International Journal For Research in Applied Science and Engineering Technology

# INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

**Volume:** 13 **Issue:** VII **Month of publication:** July 2025

**DOI:** https://doi.org/10.22214/ijraset.2025.73237

# A Data-Driven Approach to Comprehensive Pothole Management Using GIS for NH-848 from Trimbakeshwar to Nashik

Rohan Ahire[1], Prof. Tejas Bansode[2], Prof. Sourabh Joshi[3]
[1]P.G. Student, Government College of Engineering, Karad, Satara, Maharashtra, India
[2]Assistant Professor, Dept. of Civil Engineering, Government College of Engineering, Karad, Satara, Maharashtra, India
[3]Professor& HOD, Dept. of Civil Engineering, Government College of Engineering, Karad, Satara, Maharashtra, India

***Abstract: This India has the second-largest road network in the world; however, potholes pose a significant maintenance and safety issue, especially in areas with heavy traffic and challenging environmental conditions. The 25-kilometer stretch of NH-848 between Nashik and Trimbakeshwar in Maharashtra is particularly affected due to its steep terrain, clayey soils, intense monsoons, and high traffic, especially during pilgrimage seasons. Between 2022 and 2024, this section recorded 267 traffic incidents, primarily caused by recurrent potholes. These incidents resulted in 178 fatalities and 97 serious injuries.To evaluate and address these concerns geographically, the project titled "Application of GIS for Comprehensive Pothole Analysis - A Data-Driven Approach for NH-848 Nashik to Trimbakeshwar" utilizes GIS methodologies. Field surveys conducted with Avenza Maps allowed for easier geotagging and categorization of potholes based on severity, frequency, and size. Thematic maps, such as the Pothole Occurrence Categories and Hotspot Analysis, were created using QGIS 3.36. The study recommends using durable repair materials and treating potholes frequently as part of a data-driven intervention strategy. through encouraging continuous surveillance, optimal resource allocation, as well as predictive maintenance, this methodology offers a repeatable framework for enhancing the sustainability of infrastructure.***
***Keywords: Potholes, Road Safety, Accidents, Hotspot Analysis, GIS, QGIS, NH-848.***

## I. INTRODUCTION

This Road distresses such as cracks, potholes, and sub-grade settlements are becoming more common as a result of climate variations such as excessive rainfall and temperature fluctuations caused by global warming, which are exacerbated by the use of traditional building methods. In India, this has become a major issue, with traditional road maintenance methods unable to keep up with increased traffic density and deteriorating road conditions. According to government data, there were around 4,446 pothole-related incidents and 1,800+ fatalities in 2022 alone.

A clear example of the issue is the NH-848 segment that runs between Nashik and Trimbakeshwar. This region experienced 95 accidents in 2022, 85 in 2023, and 87 in 2024. Many of these incidents were caused by poor road conditions, including surface depressions, faded markings, and water-filled potholes. Additionally, the corridor's pavement infrastructure is further challenged by its sensitive terrain and seasonal traffic spikes during pilgrimage periods.

This study identifies pothole-prone areas along NH-848 using Geographic Information Systems (GIS). GIS is an effective tool for managing long highway corridors as it facilitates the integration of spatial data, real-time visualization, and analysis of trends over time. Field assessments indicated that the primary causes of potholes included inadequate drainage, water stagnation, unexpected utility outages, poor repair work, and terrain-related factors such as low-lying areas and steep grades. Once geotagged, potholes were classified as mild, moderate, or severe.Their geographic distribution was analyzed in both directions using QGIS.This GIS-based approach ensures that maintenance programs are targeted, data-supported, and capable of producing long-lasting improvements to road infrastructure and public safety. Similar semi-urban highway corridors can benefit from the study's approach and results, which show the ground-breaking potential of GIS in modern transportation planning and safety management.

### *A. GIS Insights*

The Geographic Information System (GIS) is a useful tool for gathering, analyzing, visualizing, and making decisions on data on roadways.

This project uses a GIS to fix potholes on Nashik City's urban road.

1) Data Collection: Conducting field surveys to identify potholes and collect GPS-based location data, photographs, and measurements.
2) Classification: Categorizing potholes based on size, severity, and type.
3) Geospatial Analysis for Repair Recommendation: The process of using geographic and spatial data analysis to determine the most suitable road repair techniques and materials.
4) Repair: Developing effective pothole management and prioritizing repairs based on impact.

This strategy uses Geographic Information System (GIS) technology to increase efficiency and lower costs while improving the overall quality of road infrastructure in both rural and urban locations. GIS has become a vital tool for infrastructure management due of its sophisticated processing and visualization capabilities. The project's primary goals are to locate, geotag, categorize, and perform a hotspot analysis of potholes on the road span. This GIS-based strategy seeks to support timely and effective maintenance plans and data-driven decision-making in Nashik's road network.

This study uses geographic analysis and field data to systematically locate potholes and classify them according to their severity. This study offers policymakers, engineers, and local governments useful information. It also promotes prompt repairs and long-term planning for road maintenance, making it a model for other municipalities dealing with comparable problems. The main emphasis is on mapping impacted areas, collecting spatial data from pothole assessments, and utilizing size-based descriptors to determine the extent of damage. Maintaining road infrastructure has become more crucial as a result of increased urbanization and vehicle traffic, particularly on vital routes like NH-848 (Nashik to Trimbakeshwar).This method entails identifying potholes, geotagging their locations, classifying their severity, conducting hotspot analyses, prioritizing repairs, and offering location-specific repair recommendations. It employs a systematic, data-driven approach to discover, assess, and manage road issues. To enhance road safety and infrastructure resilience, this strategy considers factors such as the geographical context and deterioration patterns unique to each specific route.

## II. RESEARCH GAP

Despite ongoing research, critical aspects of pothole management are often overlooked, especially on rural and semi-urban highways like NH-848. Advanced geospatial tools, including QGIS 3.36, Avenza Maps, and Google Earth Pro 7.3.6, are underused for integrated pothole detection and monitoring. This underutilization limits the generation of high-resolution, location-specific maps needed for real-time decision-making. Existing studies frequently offer broad repair suggestions that overlook site-specific factors such as Nashik's heavy rainfall, black cotton soil, low water tables, traffic patterns, and recurring waterlogging. Additionally, there is a notable lack of focus on long-term management strategies and the underlying causes of pothole formation, such as inadequate drainage. The effectiveness of proposed solutions is further reduced by periodic traffic congestion and subgrade instability. There is an urgent need for data-driven decision-making frameworks that take into account road conditions, traffic volume, and terrain when recommending particular and sustainable infrastructure upgrades. Road infrastructure may become more durable and resilient by identifying problematic regions and prioritizing repairs through intelligent spatial integration of road-related variables.

## III. OBJECTIVES

1) Identified, mapped, and classified potholes on NH-848 (Nashik-Trimbakeshwar) using GPS and geospatial analysis in QGIS.
2) Utilize Avenza Maps, Google Earth Pro 7.3.6, and QGIS 3.36 to analyze and evaluate pothole occurrences and hotspots along NH-848. Identify critical high-priority zones.
3) Use GIS analysis to suggest suitable repair techniques based on severity, waterlogging, and site-specific conditions.

## IV. METHODOLOGY

Effective road monitoring is essential for facilitating timely repairs and enhancing safety. This study utilizes integrated analytical methods to analyze the frequency and spatial distribution of potholes in Nashik. High-risk areas are identified through spatial overlay techniques, including hotspot analysis and pothole mapping. The results are presented as themed maps that highlight pothole size, frequency, and severity. The methodology used in this investigation is discussed in the following section.

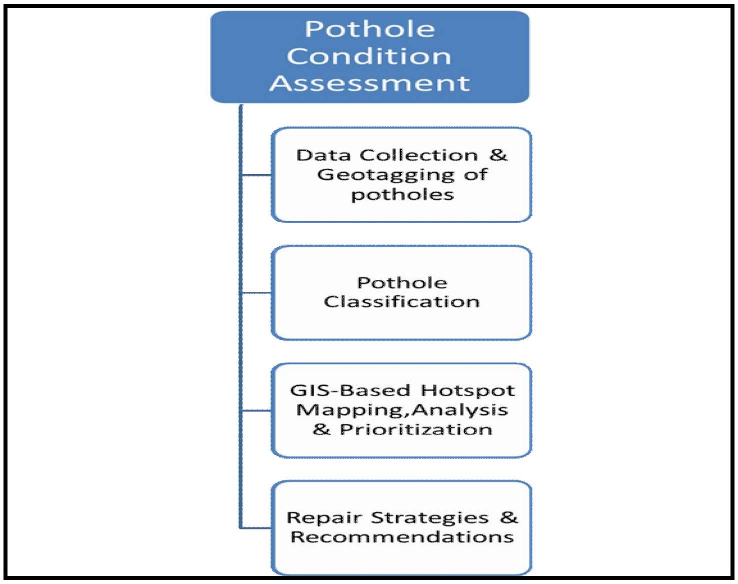



Chart. 1 Methodology Flowchart

*A. Study Area NH-848 Nashik to Trimbakeshwar*


Fig. 1 Study Area

The study area is located in Maharashtra, western India, along National Highway 848 (NH-848), which stretches from Nashik to Trimbakeshwar. This corridor is situated in the Nashik district, known for its diverse topography, religious significance, and rapidly developing urban infrastructure. The route traverses various urban areas, peri-urban towns, agricultural fields, and steep terrains, making it important for socioeconomic and geospatial research. The Godavari River originates at Trimbakeshwar, a renowned pilgrimage site nestled in the foothills of the Brahmagiri range. To help international visitors better understand the study region within India's natural and cultural landscapes, the following maps provide both a district-level perspective and a broader national context.


Fig -2: Case Study

For the case study, a 22.7 kilometer road from Nashik to Trimbakeshwar via Gangapur Road via NH 848 was chosen.

*B. Pothole Data Collection and Classification*

To investigate street and road issues and their geographic extent, extensive data collection is required. The main goal of this project is to identify and map large potholes, which serve as significant indicators of road surface degradation. Data was collected along the Gangapur Road segment of National Highway 848 (NH 848), which runs through both semi-urban and urban areas between Nashik and Trimbakeshwar. This route was selected due to its heavy traffic and documented road deterioration. According to IRC:82-2015, potholes on bituminous road surfaces are classified into three sizes: small, medium, and large. This classification is based on the size of the pothole and its impact on safety and traffic flow. It helps prioritize repairs and maintenance efforts related to road safety.

- A small pothole is defined as 25 mm deep and up to 200 mm wide.
- The medium pothole is defined as 25 to 50 mm deep and 201-500 mm wide.
- The large potholes are those greater than 50 mm deep and above 500 mm width.

TABLE I
FIELD POTHOLES SCALE CHARACTERISTIC

| POTHOLE CATEGORIES | DESCRIPTION |
|---|---|
| Small | Pothole That Have No Effect On Traffic |
| Medium | Pothole That Have Significant Impact On Traffic |
| Large | Pothole That Have Significant Impact On Traffic |

To investigate street and road issues and their geographic extent, extensive data collection is essential. This study primarily focuses on identifying and mapping large potholes as indicators of road surface degradation. Data was collected along the Gangapur Road stretch of NH-848, passing through semi-urban and urban zones between Nashik and Trimbakeshwar, selected due to high traffic volume and visible damage. As per IRC:82-2015, potholes on bituminous roads are classified as small, medium, or large based on size and their impact on traffic and safety, helping prioritize road maintenance strategies. A detailed field survey in both directions of NH-848 led to a pothole dataset capturing size, coordinates, and classification—crucial for GIS-based road condition analysis.

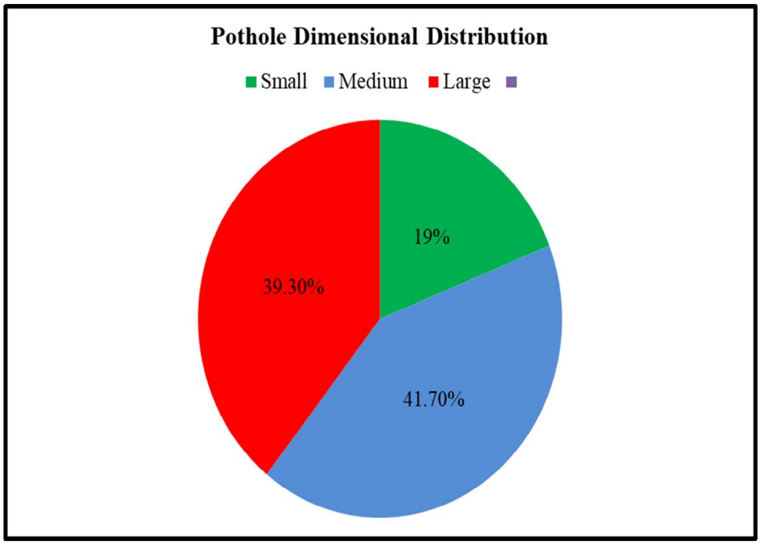



Chart -2 : Distribution of Pothole Dimensions

A thorough analysis of pothole size along the NH-848 route from Nashik to Trimbakeshwar is shown in the pie diagram. Significant pavement deterioration is indicated by the fact that over 80% of potholes are medium-sized (41.7%) or large (39.3%). Road safety is put at risk by such high concentrations of medium and large potholes because they raise the possibility of accidents, vehicle damage, and loss of control. Large potholes can result in unexpected shocks, tire blowouts, or suspension damage, creating dangerous driving conditions. Medium potholes force cars to brake or swerve, increasing collision risks.Only 19% of potholes are categorized as small, suggesting that minor damage is either rare or quickly worsens due to traffic and poor repairs. Medium and large potholes reflect long-term surface deterioration and deferred maintenance. This situation highlights the need for proactive programs that prioritize early detection and timely repair of small potholes. These findings emphasize the importance of data-driven repair priorities to enhance safety and extend pavement life on this key transit route.

*C. Pothole Identification and Data Collection Through Visual Evidence*

Site Detail-: Nashik to Trimbakeshwar Road Via NH 848


Fig -3 : Site visit Image

As we start our site tour, I'm standing next to NH 848. I'm evaluating the state of the road and the area around it. As seen in this picture, this is the start of our site survey, which aims to identify and record the state of the roads along NH 848, which connects Nashik and Trimbakeshwar.

*ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538*
*Volume 13 Issue VII July 2025- Available at www.ijraset.com*

*1) On-Site Potholes Images*


Fig -4 :Medium_Dudgaon


Fig -5 : Medium_Pegalwadi


Fig -10: Large_Anjaneri


Fig -11: Large_Nashik

This image shows a medium to large pothole accompanied by extensive surface cracks on NH 848 near Nashik city. The surrounding asphalt exhibits advanced signs of aging and erosion, indicating poor surface integrity. This picture captures a deep pit in National Highway 848 near Nashik with wide cracks on the bituminous layer. The immediate asphalt appears severely weathered and deteriorated. In such a layman description, the surface durability is badly compromised, and the pothole is likely to expand further if not addressed in time.


Fig -6: Cluster of Potholes


Fig -6: Cluster of Potholes


Fig -6: Cluster of Potholes

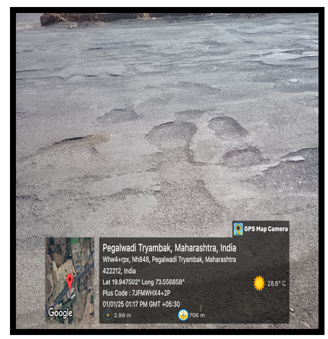



Fig -6: Cluster of Potholes

In this section of NH 848, multiple potholes form a cluster on an extensively degraded road surface. The interconnected potholes create uneven terrain, significantly disrupting traffic flow. Such clustering indicates persistent surface failure and lack of timely maintenance, posing serious safety risks to vehicles and increasing the chances of accidents.

Fig -8: Recurring_Anjaneri


Fig -8: Recurring_Anjaneri


Fig -12: Recurring_Khambale


Fig -12: Recurring_Khambale

It seems that due to persistent issues like waterlogging, unstable soil conditions, heavy traffic loads, and the use of subpar construction materials, several potholes on NH-848 have reappeared despite previous repair efforts. The situation has only worsened over time, largely due to ineffective and temporary repair methods that fail to address the root causes. This recurring damage not only disrupts road safety and mobility but also leads to increased maintenance costs and public inconvenience. The scenario underscores an urgent need for durable, location-specific, and scientifically backed repair strategies to ensure long-term stability and resilience of the highway infrastructure.


Fig -14: Large_Khambale


Fig -15: Large_Anjaneri


Fig -16: Large_Khambale

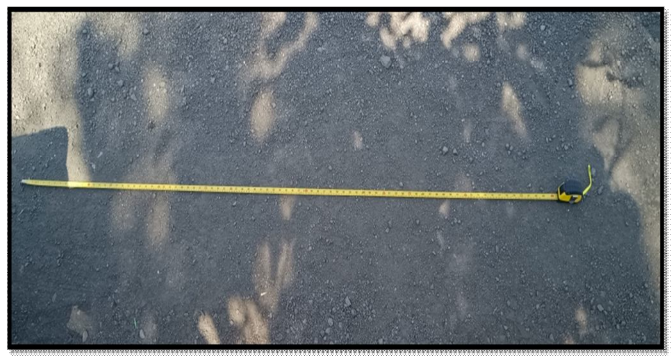


Fig -17: Large Pothole Measurement With Tape

The image shows a large pothole on NH-848 close to Trimbakeshwar. Its deep, crumbling edges present a serious risk to vehicles, especially two-wheelers. Its placement in a high-speed area promotes sudden lane changes, which raises the risk of collisions and skidding. The damage is made worse by heavy traffic, weather, and inadequate drainage, highlighting the urgent need for improved highway maintenance and repair. This location experiences frequent waterlogging during the monsoon, accelerating pavement deterioration and making the pothole more hazardous. Continuous vehicular pressure from buses and heavy trucks further weakens the surrounding surface, causing the damage to expand rapidly. Without immediate, durable, and location-specific intervention, the risk to daily commuters will only continue to grow.


Fig -18: Pothole Measurement Safety

During a site survey along NH-848 from Nashik to Trimbakeshwar, significant pothole issues that jeopardize road safety and travel efficiency were identified. The primary causes of these problems, which lead to more frequent accidents, vehicle damage, and longer travel times, include heavy traffic, inadequate drainage, and delayed repairs.

While larger potholes require long-term solutions such as improved drainage systems, high-quality resurfacing, and ongoing maintenance, minor potholes can be addressed more easily. Field observations of pothole depth and diameter were combined with GIS techniques for geographical mapping. One particularly large pothole near Trimbakeshwar, characterized by deep, crumbling edges and exacerbated by waterlogging and heavy traffic, poses a serious risk to vehicles, especially two-wheelers. This pothole prompts rapid lane changes by drivers, increasing the likelihood of collisions and skidding. To prevent further deterioration, rising accident rates, and increased costs, immediate repairs and drainage upgrades are necessary.

TABLE III
POTHOLE DATASET – NASHIK TO TRIMBAKESHWAR

| Pothole | Coordinates | Length (mm) | Width (mm) | Depth (mm) | Classification |
|---|---|---|---|---|---|
| Pothole-1 | Lat-19.97796647 Long-73.69657505 | 400 | 320 | 30 | Medium |
| Pothole-2 | Lat-19.96756998 73.66645498 | 450 | 1100 | 40 | Large |
| Pothole-3 | Lat-19.96635526 Long-73.66191211 | 380 | 250 | 50 | Medium |
| Pothole-4 | Lat-19.96587833 Long-73.65991167 | 600 | 500 | 45 | Medium |
| Pothole-5 | Lat-19.96573667 Long-73.65882167 | 250 | 290 | 60 | Large |
| Pothole-6 | Lat-19.96535167 Long-73.65345833 | 510 | 340 | 65 | Large |
| Pothole-7 | Lat-19.96521167 Long-73.65197833 | 600 | 650 | 70 | Large |
| Pothole-8 | Lat-19.96363667 Long-73.64680333 | 1500 | 300 | 31 | Medium |
| Pothole-9 | Lat-19.96038 Long-73.64161167 | 900 | 300 | 22 | Medium |
| Pothole-10 | Lat-19.959755 Long-73.63726333 | 290 | 320 | 20 | Small |
| Pothole-11 | Lat-19.95968598 Long-73.63508873 | 270 | 300 | 48 | Medium |
| Pothole-12 | Lat-19.95972 Long-73.63487167 | 600 | 380 | 30 | Medium |
| Pothole-13 | Lat-19.95492833 Long-73.59649333 | 700 | 200 | 24 | Small |
| Pothole-14 | Lat-19.95493524 Long-73.59652331 | 1350 | 260 | 20 | Small |
| Pothole-15 | Lat-19.95485833 Long-73.59571833 | 650 | 400 | 60 | Large |
| Pothole-16 | Lat-19.95197304 Long-73.57508309 | 1100 | 300 | 20 | Medium |
| Pothole-17 | Lat-19.951945 Long-73.57500667 | 300 | 170 | 24 | Small |
| Pothole-18 | Lat-19.95118 Long-73.56607833 | 390 | 350 | 21 | Medium |
| Pothole-19 | Lat-19.94730833 Long-73.55696667 | 900 | 700 | 30 | Large |
| Pothole-20 | Lat-19.94597333 Long-73.554785 | 90 | 130 | 120 | Large |
| Pothole-21 | Lat-19.94572667 Long-73.55437833 | 270 | 150 | 12 | Small |
| Pothole-22 | Lat-19.945185 Long-73.55346833 | 510 | 440 | 48 | Medium |
| Pothole-23 | Lat-19.9473003 Long-73.55690384 | 450 | 320 | 30 | Medium |
| Pothole-24 | Lat-19.94571958 Long-73.55430927 | 240 | 200 | 15 | Small |
| Pothole-25 | Lat-19.94580613 Long-73.55449435 | 440 | 430 | 35 | Medium |
| Pothole-26 | Lat-19.94579505 Long-73.55447966 | 360 | 380 | 22 | Small |
| Pothole-27 | Lat-19.94579959 Long-73.55445572 | 540 | 480 | 35 | Medium |
| Pothole-28 | Lat-19.9458 Long-73.55449086 | 430 | 470 | 45 | Medium |
| Pothole-29 | Lat-19.94579669 Long-73.5544731 | 600 | 350 | 35 | Medium |
| Pothole-30 | Lat-19.94580742 Long-73.55450813 | 400 | 320 | 35 | Medium |
| Pothole-31 | Lat-19.94581316 Long-73.55450148 | 400 | 320 | 23 | Small |
| Pothole-32 | Lat-19.94579437 Long-73.554446 | 450 | 320 | 50 | Medium |
| Pothole-33 | Lat-19.94582052 Long-73.554538 | 420 | 340 | 35 | Medium |
| Pothole-34 | Lat-19.94579367 Long-73.55446553 | 900 | 310 | 20 | Small |
| Pothole-35 | Lat-19.9662397 Long-73.66155113 | 350 | 150 | 38 | Medium |
| Pothole-36 | Lat-19.95325 Long-73.584834 | 800 | 350 | 80 | Large |
| Pothole-37 | Lat-19.96025477 Long-73.64108013 | 900 | 160 | 60 | Large |
| Pothole-38 | Lat-19.95520369 Long-73.59877666 | | | 50-80 | Medium-Large |
| Pothole-39 | Lat-19.95520367 Long-73.59879304 | 300 | 250 | 35 | Medium |
| Pothole-40 | Lat-19.95520562 Long-73.59881122 | 340 | 540 | 51 | Large |
| Pothole-41 | Lat-19.955204 Long-73.598772 | 600 | 350 | 52 | Large |
| Pothole-42 | Lat-19.955208 Long-73.598763 | 500 | 220 | 53 | Large |
| Pothole-43 | Lat-19.955159 Long-73.598618 | 520 | 600 | 58 | Large |
| Pothole-44 | Lat-19.9534 Long-73.585681 | 1000 | 550 | 90 | Large |
| Pothole-45 | Lat-19.953415 Long-73.585735 | 1800 | 650 | 60 | Large |
| Pothole-46 | Lat-19.95333565 Long-73.58531304 | 350 | 550 | 100 | Large |
| Pothole-47 | Lat-19.96538422 Long-73.65311555 | 430 | 570 | 53 | Large |
| Pothole-48 | Lat-19.96573173 Long-73.65820919 | 420 | 520 | 72 | Large |
| Pothole-49 | Lat-19.96536659 Long-73.65294045 | 700 | 340 | 85 | Large |
| Pothole-50 | Lat-19.96603088 Long-73.65984527 | 550 | 500 | 74 | Large |

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue VII July 2025- Available at www.ijraset.com

TABLE IIIII

POTHOLE DATASET –TRIMBAKESHWAR TO NASHIK

| Pothole | Coordinates | Length (mm) | Width (mm) | Depth (mm) | Classification |
|---|---|---|---|---|---|
| Pothole - 1 | Lat-19.94706 Long-.556155 | 500 | 300 | 20 | Small |
| Pothole - 2 | Lat-19.95225667 Long-73.575875 | 570 | 320 | 41 | Medium |
| Pothole - 3 | Lat-19.95811 Long-73.6219566 | 1200 | 800 | 94 | Large |
| Pothole - 4 | Lat-19.95983333 Long-73.6358083 | 350 | 400 | 70 | Large |
| Pothole - 5 | Lat-19.96603656 Long-73.65977854 | 560 | 600 | 55 | Large |
| Pothole - 6 | Lat-19.96598756 Long-73.65994998 | 450 | 350 | 32 | Medium |
| Pothole - 7 | Lat-19.965976 Long-73.659831 | 430 | 540 | 45 | Medium |
| Pothole - 8 | Lat-19.965976 Long-73.659831 | 445 | 610 | 54 | Large |
| Pothole - 9 | Lat-19.966009 Long-73.659591 | 280 | 270 | 24 | Small |
| Pothole -10 | Lat-19.966009 Long-73.659591 | 380 | 410 | 40 | Medium |
| Pothole -11 | Lat-19.966009 Long-73.659591 | 470 | 450 | 43 | Medium |
| Pothole -12 | Lat-19.96613833 Long-73.660775 | 600 | 550 | 65 | Large |
| Pothole -13 | Lat-19.94670824 Long-73.55554596 | 250 | 150 | 13 | Small |
| Pothole -14 | Lat-19.946721 Long-73.55556111 | 300 | 200 | 20 | Small |
| Pothole -15 | Lat-19.94671187 Long-73.55558563 | 580 | 320 | 24 | Medium |
| Pothole -16 | Lat-19.94673134 Long-73.55560488 | 110 | 120 | 100 | Medium |
| Pothole -17 | Lat-19.94645108 Long-73.55507195 | 550 | 350 | 27 | Medium |
| Pothole -18 | Lat-19.9465316 Long-73.55515876 | 1300 | 200 | 28 | Medium |
| Pothole -19 | Lat-19.94668272 Long-73.55549339 | 900 | 300 | 23 | Small |
| Pothole -20 | Lat-19.9466564 Long-73.55547287 | 1800 | 400 | 28 | Large |
| Pothole -21 | Lat-19.94691387 Long-73.55596352 | 2500 | 500 | 23 | Medium |
| Pothole –22 | Lat-19.94696866 Long-73.55605709 | 900 | 340 | 27 | Medium |
| Pothole -23 | Lat-19.94705896 Long-73.55616696 | 400 | 200 | 24 | Small |
| Pothole -24 | Lat-19.95220154 Long-73.57544373 | 1300 | 600 | 40 | Large |
| Pothole -25 | Lat-19.95216341 Long-73.57527106 | 1350 | 400 | 40 | Medium |
| Pothole -26 | Lat-19.95220691 Long-73.57549478 | 900 | 520 | 30 | Medium |
| Pothole -27 | Lat-19.95217697 Long-73.57534553 | 600 | 400 | 35 | Medium |
| Pothole -28 | Lat-19.95226406 Long-73.57583141 | 900 | 600 | 36 | Large |
| Pothole -29 | Lat-19.95226533 Long-73.57589848 | 200 | 500 | 20 | Small |
| Pothole -30 | Lat-19.95225648 Long-73.57581905 | 500 | 800 | 30 | Large |
| Pothole -31 | Lat-19.95224613 Long-73.57579247 | 900 | 600 | 34 | Large |
| Pothole -32 | Lat-19.958001 Long-73.622298 | 1300 | 500 | 52 | Large |
| Pothole -33 | Lat-19.981745 Long-73.713264 | 1300 | 320 | 51 | Large |
| Pothole -34 | Lat-19.965844 Long-73.65805 | 330 | 490 | 54 | Large |

TABLE IVV

POTHOLES CLUSTER DETAILS

| Potholes Cluster | Span Length (metre) | Start (Lat, Long) | End (Lat, Long) |
|---|---|---|---|
| Cluster 1 N-T | 45-50 | Lat- 73.70000 Long-19.97847 | Lat- 73.69954 Long-19.97838 |
| Cluster 2 N-T | 5-10 | Lat-73.65994 Long-19.96588 | Lat-73.65987 Long-19.96588 |
| Cluster 3 N-T | 25-30 | Lat-73.56865 Long-19.95194 | Lat- 73.56838 Long-19.95188 |
| Cluster 4 N-T | 10-15 | Lat-73.56530 Long-19.95096 | Lat- 73.56518 Long-19.95091 |
| Cluster 5 N-T | 15-20 | Lat-73.56395 Long-19.95045 | Lat- 73.56380 Long-19.95038 |
| Cluster 6 N-T | 15-20 | Lat-73.55995 Long-19.94872 | Lat- 73.55978 Long-19.94865 |
| Cluster 7 N-T | 85-90 | Lat-73.55848 Long-19.94808 | Lat- 73.55772 Long-19.94776 |
| Cluster 8 N-T | 80-85 | Lat- 73.55424 Long-19.94565 | Lat-73.55492 Long-19.94610 |
| Cluster 9 N-T | 110-115 | Lat-73.66664 Long-19.96775 | Lat- 73.66570 Long-19.96723 |
| Cluster 10 N-T | 40-45 | Lat-73.66107 Long-19.96606 | Lat- 73.66065 Long-19.96598 |
| Cluster 11 N-T | 5-10 | Lat-73.63533 Long-19.95970 | Lat- 73.63526 Long-19.95971 |
| Cluster 12 N-T | 40-45 | Lat-73.56640 Long-19.95132 | Lat- 73.56603 Long-19.95119 |
| Cluster 13 N-T | 100-105 | Lat-73.55713 Long-19.94746 | Lat- 73.55631 Long-19.94696 |
| Cluster 14 T-N | 10-15 | Lat- 73.55505 Long-19.94629 | Lat-73.55516 Long-19.94637 |
| Cluster 16 T-N | 25-30 | Lat- 73.55824 Long-19.94809 | Lat-73.55850 Long-19.94820 |
| Cluster 17 T-N | 75-80 | Lat- 73.57524 Long-19.95212 | Lat-73.57600 Long-19.95222 |
| Cluster 18 T-N | 65-70 | Lat- 73.64670 Long-19.96371 | Lat-73.64723 Long-19.96403 |
| Cluster 19 T-N | 70-75 | Lat-73.65938 Long-19.96590 | Lat-73.66008 Long-19.96599 |
| Cluster 20 T-N | 20-25 | Lat- 73.69047 Long- 19.97546 | Lat-73.69067 Long- 19.97553 |
| Cluster 21 T-N | 330-340 | Lat- 73.55543 Long-19.94651 | Lat-73.55817 Long-19.94805 |
| Cluster 22 T-N | 100-110 | Lat- 73.56906 Long-19.95207 | Lat-73.57006 Long-19.95203 |
| Cluster 23 T-N | 230-240 | Lat-73.64722 Long-19.96403 | Lat-73.64931 Long-19.96488 |
| Cluster 24 N-T | 130-140 | Lat-73.65757 Long-19.96567 | Lat-73.65626 Long-19.96560 |
| Cluster 25 T-N | 140-150 | Lat-73.65676 Long-19.96572 | Lat-73.65813 Long-19.96580 |
| Cluster 26 T-N | 30-35 | Lat- 73.65556 Long-19.96566 | Lat-73.65588 Long-19.96567 |

Comprehensive pothole data collected along both directions of the NH-848 corridor is presented in the tables above. Each entry includes geographic coordinates, dimensions (length, width, and depth), and a severity level. Table 34 compiles the clustered pothole zones identified through spatial analysis, highlighting areas that require immediate attention. These clusters indicate locations where maintenance failures are prevalent and structural integrity is significantly compromised. This data-driven approach not only prioritizes high-risk areas but also enables the development of tailored repair plans and effective budget allocation, ensuring long-term pavement durability.

### D. Geo-Tagging of Potholes

This project developed a cost-effective geospatial technique using Avenza Maps for geotagging during field surveys and QGIS for mapping and spatial analysis. This approach enabled accurate tracking of pothole locations and the creation of a comprehensive map displaying pothole distribution along the NH-848 corridor. By combining mobile mapping tools with GIS, we developed a reliable and scalable solution for pothole detection, allowing for prompt assessment and scheduling of maintenance.This approach eliminated the need for human data entry, reduced errors, and improved data synchronization between field and office activities. It also enabled real-time viewing of potholes and allowed for their classification based on severity, which facilitated data-driven decision-making regarding repair priorities. The geotagging in the image below illustrates how this method can be replicated in other locations facing similar infrastructure challenges.

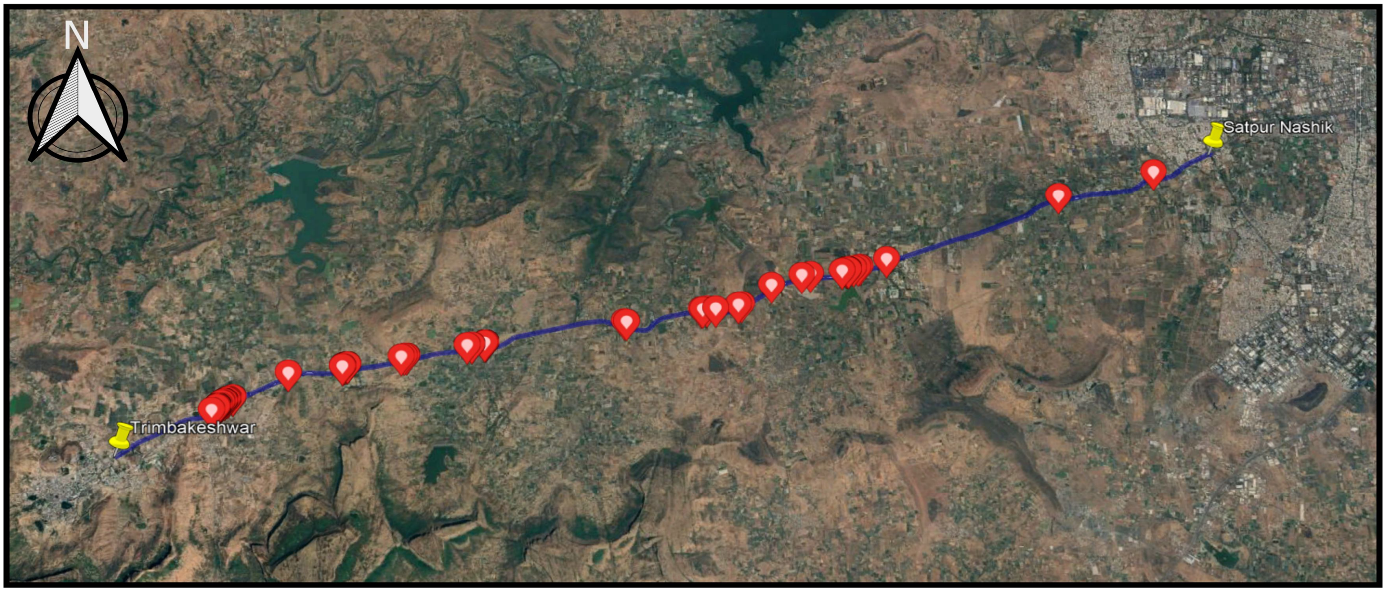



Fig -19 : Geo-Tagged Potholes

### E. Pothole Hotspot Mapping and Prioritization

In order to find both individual pothole occurrences and spatial clusters along NH-848 from Nashik to Trimbakeshwar, a GIS-based hotspot analysis was carried out using QGIS and additional spatial analysis tools. The study offers a comprehensive picture of the distribution and density of potholes along the route based on data from field surveys. To gain a better understanding of the factors that contribute to road surface deterioration, the investigation considered contour height, nearby water bodies, and other relevant geographical parameters in addition to pothole locations. Based on their measured dimensions, the potholes that were recorded were categorized as small, medium, and huge. It was discovered that the proportions of small, medium, and large potholes were 19.05%, 41.67%, and 39.29%, respectively. Although small potholes were the most frequent, the presence of medium and large potholes indicates substantial risk to road users and infrastructure.

To enhance spatial comprehension, the analysis made use of contour elevation data. Finding low-lying areas and depressions along the route where water tends to collect, especially during the monsoon season, is made simple by elevation mapping. These areas are especially vulnerable to pavement deterioration, which frequently leads to the development of potholes, due to the extended water stagnation and poor drainage. It became evident that a significant portion of potholes were located in low-elevation areas when contour layers were applied to the pothole sites. This study emphasizes how crucial topography is to comprehending the underlying factors that lead to surface degradation and how crucial it is to include elevation data in effective and proactive management initiatives.

#### 1) Pothole Occurance Category

The map illustrates the location and severity of potholes along the NH-848 corridor from Nashik (NSK) to Trimbakeshwar (TBK). It is presented on a contour map to reflect topographical variations. Based on observations from field surveys, potholes are classified into three categories: small (green), medium (yellow), and large (red). Dark clusters indicate areas where potholes are frequently found. Additionally, the contour and waterbody layers highlight the relationship between elevation, water accumulation, and pothole formation, helping to identify regions with drainage issues. This visualization highlights key areas that need repair, allowing for targeted maintenance efforts. The map helps identify the frequency of potholes based on topographical features and natural drainage processes that contribute to their formation. Ground-based field surveys and geospatial studies play a crucial role in planning preventative road maintenance. This approach assists in establishing repair priorities for high-risk corridor segments.

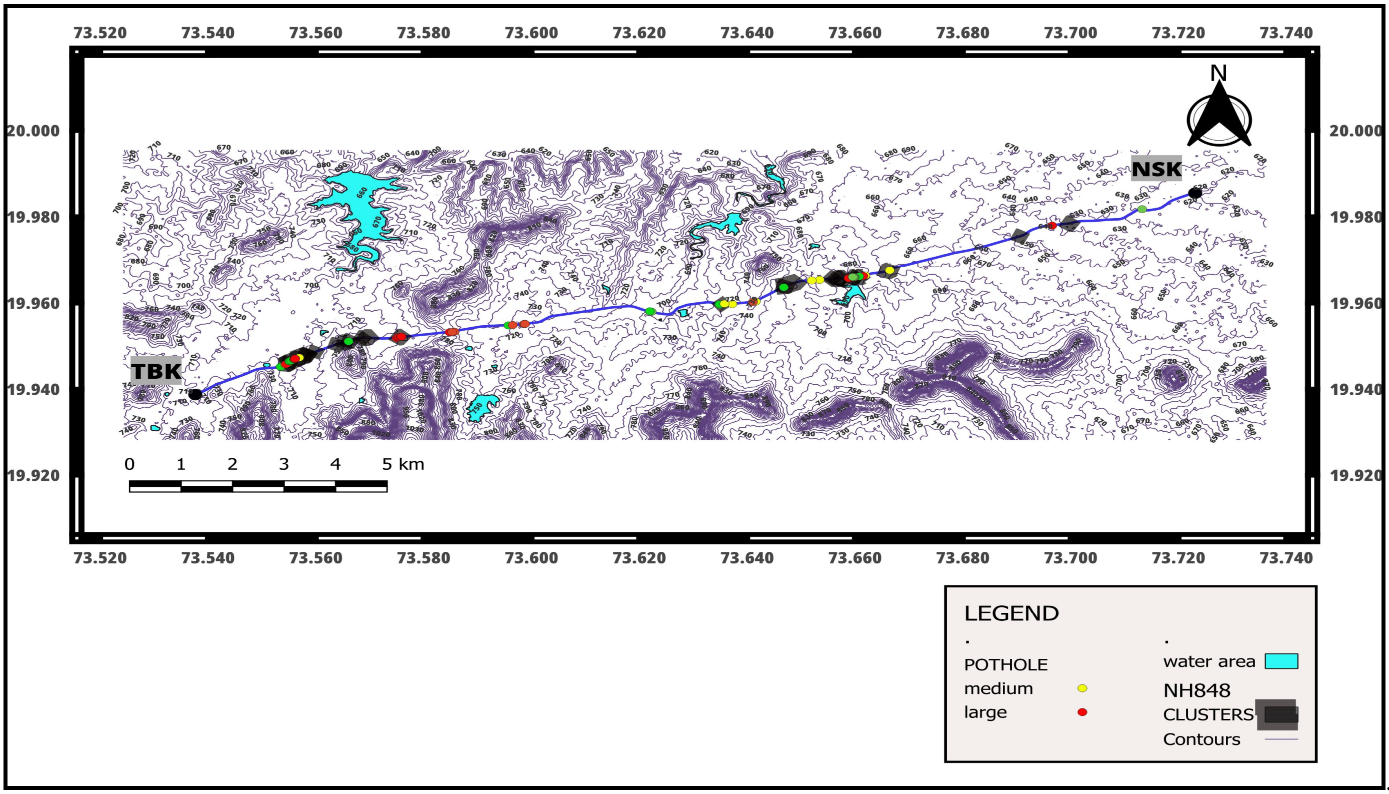



Fig -20 : Pothole occurance category

2) *Pothole Hotspot Analysis Nashik to Trimbakeshwar*

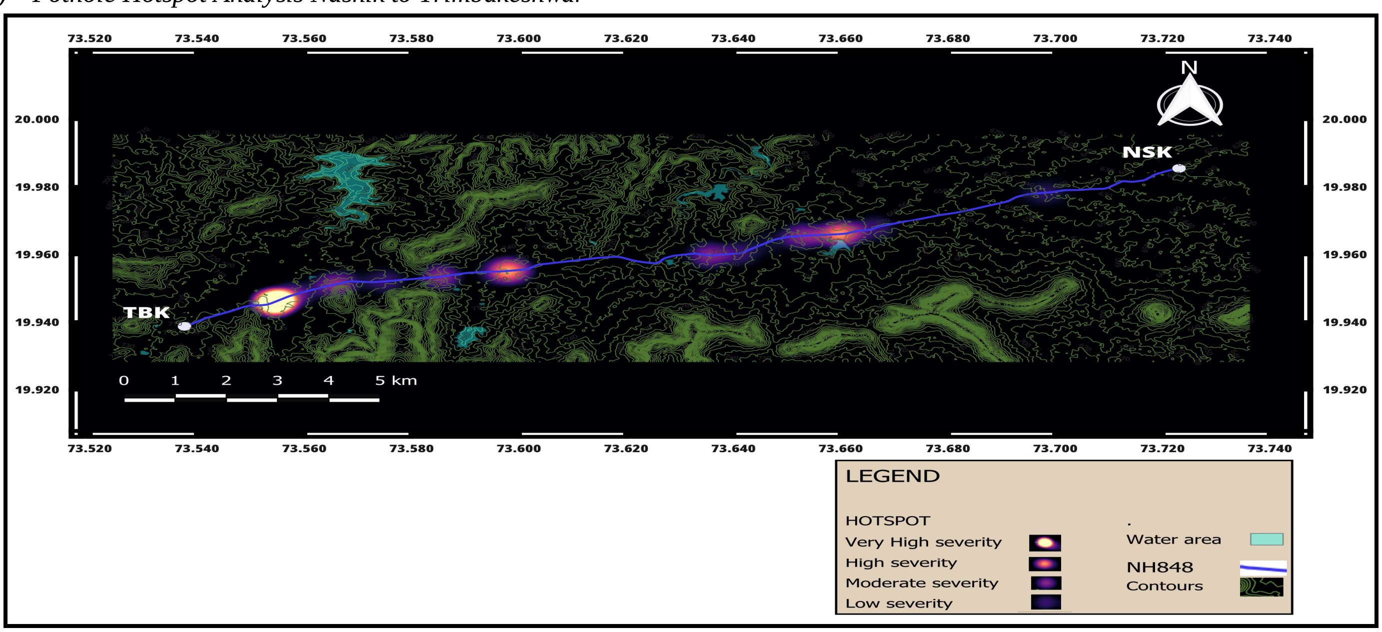



Fig -21: Pothole Hotspot Analysis

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue VII July 2025- Available at www.ijraset.com

*3) Critical Road Safety Alert*

This QGIS-based analysis highlights the deterioration of NH-848 along the critical stretch between Trimbakeshwar and Nashik, where potholes have become common and predictable causes of accidents. The heatmaps generated from this analysis reveal areas with significant safety risks in addition to surface deterioration. With an estimated 10,000 to 15,000 daily travelers—including pilgrims, locals, and heavy truck drivers—these locations pose an urgent threat to safety. To prevent future tragedies and ensure safe passage along this vital corridor, the spatial analysis emphasizes the importance of prompt, data-driven interventions.

*a) Mihiravani to Talegaon Anjaneri Phata*

Severity: High to Moderate

Potholes that develop on curved sections of the road, which follow the natural slope of the terrain, are a common cause of vehicle skidding incidents in this area. These bends can create instability and hazardous conditions, especially when they reduce tire grip during turns. This risk is heightened when drivers brake suddenly or maneuver at high speeds.

*b) Beje Phata to Brahma Valley College*

Severity: High to Moderate

The college road is often crowded with pedestrians and cyclists, especially during the morning and afternoon when classes begin and end. Many potholes are concealed by trees, making them difficult to see, particularly in the early morning or late at night.

*c) Pegalwadi to Tryambakeshwar (Most Critical Zone)*

Severity: Very High

Due to the large number of local pilgrims and religious tourists, vehicles are usually crammed along this road. Along the route's steep ascents and descents, potholes serve as concealed crash sites, especially for novice drivers.

*4) Pothole Hotspot Analysis Trimbakeshwar to Nashik*

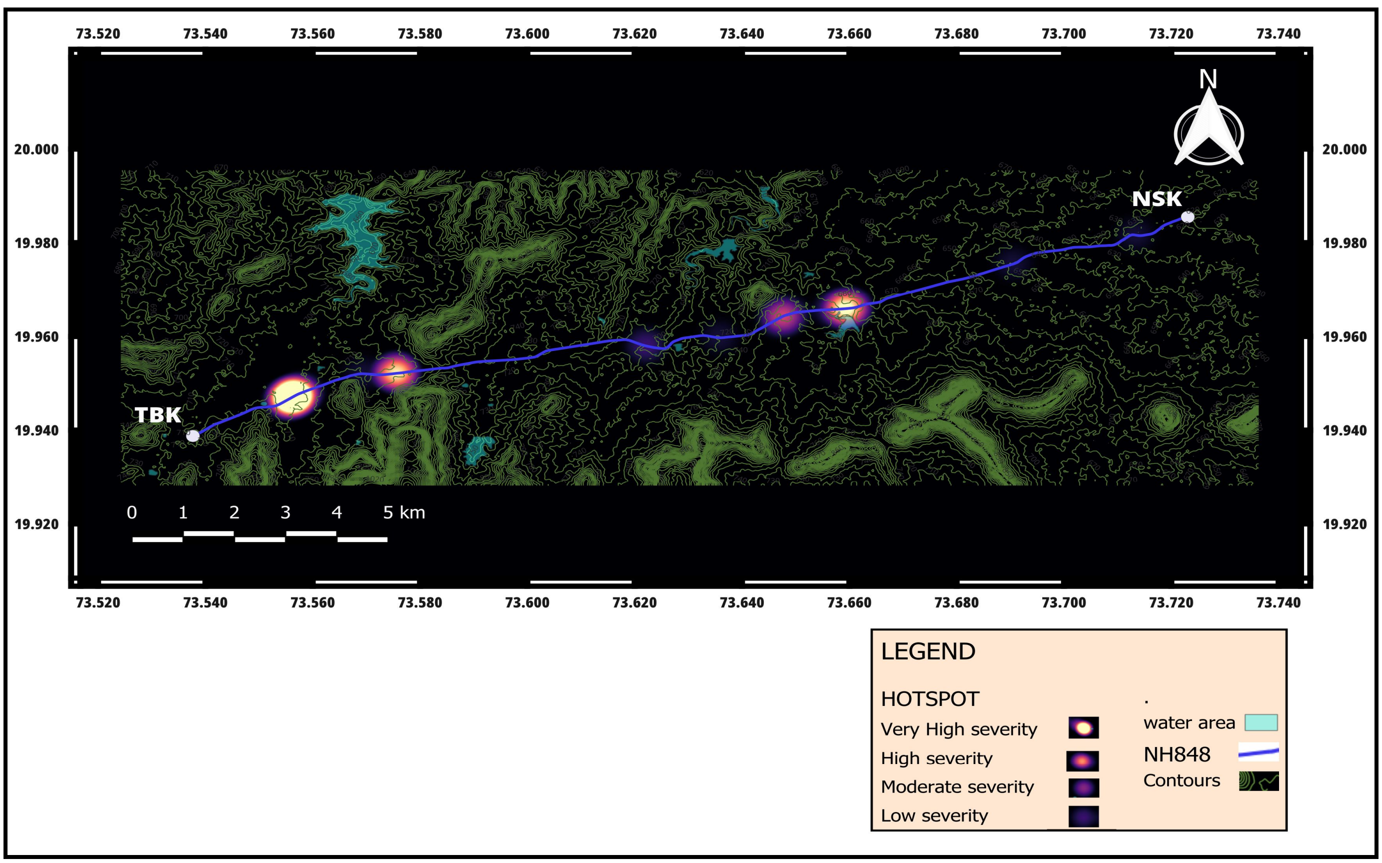



Fig -22 : Pothole Hotspot Analysis

*5) Critical Road Safety Alert*

A QGIS-based study reveals that the NH-848 stretch between Nashik and Trimbakeshwar has experienced significant degradation. Potholes have become a major cause of traffic accidents, particularly in areas with heavy traffic. The most hazardous locations are highlighted in red zones on the heatmaps, indicating severe surface distress and an increased risk of accidents. Approximately 10,000 daily commuters are directly affected by these high-risk areas, which pose threats to their safety and mobility. The findings underscore the urgent need for targeted maintenance, improved road engineering measures, and the swift implementation of safety initiatives to prevent further loss and inconvenience.

*a) Mihiravani to Talegaon Anjaneri Phata*

Severity: Very High to Moderate

This steep and winding stretch is dangerous, especially when it rains. Potholes frequently form near sharp curves, causing drivers to lose control, especially on two-wheelers. Water gathers in low areas, causing vehicles to skid.

*b) Khambale Nearby Region*

Severity: Low

While this section has fewer potholes and less traffic, it still needs regular maintenance to prevent minor damage from developing into more serious issues. Conducting regular inspections during the monsoon season and making prompt surface repairs will help keep the road safe and reduce future repair costs.

*c) Brahma Valley College of Engineering and Research Institute*

Severity: High

This route, which is located in an academic zone, is always congested with students and personnel riding bikes or walking. Potholes near the entrance and shady places are difficult to see, particularly in the morning and evening.

*d) Pegalwadi Tryambak Region*

Severity: Very High

This is a popular religious route with strong inclines. Heavy cars and numerous visits exacerbate road degradation rapidly. During festivals or holidays, the hazard increases dramatically. Potholes here can lead to serious accidents.

## V. GEOSPATIAL ANALYSIS FOR REPAIR RECOMMENDATION

In this geospatial analysis plays a critical role in identifying suitable repair recommendations. By leveraging GIS tools, various factors such as pothole severity, traffic density, waterlogging conditions, and underlying water levels are considered. The analysis focuses on areas with varying water table depths (0-2 meters and beyond), influencing the repair approach. High-risk zones prone to waterlogging and severe pothole conditions are prioritized based on their impact on road users and infrastructure. This data-driven framework ensures repairs are targeted to areas with the highest need, enhancing efficiency, safety, and sustainability.

Recommendation based on

- Severity of Potholes (Mild, Moderate, Severe)
- Water Table Depth (0-2 meters, >2 meters)
- Traffic Volume and Intensity
- Proximity to Water Bodies and Waterlogging Areas
- Type of Road Surface
- Frequent Occurrence of Potholes in Specific Areas

## VI. REPAIR RECOMMENDATIONS

The corridor has several high-risk and moderate-risk areas that contain numerous potholes, as indicated by field surveys and accident data. To enhance safety, high-risk areas should be equipped with better drainage systems to prevent water damage, and prompt repairs should be made using durable materials like polymer-modified bitumen and comprehensive patching for deep potholes. Moderate-risk areas should also undergo regular inspections.

To eliminate potholes and maintain smooth road conditions, routine measures such as patching, crack sealing, surface leveling, and inspections are recommended. These actions aim to minimize vehicle damage, extend the lifespan of the roads, and reduce the likelihood of accidents.

1) *Implementation of Rigid Pavement with Fiber-Reinforced Concrete (FRC) at High-Risk Segments*
   a) Pegalwadi to Trimbakeshwar
   b) Mihiravani to Anjaneri Phata
   c) Brahma Valley College Entrance

2) *Moderately Risky Areas with Seasonal Asphalt Failures*

Polymer-Modified Cold Mix Asphalt (PM-CMA) is designed as a high-performance repair solution for persistent pothole problems and deteriorating pavement conditions on moderately damaged sections of NH-848. PM-CMA is more flexible, adheres better, and has a longer lifespan compared to standard asphalt mixes, making it an excellent choice for areas with variable weather and moderate traffic volumes. Its cold application method is particularly beneficial during the monsoon season, allowing for quick and cost-effective repairs with minimal disruption to traffic flow. By utilizing PM-CMA, maintenance frequency on this crucial corridor can be significantly reduced, enhancing commuter safety and overall ride quality.

## VII. RESULT AND DISCUSSION

The findings show that vehicle performance and traffic safety are significantly impacted by pothole-related pavement distress on the NH-848 between Nashik and Trimbakeshwar. One of the most hazardous road conditions for drivers is a large, deep pothole, which raises the risk of accidents, loss of control, and damage to the vehicle, especially for light cars and two-wheelers. These damaged sections result in poor ride quality and increased maintenance costs for regular commuters and freight carriers. This study uses field survey data and GIS-based spatial mapping to examine the frequency, severity, and contributing factors of potholes. Finding pothole-prone areas and investigating the structural and physical factors that contribute to their frequent occurrence were the main goals. Potholes were categorized based on size and depth, and their spatial patterns were overlaid with data on road design, drainage availability, and terrain profile.

The results indicate that areas with uneven topography, poor pavement construction, and insufficient surface drainage are more prone to the formation and persistence of potholes. Heat maps created using QGIS reveal concentrated regions of high pothole density, particularly in locations with inadequate cross-drainage, pavement fatigue, and water accumulation due to terrain features. This issue poses safety concerns, as many of these areas are reported by drivers to cause vehicle instability. The recurrence of potholes after patch repairs suggests deeper structural problems and highlights ineffective maintenance practices.

These findings underscore the importance of enhancing drainage design and adhering to high-quality construction standards to improve road performance and safety. Additionally, they can help prioritize long-term, site-specific repair strategies.Key findings were drawn regarding spatial pothole distribution, severity classification, and the influence of road geometry,terrain and environmental conditions on surface failures along this corridor. The following are the major findings of the study:

1) Using field data collection and classification, I discovered that the majority of potholes on this highway segment are medium-sized (41.7%) and large-sized (39.3%). Given their depth, location, and frequency, more than 80% of the potholes that have been identified pose a serious risk to road users, particularly heavy vehicles and two-wheelers. Given the high proportion of large potholes, it is evident that patching the pavement superficially or temporarily is no longer adequate. Long-lasting and structurally sound repair methods are urgently required. This observation is visually supported by the Pothole Occurrence Category Map, which shows the size and spatial distribution of potholes (small, medium, large) and highlights clustered areas of frequent occurrence with black zones. The inclusion of contour lines and nearby water bodies underscores the need for terrain-informed intervention strategies, particularly in low-lying areas that are susceptible to water accumulation and quick pavement failure.
2) By overlaying pothole data with contour lines and nearby waterbody layers using QGIS, I observed a distinct spatial pattern: low-lying areas with poor drainage tend to have a higher likelihood of pothole recurrence. In some locations, water stagnation contributes to accelerated pavement deterioration. The correlation between potholes and terrain drainage was particularly evident in areas where the road passes through natural depressions. The Pothole Occurrence Category Map facilitated the zoning of vulnerabilities for preventative measures and terrain-informed maintenance planning by linking pothole frequency with drainage and topographical features.

3) Using GIS-based heatmap tools, I identified three major accident-prone zones that show a strong correlation with pothole presence:

- Mihiravani – Talegaon Anjaneri Phata
- Beje Phata – Brahma Valley College stretch
- Pegalwadi – Trimbakeshwar

In addition to being susceptible to pothole formation, these regions face other significant risk factors, including steep grades, sharp curves, and heavy traffic volumes. Poor road conditions substantially increase the severity of accidents in these areas, particularly on hills and twists where maintaining vehicle control is more challenging.

My research reveals several notable danger zones on the Pothole Hotspot Analysis Maps for the routes between Nashik and Trimbakeshwar. The section from Pegalwadi to Trimbakeshwar is identified as the most critical zone, experiencing very high severity. In contrast, the segments from Mihiravani to Talegaon Anjaneri Phata and from Beje Phata to Brahma Valley College are categorized as having high to moderate severity on the Nashik to Trimbakeshwar route. On the way back, the Brahma Valley College area is classified as high severity, Pegalwadi-Tryambak remains classified as very high severity, Khambale is classified as low severity, and the stretch from Mihiravani to Talegaon is classified as very high to moderate severity. These pothole zones pose serious risks to commuters, especially during rush hours, particularly around curves and in areas shaded by college buildings.

## VIII. CONCLUSION

Serious safety and maintenance problems were discovered along NH-848 after a detailed investigation into the underlying causes of pavement failure. Through field surveys, terrain evaluation, and spatial mapping, I identified zones where high pothole density, steep slopes, poor road alignment, and inadequate drainage come together—creating conditions that rapidly accelerate surface degradation and structural wear. These overlapping risk factors highlight an urgent need for infrastructure upgrades, including slope-sensitive pavement treatments, efficient drainage systems, and design strategies tailored to the topography. It's clear that routine patchwork repairs are no longer effective; what's needed now are targeted, long-term solutions that address the root causes. This integrated, data-driven approach allows for precise identification of the most vulnerable stretches, enabling smarter intervention planning and improving the long-term safety and durability of this vital corridor. The following conclusions serve as a foundation for focused action and future improvements.

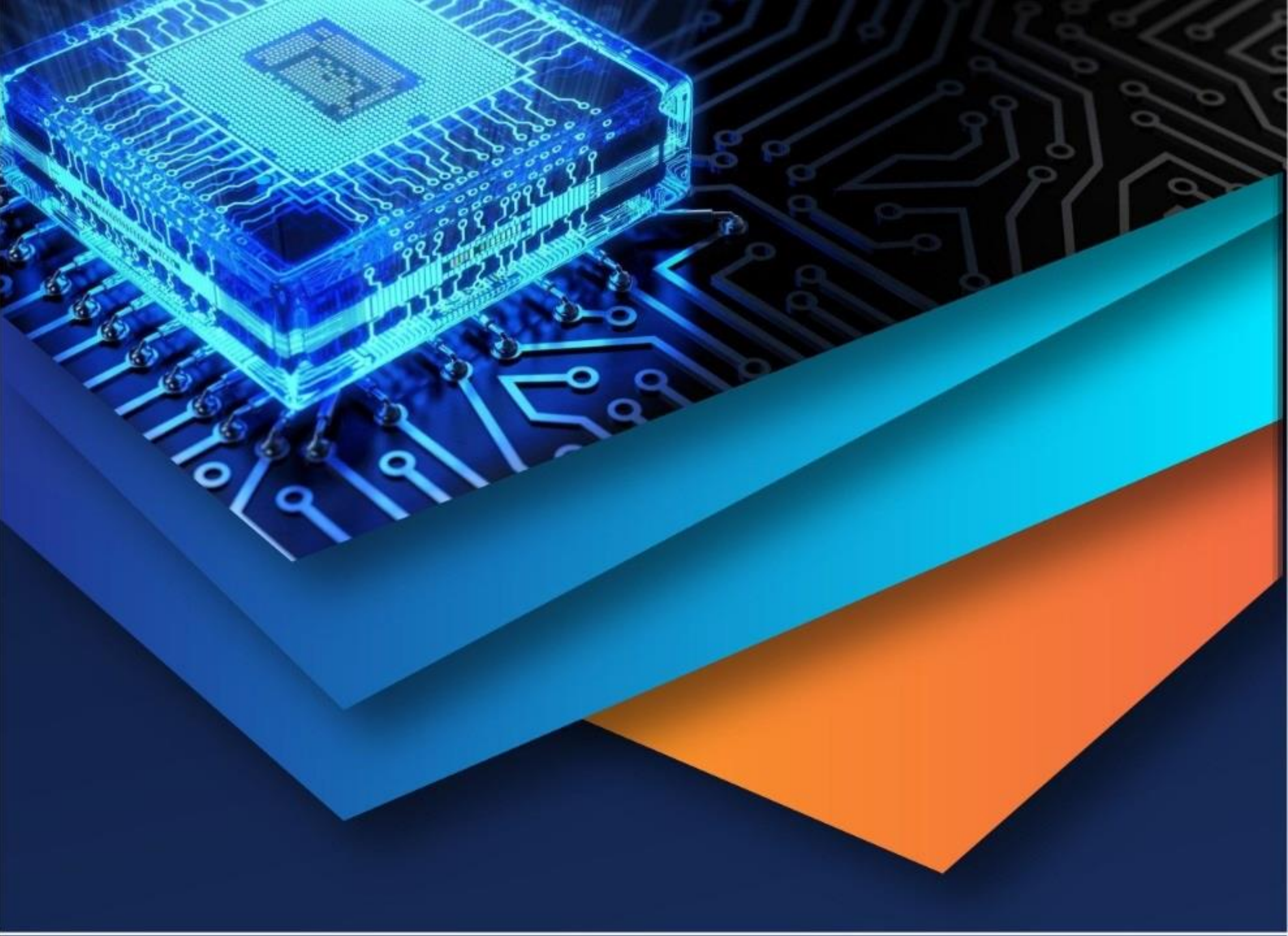
1) NH-848 is dominated by medium and large potholes, which obviously create dangerous conditions that increase the risk for road users, especially in areas that are prone to accidents. These road imperfections clearly impair vehicle control and raise the risk of collisions. Accordingly, I believe that timely maintenance and location specific resurfacing are crucial measures to stop additional damage and improve general safety.
2) The GIS-based analysis of pothole distribution and terrain features reveals clear patterns that highlight the most vulnerable stretches along NH-848. This spatial understanding offers a valuable framework for prioritizing long-term maintenance interventions. Utilizing such data-driven insights enables targeted action, ensuring that resources are efficiently allocated to areas where pavement failures are most severe. Adopting this approach can lead to more effective and sustainable road management, ultimately enhancing durability and performance across the corridor.
3) For severely distressed sections of NH-848, rigid pavement with Fiber-Reinforced Concrete (FRC) offers a durable, long-term solution capable of withstanding heavy traffic and repeated failures. In moderately damaged areas, Polymer-Modified Cold Mix Asphalt (PM-CMA) provides a flexible, weather-resistant alternative with better adhesion and longevity than standard asphalt. Its cold application is especially effective during the monsoon, enabling faster, cost-efficient repairs with minimal disruption. By strategically applying FRC in high-risk zones and PM-CMA in moderately affected stretches, maintenance can be streamlined, safety improved, and road performance significantly enhanced across the corridor.
4) This study establishes a foundation for future research on road distress and accident patterns at the district level. It offers valuable insights into the underlying causes and key factors that contribute to road failures. These findings can inform future investigations and help develop more effective prevention and management strategies.

## IX. ACKNOWLEDGMENT

I have great pleasure in presenting this dissertation work report entitled "Application of GIS for Comprehensive Pothole and Road Accident Hotspot Analysis - A Data-Driven Approach for NH-848 Nashik to Trimbakeshwar." for partial fulfillment of the Master of Technology in Construction Management. I take this opportunity to express my deep sense of gratitude towards my guide Prof. S. V. Joshi, Associate Professor, Civil Engineering Department Govt. College of Engineering, Karad for well formulated and indispensable guidance in the accomplishment of this report, without which this would not have been possible. My thanks are due to Prof. S. V. Joshi, Head of Civil Engineering Department, permitting me to carry out my research and providing technical facilities and support. I am thankful to all the faculty members of, Civil Engineering Department, Government College of Engineering, Karad for the help they have provided in my work. I extend my sincere thanks to Dr V. N. Kulkarni, Principal, Government College of Engineering, Karad for providing institutional facilities, as well as extending all kinds of co- operation. Last but not the least; I am thankful to my parents and friends who helped me directly or indirectly for the completion of this course. I am thankful to all those who wished me success. Above all I render my gratitude to all who gave me inspiration and strength to complete this work.

## REFERENCES

[1] Mednis, A.Strazdins, G. Zviedris, R. Kanonirs, G.& Selavo, L. (2011).Real-time pothole detection using Android smartphones with accelerometers. IEEE (pp. 1–6).
[2] Rizky, A. M.Zahra, A. A.Astor, Y., Septian, R. Munawar, G. Sihombing, A. V.& Fauzi. C (2023).Road maintenance management based on geographic information system (GIS). (IJASEIT).
[3] Casas Avellaneda, D. A.& López-Parra, J. F. (2016). Detection and localization of potholes in roadways using smartphones. Dyna, 83(195), 156–162.
[4] Yadav, C. Shinde, H. Sude, S., Shinde, P. Ganla, S. & Kulkarni, S. (2019). Assessment of pothole using QGIS & AutoCAD software. (IRJET), 6(4).
[5] Ghayal, D. R.& Kale, K. V. (2018). Application of remote sensing and GIS for road monitoring. (IJSRCSEIT), 3(3).
[6] Ghayal, D. R., hingne, N. N., & Kale, K. V. (2019). Application of GIS for road condition monitoring with comparative analysis of different implemented techniques. (JETIR), 6(4).
[7] Ibrahim, D. I. M. E. (2020). Using GIS to classify urban street potholes in Khartoum city capital of Sudan. ResearchGate.
[8] Nodrat, F., & Kang, D. (2018). Prioritizing road maintenance activities using GIS platform and VB.NET. (IJACSA), 9(10).
[9] Fendi, K. G., Adam, S. M., Kokkas, N., & Smith, M. (2014). An approach to produce a GIS database for road surface monitoring. APCBEE Procedia, 9, 235–240.
[10] Ewadh, H. A., Almuhanna, R. R. A., & Alasadi, S. J. M. (2018). Using PAVER 6.5.7 and GIS program for PMM for selected roads in Kerbala city. International Journal of Civil Engineering and Technology (IJCIET), 9(4), 1127–1136.
[11] Kamal, K., Mathavan, S., Zafar, T., Moazzam, I., Ali, A., Ahmad, S. U., & Rahman, M. (2016). Performance assessment of Kinect as a sensor for pothole imaging and metrology.IJPE, 1–12.
[12] Fendi, K. G., Adam, S. M., Kokkas, N., & Smith, M. (2014). An approach to produce a GIS database for road surface monitoring. APCBEE Procedia, 9, 235–240.
[13] Alfar, E. (2016). "GIS-based pavement maintenance management model for local roads in the UK .Doctoral dissertation, University of Salford.
[14] Mehdi, M. A., Cherradi, T., El Karkouri, S., & Qachar, A. (2020). Applying geographic information systems (GIS) for surface condition indicators modeling of a flexible pavement. ICCR (pp. 1–6).
[15] Deshmukh, M. S., & Rajput, S. R. (2016). Smartphone-based citizen complaint system for urban maintenance using GIS. (IJSER), 7(5), 1591–1599.
[16] Sabri, M. I. S. A., & Sarif, A. S. (2023). Analysis of pavement maintenance using geographical information system. (IJEAT), 12(3), 112–120.
[17] Nikhith, N. Shravan, S. Rai, K. S. Shastry, P. K., & Pinto, F. J. (2022). Real-time pothole detection system. (IJCRT), 10(1).
[18] Onuigbo, I. C. & Orisakwe, K. U. (2013). Applications of GIS and remote sensing in road monitoring in Minna and environs, Nigeria. Journal of Environmental Science, 7(2), 45–52.
[19] Li, Q. Yao, M., Yao X. & Xu, B. (n.d.). A real-time 3D scanning system for pavement distortion inspection. Measurement Science and Technology, 21(1), 015702.
[20] Mane, S. Gujarathi, S. N. Arkatkar, S. S., Sarkar, A. K., & A. P. (2016). Methodology for pavement condition assessment and maintenance of rural roads. In Proceedings of IIT Roorkee National Conference on FYPMGSY (pp. 1–14).
[21] Software, B. & Tools, D. (2000). Integrating GIS and spatial statistical tools for the spatial analysis of health-related data. Spatial Analysis Journal, 97(800).
[22] Venkatesh, S. Abhiram, E., Rajarajeswari, S. Kumar, S., & Jagadish, N. (2014). An intelligent system to detect, avoid and maintain potholes: A graph-theoretic approach. (ICMU) (p. 80).
[23] Global Highways. (2024). Global highways report. . Link
[24] Ministry of Road Transport & Highways, Government of India. (2024). Annual report 2024–25. Link
[25] Vajiram & Ravi. (2024). Challenges to road safety in India. . Link




10.22214/IJRASET

INDEX COPERNICUS 45.98

IMPACT FACTOR: 7.129

TOGETHER WE REACH THE GOAL

IMPACT FACTOR: 7.429


# INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY