top of that, digital shape layers mark key terrain elements across Khadka Village. Each segment fits together without gaps, forming one complete picture.

ArcGIS generated the full topographic layout of Khadka Village seen in Figure 6. This version includes every mapped layer laid over an Topographic base. Each element appears exactly where recorded, forming a clear visual whole. The image captures terrain details through carefully traced features. Background imagery supports precise placement of each symbol and line. What you see reflects digital tracing work done directly on aerial data.

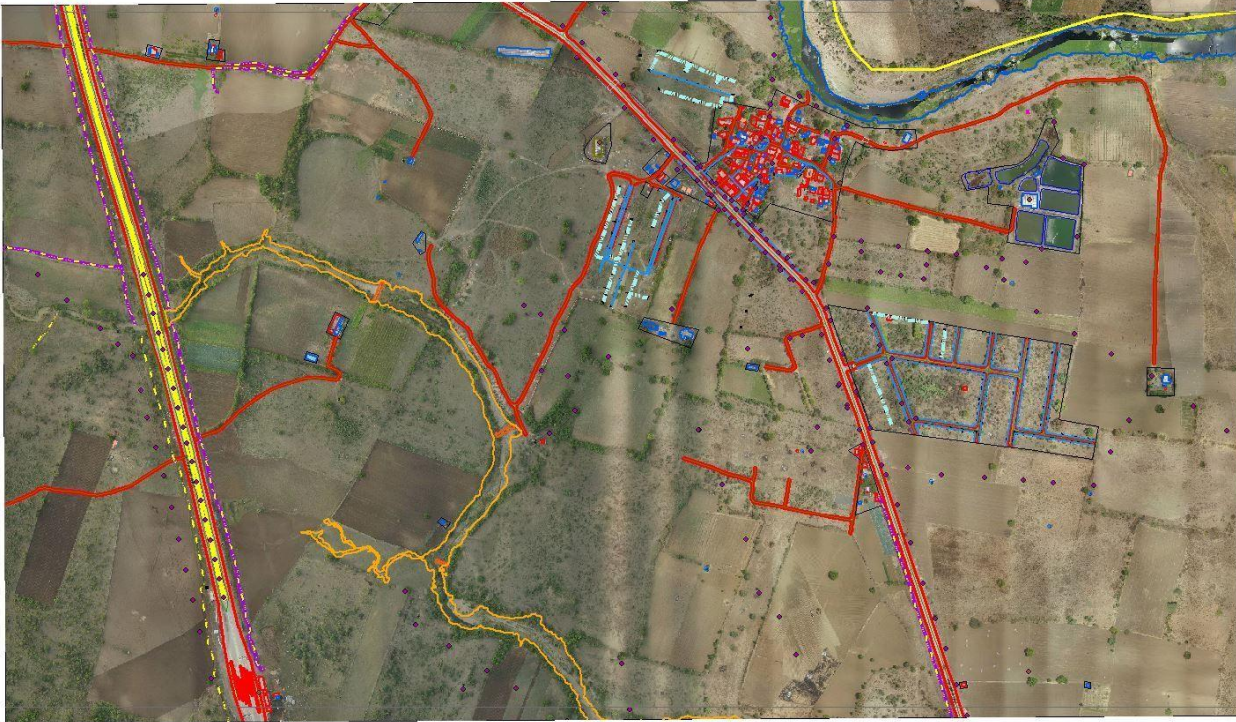


Fig. 5: Complete Topographic Feature Map of Khadka Village, Nagpur

5.2 Thematic Feature Maps

Out in the open data, separate theme-based maps came out to show one piece at a time - how things like roads or streams sit across the land. Four main pieces laid bare: paths people travel on, where homes cluster, poles carrying power lines, and how water moves through ditches and channels.

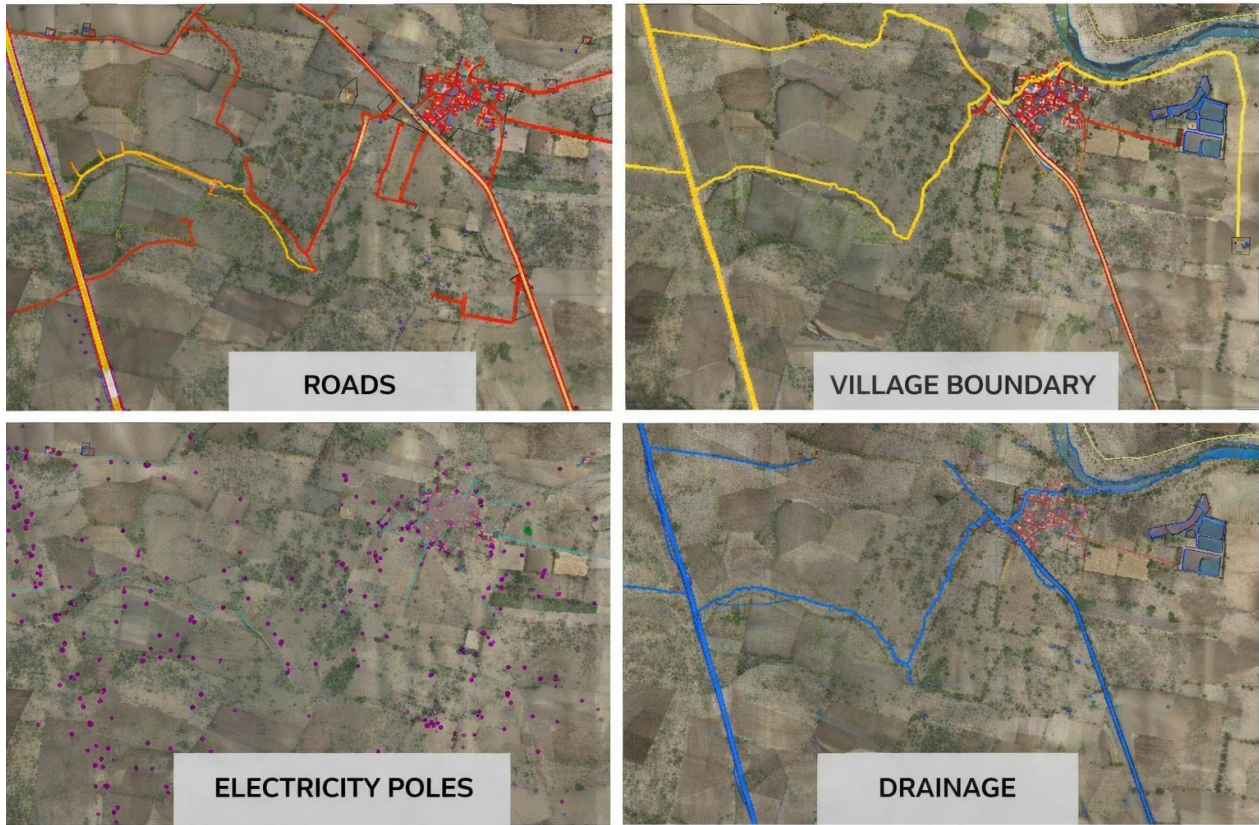


Fig. 6 : Figure 7 Thematic Feature Maps showing road network village boundary electricity poles DGPS

5.3 Map Legend and Feature Interpretation

Table 4 provides a complete interpretation of the colour-coded feature symbology used in the topographic maps, as established during the ArcGIS digitisation process.

Table 4: Feature Symbology and Interpretation

Symbol / Colour	Feature Represented	Survey Method	Application
Red Lines / Polygons	Road network (major & minor), Built-up area boundaries, Internal streets	UAV Topographical Digitisation	Transportation & urban planning
Yellow Lines	Village boundary, Outer limits, Stream embankments	UAV + DGPS Combined	Administrative & revenue mapping
Blue Lines / Polygons	Drainage lines, Nallahs, Water channels, Water bodies & ponds	UAV Topographical & Digitisation	Drainage & flood management
Purple Dots	Electric poles, Utility infrastructure points	DGPS Point Survey	Utility corridor planning
Cyan (Light Blue) Polygons	Planned layouts, Plot boundaries, Open land parcels	UAV + NMRDA Data	Land use & layout planning
Orange Lines	Nallah (seasonal stream) centrelines & catchment boundary	UAV Topographical Digitisation	Hydrological analysis

Green/Brown Background	Agricultural land, Vegetation, Open terrain (Topographical base)	UAV Photography	Aerial	Land use base layer
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5.4 Accuracy and Efficiency Assessment

To test how close the map matched real positions, separate GPS measurements were used as reference. When measuring the same 493.3621 Ha site, the drone combined with high-precision GPS showed these results versus using a traditional ground-based instrument:

Table 5: Comparison — DGPS+UAV vs. Conventional Total Station Survey

Parameter	DGPS + UAV (This Study)	Conventional Total Station
Survey Area Coverage	354 Ha (complete)	Partial (spot levels only)
Estimated Field Duration	3–4 days	20–25 days
Field Personnel	3–4 persons	8–10 persons
Point Data Density	High (continuous raster)	Sparse (discrete points)
Horizontal Accuracy	± 8–15 mm (GCPs)	± 20–30 mm
Vertical Accuracy	± 15–20 mm (GCPs)	± 30–50 mm
Output Products	Topographical + DEM + Vector layers	Spot levels + Contours only
Time Saving (approx.)	~75%	Baseline
Cost Saving (approx.)	~60%	Baseline

5.5 Key Survey Findings for Khadka Village

Out here, elevation details pulled from aerial images plus land classifications showed patterns useful for NMRDA strategy. Where shadows meet slope breaks, terrain shifts reveal where infrastructure might face limits. Instead of flat zones, rolling ground dominates - this shapes how space gets used. Drainage lines spotted on layered maps hint at water movement others miss. Rough patches stand out when color-coded overlays highlight change. From above, clusters of built areas edge into open stretches, suggesting pressure points ahead. Each contour bend tells a story about stability below

A fork of sturdy paved highways meets right in the middle of the village. Where homes group together, dirt paths branch out toward those main routes. One edge of the settlement brushes up against NH-44 - the expressway linking Nagpur and Mumbai - running along its south-west rim.

A stretch of open land slopes gently west, guiding water flow toward a main stream cutting across the middle part. This channel carries field runoff while moving north. On the far edge, another path runs close to the east border, collecting its own share of excess rainwater.

Most homes sit toward the northern middle part of the village. These include strong brick buildings alongside less durable ones. Around 15 to 18 hectares are covered by such constructions altogether.

West and southeast zones show cyan-colored planned housing areas, mapped by NMRDA across the surveyed region. These patches suggest ongoing layout design activity where new homes may go.

Out near the fields and homes, teams mapped more than 140 power poles. Using high-precision GPS tools, each pole got a clear spot on record. Work stretched across farmland edges along with settled areas. Location accuracy mattered most during data capture. Every reading came straight from digital ground surveys.

Out past the cluster of homes lies farmland stretching wide - about 22 to 25 hectares marked within the official village edge. Open fields wrap around the built-up area, leaving breathing space between plots and pathways.

VI. CONCLUSION

This work managed a full landscape mapping job across Khadka Village, Nagpur - covering 493.3621 hectares within the NMRDA South-A zone - by combining DGPS tools with drone-based image analysis. Key outcomes emerged through that blend: one clear picture took shape after data from ground units met aerial shots

Above the fields, the drone wove through its flight pattern, capturing images row after row. Trimble DGPS marked precise ground spots before any flying began. Instead of guessing positions, each point was confirmed by physical measurements on site. The drone made two passes overhead, layering one grid over another. Data from both grids combined later in processing. Each pixel in the final image aligns within less than ten centimetres of reality. Independent test markers across the land were used to confirm precision. Results held steady across the entire 354 hectares. Accuracy did not fade at edges or corners. What emerged was a seamless map built from sky and soil working together.

Out in the open fields of data, six clear layers took shape through ArcGIS: roads wound through space, village edges drew their line. Drainage paths split across the land while buildings clustered tightly. Electricity poles stood marked at intervals. Laid out plans appeared next to what already existed. For once, every piece fit together without gaps.

A third approach using DGPS paired with UAVs cut down on-site work duration by about three quarters when measured against traditional Total Station methods across identical plots. That setup also trimmed expenses close to sixty percent. Better coverage emerged alongside richer data points despite fewer days spent outdoors. Superior detail spread appeared without needing more ground visits.

Northward flow marks the two main drainage nallahs in Khadka Village. About 22 to 25 hectares hold most homes tightly grouped at the centre. Out west and toward the southeast, layout plans by NMRDA are already moving forward. More than 140 electric poles stand needing updates as part of upcoming infrastructure work.

Out in Khadka Village, the new elevation data feeds right into work on NMRDA planning. Drainage layouts rely on it just as much as routes for roads do. Instead of guessing, teams now pinpoint where check dams fit best. Even property records under SVAMITVA pull from this set. Master plans gain accuracy because details come alive through terrain shapes.

Start with better tools, like combining DGPS and UAVs - it makes mapping villages within the NMRDA zone faster, cheaper, wider in reach, and sharper in detail. This approach works well enough that it should become the go-to method. Regular ways of doing these surveys can't keep up when speed, expense, range, or precision matter. Because results are clear, shifting to this combo just makes sense for local terrain work.

VII. ACKNOWLEDGMENT

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VIII. ABBREVIATIONS

Abbreviation	Full Form
DGPS	Differential Global Positioning System
UAV	Unmanned Aerial Vehicle
GCP	Ground Control Point
GSD	Ground Sampling Distance
AGL	Above Ground Level
PPK	Post Processing Kinetics
NMRDA	Nagpur Metropolitan Regional Development Authority
TBC	Trimble Business Centre
DTM	Digital Terrain Model
DSM	Digital Surface Model
DEM	Digital Elevation Model
GNSS	Global Navigation Satellite System
GLONASS	Globalnaya Navigatsionnaya Sputnikovaya Sistema
ELU	Existing Land Use
PLU	Proposed Land Use
SFM	Structure-from-Motion
RTK	Real-Time Kinematic
ArcGIS	Geographic Information System software by Esri

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