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To create a contour map of the selected area at Satna District by using Satellite-Based Survey

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ABSTRACT

This study presents the generation of high-resolution contour maps for selected areas within Satna district, Madhya Pradesh, through the integration of satellite-based remote sensing, GPS-enabled field data collection, and Geographic Information System (GIS) technologies. Primary spatial data-comprising geodetic coordinates and elevation-were collected systematically from two target sites: Santoshi Mata Pond and Dada Sukhendra Singh Stadium. The acquired data were processed using QGIS 3.42, Surfer 15, and Google Earth Pro to develop Digital Elevation Models (DEMs) and a series of derivative topographic products including contour maps, 3D surface and wireframe models, base maps, color relief and shaded relief maps and watershed delineations. The results validate the effectiveness of integrating field-based GPS surveys with satellite and GIS technologies for the accurate modeling of terrain features. The study confirms the applicability of this geospatial approach in supporting terrain evaluation, watershed characterization, hydrological analysis, and spatial planning. The methodology is transferable to various domains such as agricultural engineering, infrastructure design, resource management, and environmental assessment.

Key Words -Remote Sensing, GIS, GPS Survey, Digital Elevation Model, Contour Mapping, QGIS.

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INTRODUCTION

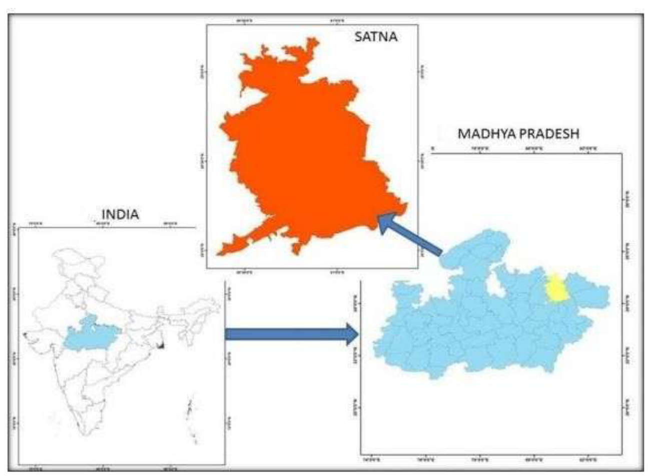
Contour maps are graphical representations of terrain elevation, providing critical insights into landforms, slopes, and drainage patterns. These maps use lines (contours) to connect points of equal elevation, helping visualize three-dimensional landscapes in two dimensions. Traditionally, contour maps were created through labor-intensive field surveys, which involved manual measurements using theodolites and leveling instruments. However, advancements in satellite remote sensing and Geographic Information Systems (GIS) have revolutionized this process, enabling faster, more accurate and cost-effective mapping. This study leverages these modern technologies to generate high-resolution contour maps for selected areas in Satna District, Madhya Pradesh. Satellite-based surveys offer significant advantages over conventional methods, particularly in accessibility and precision. Remote sensing satellites, such as those from ISRO (Indian Space Research Organization) and NASA, provide high-resolution elevation data through techniques like LiDAR (Light Detection and Ranging) and photogrammetry. These datasets can be processed using GIS software to create detailed digital elevation models (DEMs), which serve as the foundation for contour mapping. Unlike ground surveys, satellite-based methods cover large areas efficiently, reduce human error, and allow for frequent updates.

This research explores how these technologies can be applied to rural and semi-urban regions like Satna, where updated topographic data is often lacking. The primary objective of this study is to develop accurate contour maps for two key locations in Satna District-Santoshi Mata Pond and Dada Sukhendra Singh Stadium-using a combination of GPS field surveys and satellite-derived data. Specific goals include: (1) collecting precise elevation points through GPS measurements, (2) processing the data using QGIS and Surfer software, (3) generating multiple map types (e.g., contour, 3D surface, watershed), and (4) analyzing terrain features for practical applications. The study focuses on demonstrating how satellite-based methods can bridge gaps in existing topographic data, particularly in regions with limited resources for large-scale surveys. Satna District, located in the Vindhyan Plateau, features diverse topography, including plains, hills, and water bodies, making it an ideal case study for contour mapping.

The selected sites represent both natural (Santoshi Mata Pond) and man-made (Dada Sukhendra Singh Stadium) landscapes, allowing for a comparative analysis of mapping techniques. Accurate elevation data is crucial for this region due to its agricultural dependence, susceptibility to seasonal flooding, and ongoing infrastructure projects. By creating updated contour maps, this research aims to support local farmers in soil and water conservation, assist urban planners in flood mitigation, and provide a replicable model for other districts with similar geographical challenges. Beyond immediate applications, this study contributes to the growing body of research on geospatial technologies in developing regions. While much of the existing literature focuses on urban or highly developed areas, this project highlights the adaptability of satellite-based mapping in rural India. The findings will be valuable for government agencies, environmental researchers, and engineering professionals seeking reliable terrain data. Furthermore, the methodology can be scaled to other parts of Madhya Pradesh or similar regions globally, promoting sustainable land-use planning. By integrating open-source tools like QGIS with field surveys, the study also emphasizes cost-effective solutions for communities with limited access to advanced mapping resources.

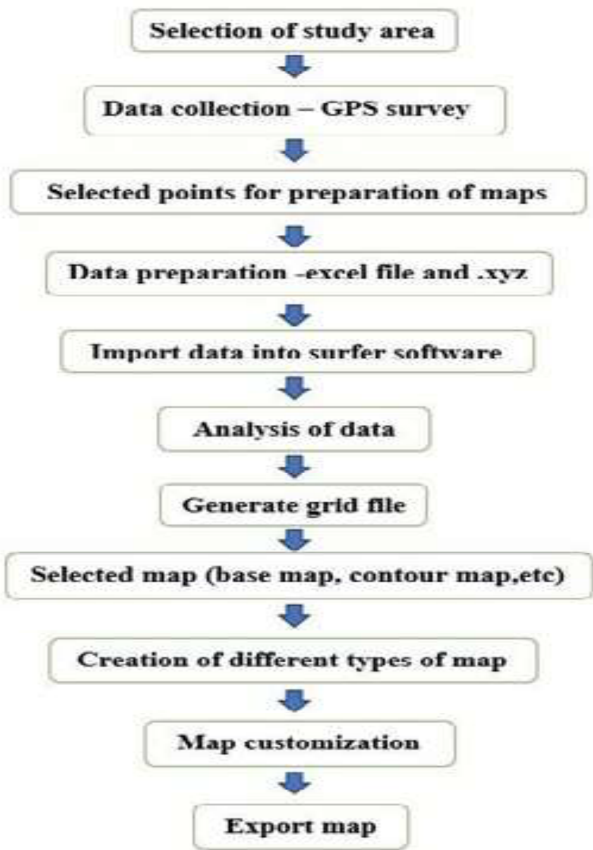
METHODOLOGY

The study focused on two distinct sites in Satna District, Madhya Pradesh: Santoshi Mata Pond (a natural water body) and Dada Sukhendra Singh Stadium (a man-made structure). These locations were chosen to represent different terrain types - one with natural elevation variations and another with engineered slopes. The selection criteria included accessibility, topographic diversity, and relevance to local agricultural and urban planning needs. Prior to fieldwork, we conducted a preliminary analysis using Google Earth imagery to identify optimal survey points and potential challenges like vegetation cover or urban obstructions. The GPS units were set to record data in WGS84 coordinate system at 10-second intervals to capture precise elevation changes. Over 150 elevation points were collected at each site, with additional measurements taken along key features like pond edges and stadium boundaries. Each data point included metadata such as time stamp, GPS accuracy estimate, and field observations about ground conditions the elevation data was imported into Golden Software Surfer 15 for advanced terrain modeling.



Study area of Satna District

We created a grid file with 1-meter resolution using kriging interpolation, which provided optimal results for our moderately dense dataset. Contour lines were generated at 0.5-meter intervals to capture subtle elevation changes. The software's smoothing algorithms were applied judiciously to maintain accuracy while improving visual clarity. Multiple test runs were conducted with different interpolation methods (including natural neighbor and polynomial regression) before selecting the most appropriate technique for each study area.

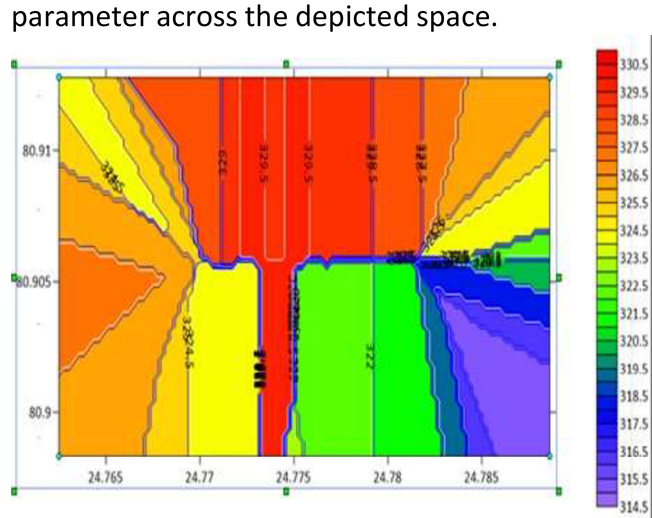


Flow chart of material methodology

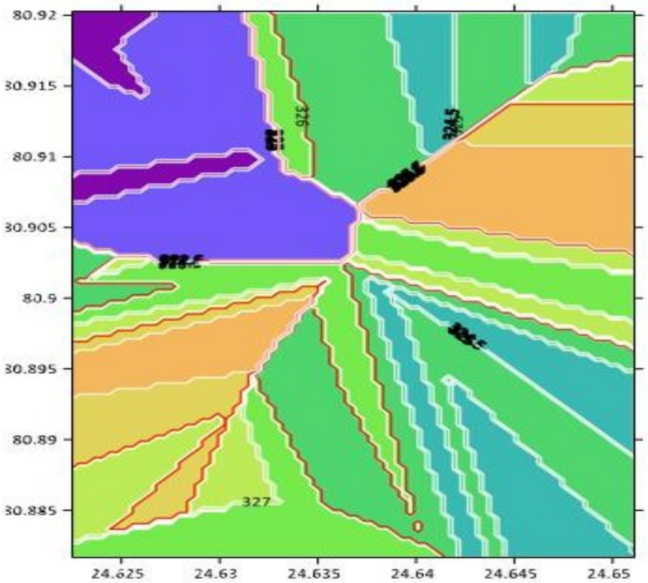
RESULT & DISCUSSION

The study successfully generated high-resolution contour maps for Santoshi Mata Pond and Dada Sukhendra Singh Stadium using satellite-derived elevation data and GPS surveys. The contour intervals were set at 1-meter increments, revealing subtle elevation changes critical for hydrological and terrain analysis. At Santoshi Mata Pond, elevations ranged from 321 to 329 meters above sea level (msl), while the stadium area varied between 314 and 330 msl. These variations were clearly visualized through contour lines, with tighter spacing indicating steeper slopes near the pond's eastern embankment and gentler gradients in the stadium's central field. Contour Map: Displays continuous lines of equal elevation; used for visualizing terrain slopes and relief. A contour map is a two-dimensional representation of three-dimensional data, using lines to connect points of equal values.

These lines, known as contour lines, visually depict the shape of a surface. Surfer uses a grid file, which is a regularly spaced array of data points, to create contour maps. The software interpolates irregularly spaced data into a grid, allowing for the generation of various map types, including contour maps, image maps, and 3D surface maps. Santoshi Mata Pond displays a contour map, characterized by distinct colored regions separated by contour lines, which represent lines of equal value for some mapped variable. The map's axes are labeled with numerical ranges, suggesting a spatial representation. The horizontal axis spans from approximately 24.625 to 24.65, and the vertical axis from 80.885 to 80.92. These coordinates likely denote a specific geographic area or a defined grid within a larger study region. The color scheme ranges from purples and blues to greens, yellows, and oranges, indicating a variation in the measured parameter across the depicted space.

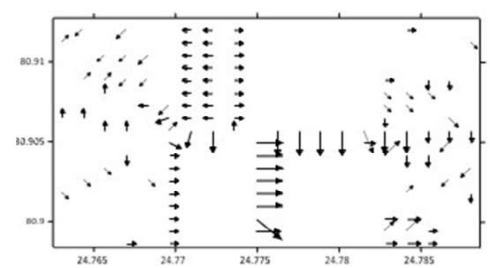


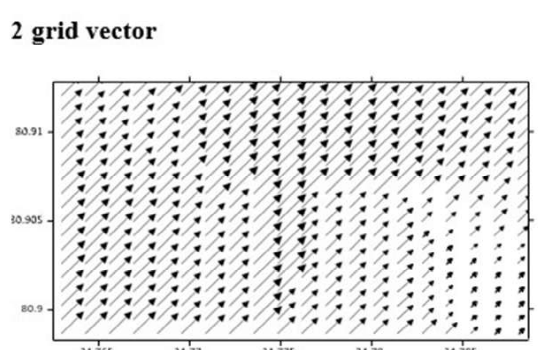
Dada Sukhendra Singh Stadium Contour Map



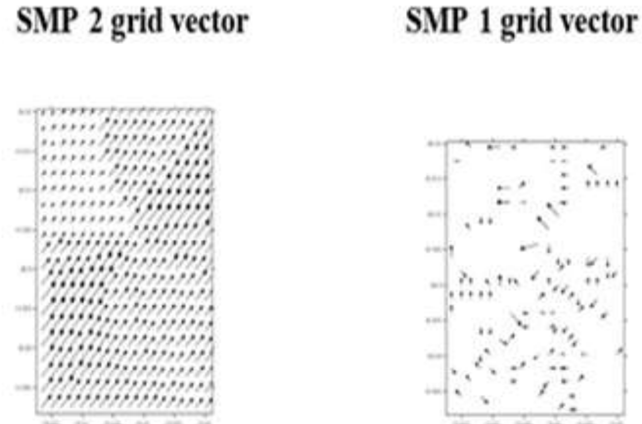
Santoshi Mata Pond Contour Map

Grid Vector Map:- Represents direction and slope flow using arrows. "Grid vector maps" are a type of map that visualizes directional and magnitude data using arrows. They come in two forms: 1-grid and 2-grid vector maps. A 1-grid vector map uses a single grid file to determine the direction and magnitude, while a 2-grid vector map uses two separate grid files (Cartesian or polar).



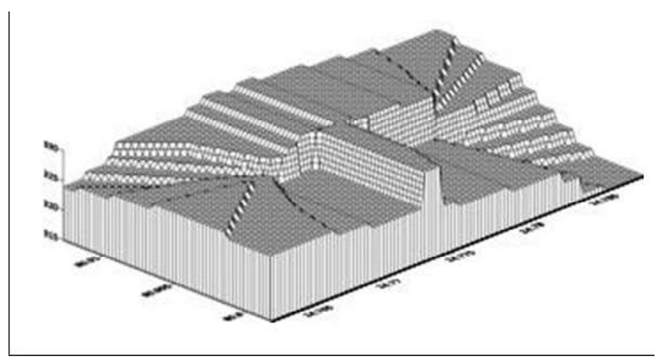


Dada Sukhendra Singh Stadium Grid Vector Map 1&2

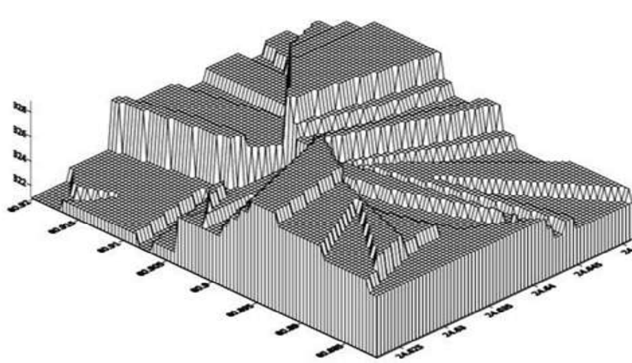


Santoshi Mata Pond Grid Vector Map 1&2

3D Wireframe Map :- A mesh-style representation of the terrain, useful for technical analysis. A 3D wireframe map is a three-dimensional representation of a grid file. It's created by connecting Z-values along lines of constant X and Y. Essentially, it's a grid where each intersection (grid node) is connected to a height based on the Z-value at that point, creating a skeletal or wireframe appearance.

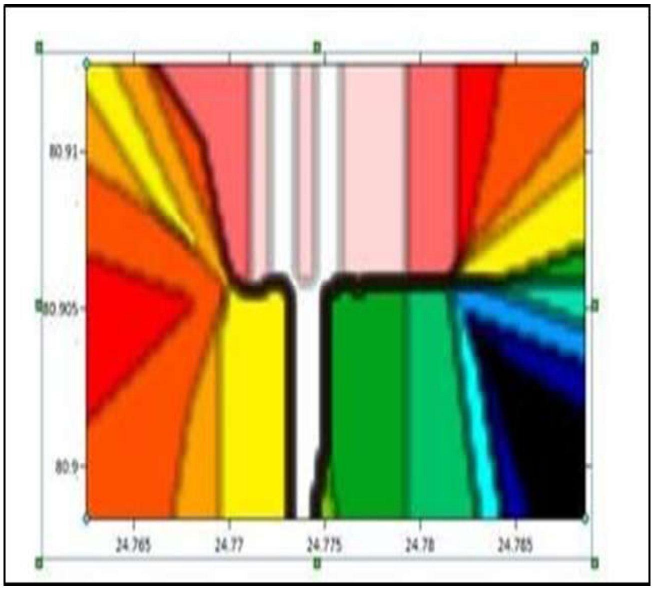


Dada Sukhendra Singh Stadium 3-D Wireframe Map

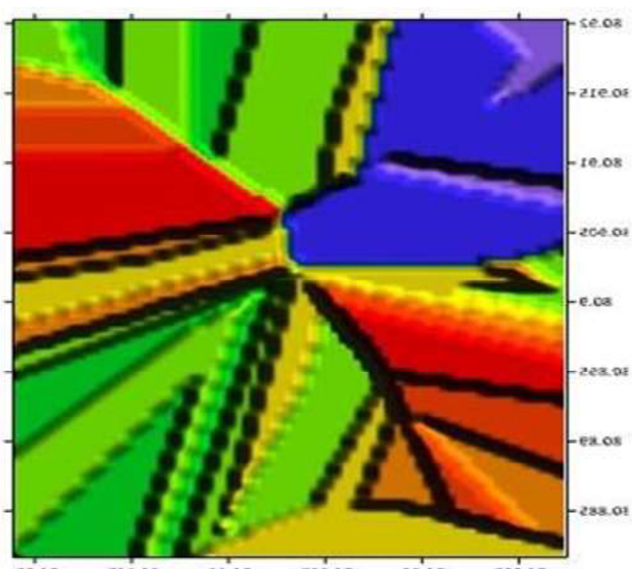


Santoshi Mata Pond 3-D Wireframe Map

Color Relief Map-Highlights elevation changes with colour gradients, enhancing visual appeal. A colour relief map is a raster image where grid values, often representing elevation, are visually represented using different colors. Each Z value in the grid is assigned a specific colour from a colour map, allowing for a continuous colour representation of the data. No data regions in the grid can be displayed with a distinct colour or transparent fill.

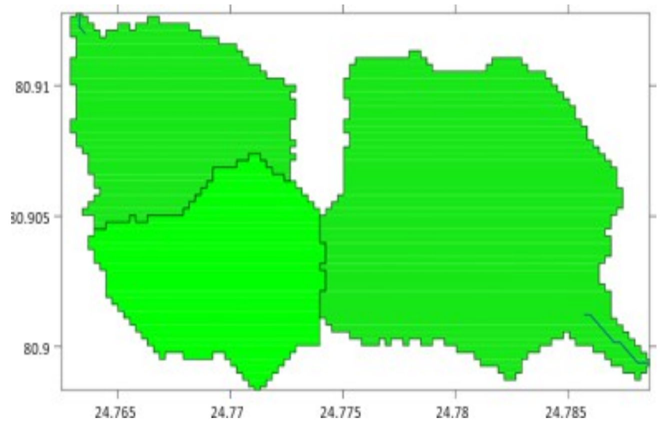


Dada Sukhendra Singh Stadium Color Relief Map

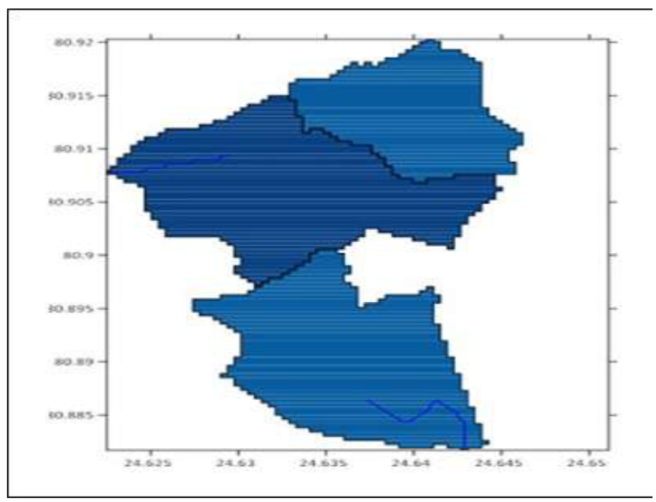


Santoshi Mata Pond Color Relief

Watershed Map:-Helps identify drainage patterns and water flow directions using elevation data. A watershed map reads the data from a grid file and splits the grid up into basin, or catchment, areas. Basin areas are areas that drain water to the stream. Stream paths are calculated based on the amount of flow into the grid node from all surrounding grid nodes. This shows the path water will take across the grid.



Dada Sukhendra Singh Stadium Watershed Map



Santoshi Mata Pond Watershed Map

FUTURE RECOMMENDATIONS

The current study has demonstrated the utility of satellite-based surveys and GIS tools in generating accurate contour maps for selected sites in Satna district. To enhance the scope and applicability of this methodology, future research should consider expanding the area of analysis to encompass larger or more topographically diverse regions across the district. This would enable a more comprehensive understanding of regional terrain dynamics and support broader applications in watershed management, infrastructure planning, and environmental monitoring. Additionally, mapping more critical sites, such as hilly terrains, flood-prone zones, and agricultural catchments, can yield valuable insights into land use planning and natural hazard mitigation.

Furthermore, the integration of advanced technologies such as Unmanned Aerial Vehicles (UAVs) or drones equipped with high-resolution cameras and LiDAR sensors could significantly improve the precision and resolution of elevation data. Drone-based photogrammetry allows for denser and more accurate data points, particularly in areas with rapid topographic variation or poor satellite visibility. Combining this with machine learning algorithms for automated feature extraction and classification could streamline the mapping process and reduce manual effort. These advancements would not only enhance data quality but also promote real-time terrain analysis, which is critical for dynamic land management and climate resilience strategies in agricultural and urban landscapes.

SUMMARY & CONCLUSIONS

This study successfully demonstrated the integration of satellite-based GPS surveys and geospatial software tools to generate detailed contour maps and topographic models for selected locations within Satna district, Madhya Pradesh. Using field-collected GPS data, processed through QGIS, Surfer 15, and Google Earth Pro, a variety of spatial outputs were produced, including Digital Elevation Models (DEMs), 3D surface maps, wireframe maps, color relief maps, shaded relief maps, and watershed delineations. These outputs effectively captured the elevation variability and geomorphological characteristics of the two study sites-Santoshi Mata Pond and Dada Sukhendra Singh Stadium-providing an accurate spatial under standing of the terrain.

The generated contour maps and associated visualizations are valuable for various applications such as land-use planning, hydrological modeling, and infrastructure development. The methodology adopted in this research proves to be efficient, cost-effective, and scalable for similar topographic studies in other regions. The findings reaffirm that modern GIS and remote sensing tools, when combined with field-based GPS data, offer a powerful solution for digital terrain analysis and decision-making in agricultural engineering, environmental assessment, and natural resource management.

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