A

Research Project Report On

“Roadsense.ai”

IN PARTIAL

FULLFILMENT OF

MASTERS OF COMPUTERS APPLICATIONS

SUBMITTED BY

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2025-2026

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CERTIFICATE OF ORIGINALITY

Date: -

This is to certify that the project entitled
………………………………………………………………………………………………
…………………………………………………………

Submitted to the Department of MCA, Indira College of Engineering and Management in partial fulfillment of the requirement for the award of the degree of **MASTER OF COMPUTER APPLICATION**, is an original work carried out by Mr./Ms.………………………………………………………………………

Exam Seat No………..

Under my guidance. The matter embodied in this project is a genuine work done by the student and has not been submitted whether to this Organization or to any other University/Organization for the fulfillment of the requirement of any course of study

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Internal Examiner

ACKNOWLEDGEMENT

I would like to express my sincere gratitude to my course instructor. **Dr Darshana Desai**, for their guidance and support throughout the development of my capstone project, " **Roadsense.ai- a civic engagement platform** ". Their valuable feedback helped me stay on track and improve the project.

I am also thankful to my family and friends for their continuous encouragement and understanding. Their support was crucial in completing this project successfully.

I would like to acknowledge the resources and tools that made this project possible, as well as my peers for their helpful suggestions and discussions.

Finally, I extend my thanks to everyone who contributed to my learning and project development.

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Abstract

Urban road infrastructure plays a vital role in ensuring smooth transportation and public safety. However, traditional road issue management systems are often inefficient, relying on manual reporting and delayed response mechanisms. RoadSense.ai is a smart, geospatial, and predictive road issue management platform designed to overcome these limitations. The system enables citizens to report road-related problems such as potholes, waterlogging, and damaged signage through a web-based interface, capturing both descriptive and geolocation data. Government officials can access these reports in real time, prioritize them based on severity, and update their resolution status through a centralized dashboard. The backend is powered by PostgreSQL integrated with PostGIS for spatial data handling, enabling accurate mapping and spatial analytics. Additionally, a machine learning module analyzes historical reports to predict future issue hotspots and seasonal trends, supporting proactive maintenance planning. The system enhances transparency, accountability, and efficiency in urban maintenance workflows while promoting citizen participation in civic governance.

1.Introduction

Efficient road infrastructure is a fundamental component of modern urban development and public welfare. In many cities, road maintenance is reactive, relying on manual complaint systems and traditional inspection methods that are often slow, uncoordinated, and lack transparency. Citizens typically report road defects such as potholes, cracks, and drainage blockages through helpline calls or written complaints, which are prone to delays, data loss, and limited accountability. As cities continue to expand, managing road networks using such conventional approaches has become increasingly challenging.

To address these shortcomings, *RoadSense.ai* proposes a smart, automated, and geospatially enabled platform that connects citizens, officials, and administrators through a unified digital ecosystem. The system leverages **PostgreSQL** integrated with **PostGIS** to efficiently manage geospatial data, enabling precise mapping of road issues across different administrative zones. It supports real-time reporting by citizens and provides authorities with intelligent dashboards to track, prioritize, and resolve issues.

Furthermore, *RoadSense.ai* incorporates **machine learning models** that analyze historical patterns and seasonal variations to predict high-risk areas and recurring problems. This predictive capability empowers municipalities to shift from reactive to proactive road maintenance strategies, ultimately reducing repair costs and improving road safety. By integrating data visualization, spatial analytics, and community participation, *RoadSense.ai* aligns with the principles of smart city governance—enhancing efficiency, transparency, and citizen engagement in urban infrastructure management.

1.1.Existing System :

Traditional road issue reporting relies heavily on manual processes such as complaint letters, helpline calls, or in-person visits to municipal offices. These methods are inefficient, non-transparent, and delay problem resolution. Existing civic portals, where available, lack real-time spatial visualization and automated tracking. Data is stored in unstructured formats without analytics, resulting in repeated issues and poor citizen engagement.

1.2. Need For System:

The motivation behind *RoadSense.ai* is to modernize civic issue management by leveraging **geospatial technology**, **machine learning**, and **citizen participation**. The system aims to:

- Enable quick, location-based reporting of road issues through a user-friendly app.
- Support government officials in tracking, prioritizing, and resolving complaints efficiently.
- Use predictive analytics to anticipate recurring road problems (e.g., potholes in monsoon).
- Improve transparency and citizen trust through public dashboards and verification features.

1.3. Scope Of Work:

The project focuses on:

- Developing a **multi-role web platform** (citizen, official, admin).
- Implementing a **PostgreSQL + PostGIS** database for geospatial analytics.
- Building a **reporting workflow** with issue submission, assignment, resolution, and feedback.
- Integrating **machine learning models** to forecast issue density and risk levels.
- Providing visualization dashboards with heatmaps, charts, and predictive analytics.

The system can be extended for integration with IoT sensors or Smart City control rooms.

1.5 Operating Environment: Hardware and Software :

1. Hardware Requirements:

- Processor: Intel i5 / AMD equivalent or higher
- RAM: Minimum 8 GB
- Storage: 250 GB SSD
- Internet Connectivity: Required for map and API access

2.Software Requirements

- Frontend: React.js
- Backend: FastAPI
- Database: PostgreSQL 15+
- Machine Learning: Python (scikit-learn, pandas)
- Server OS: Ubuntu 22.04 LTS

Client Devices:

- **Desktop/Laptop**: Any device with internet access, modern browser support (Chrome, Firefox, Safari, Edge)

1.6 Detail Description of Technology Used :

The *RoadSense.ai* platform integrates several modern technologies to achieve robustness, scalability, and geospatial accuracy. PostgreSQL serves as the primary database engine due to its reliability and ACID compliance, while the PostGIS extension adds spatial capabilities, allowing storage and querying of geometric objects such as points and polygons. This is essential for mapping road issues to specific locations and administrative zones. Node.js with Express.js is used for building the RESTful backend API that connects the database to the user interface, managing requests, authentication, and data routing. React.js powers the frontend with an intuitive and interactive user interface for citizens, officials, and administrators. Machine learning models, implemented in Python, analyze historical data and predict issue trends and high-risk zones. The use of JSONB fields in PostgreSQL adds flexibility for storing variable metadata, while APIs from GIS services support reverse geocoding and real-time map rendering.

2.Proposed System

2.1 Proposed System:

The **proposed RoadSense.ai system** is a centralized, cloud-based platform integrating **citizen reporting**, **official management**, and **AI-powered analytics**.
It allows:

- Citizens to report road defects with photos, geotags, and descriptions.
- Officials to manage reports by assigning, tracking, and updating status.
- Admins to monitor city-wide analytics and predictive insights.

Key improvements over the existing system include:

- Real-time location mapping
- Automated notifications and escalations
- Data visualization dashboards
- ML-driven predictive maintenance insights

2.2 Aim and Objective of System:

Aim:

To design and implement a smart, geospatial, and AI-driven system for efficient road issue management and predictive maintenance.

Objectives:

- Develop an intuitive web interface for citizen issue reporting.
- Integrate PostGIS for spatial data storage and mapping.
- Implement multi-role authentication and user management.
- Automate issue tracking and notification workflows.
- Use machine learning to forecast issue trends and high-risk areas.
- Provide analytics dashboards for performance monitoring

2.3

2.4 User Requirement :

- **Functional Requirements:**

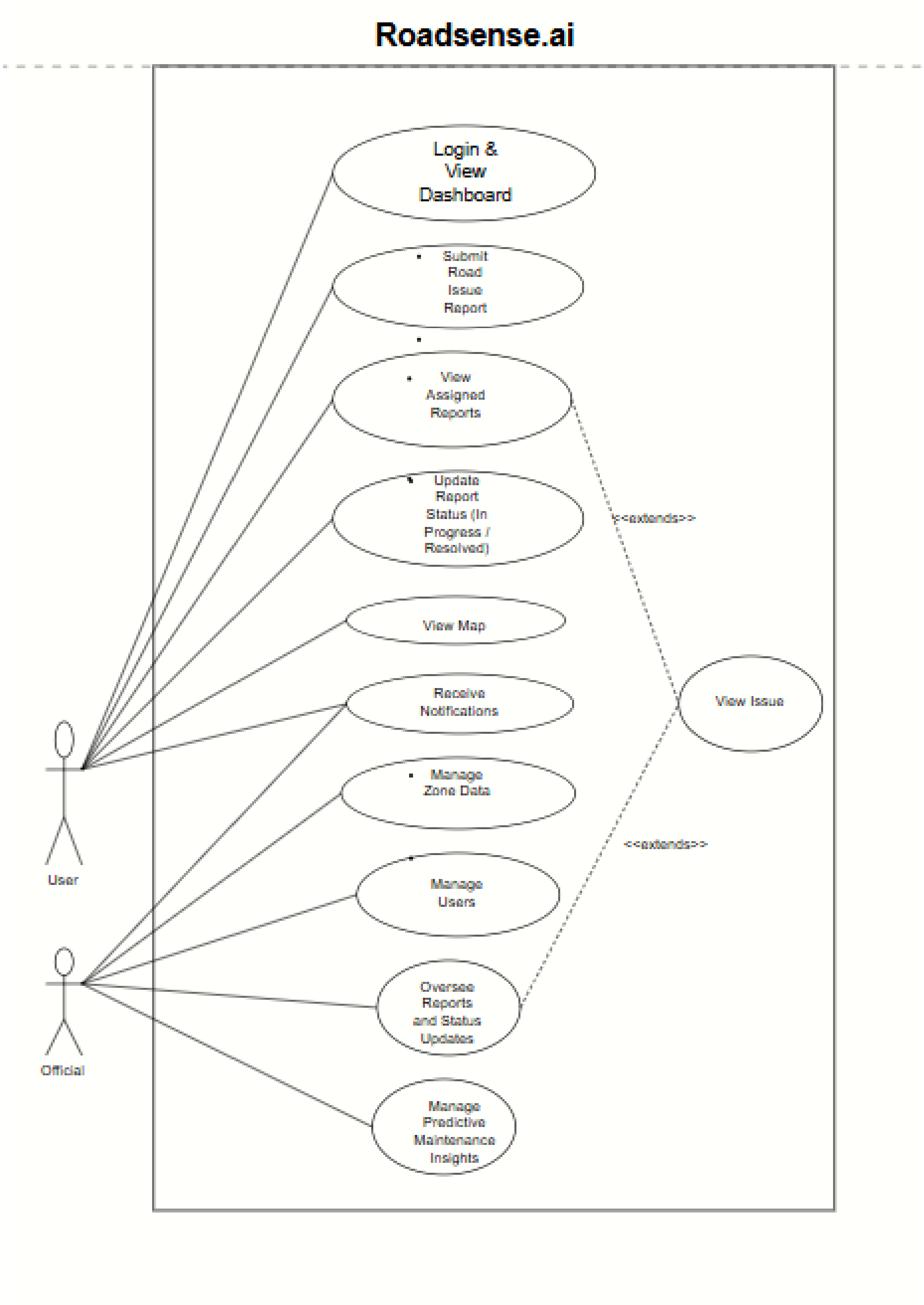
The system is designed to meet both functional and non-functional requirements. Functionally, it must allow user registration and authentication, role-based access (citizen, official, admin), and the ability to report, view, and update road issues. It must also support image uploads, real-time status tracking, and feedback mechanisms. For officials and administrators, it should include features for data visualization, report management, and analytics. Non-functional requirements include system reliability, scalability for handling large volumes of data, high security for user authentication, quick response time, and a mobile-friendly responsive design. Additionally, the system must ensure data integrity, backup support, and audit logging to maintain transparency.

- **Non-Functional Requirements:**

The system follows a modular and layered architecture comprising the frontend, backend, database, and machine learning layers. The frontend, built with React.js, provides a responsive interface for different user roles. The backend, implemented using Node.js and Express.js, handles logic, authentication, and communication with the database. PostgreSQL and PostGIS together manage structured and geospatial data efficiently. The machine learning component processes data from the reports table to forecast potential issue clusters and generate seasonal predictions. The database schema, consisting of 18 normalized tables, ensures integrity, scalability, and optimal performance. The design emphasizes modularity and flexibility, enabling easy updates and future expansion.

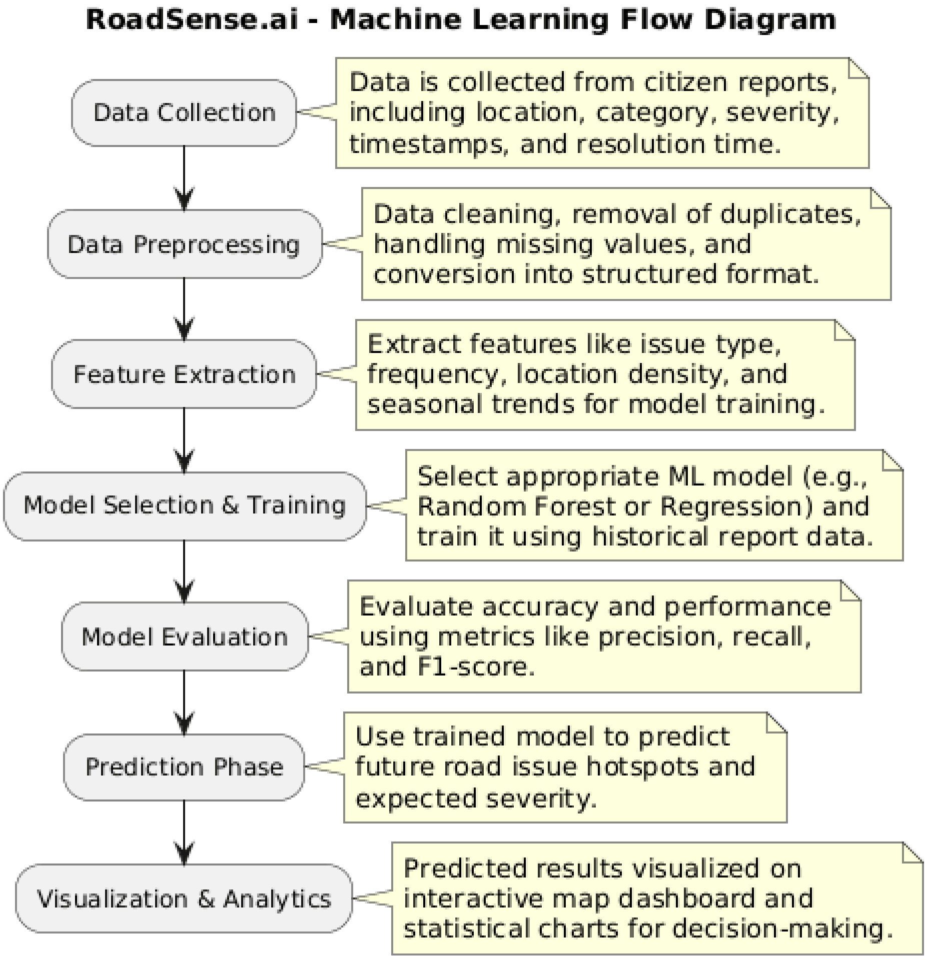
3.Analysis And Design

3.1 Use case Diagram :



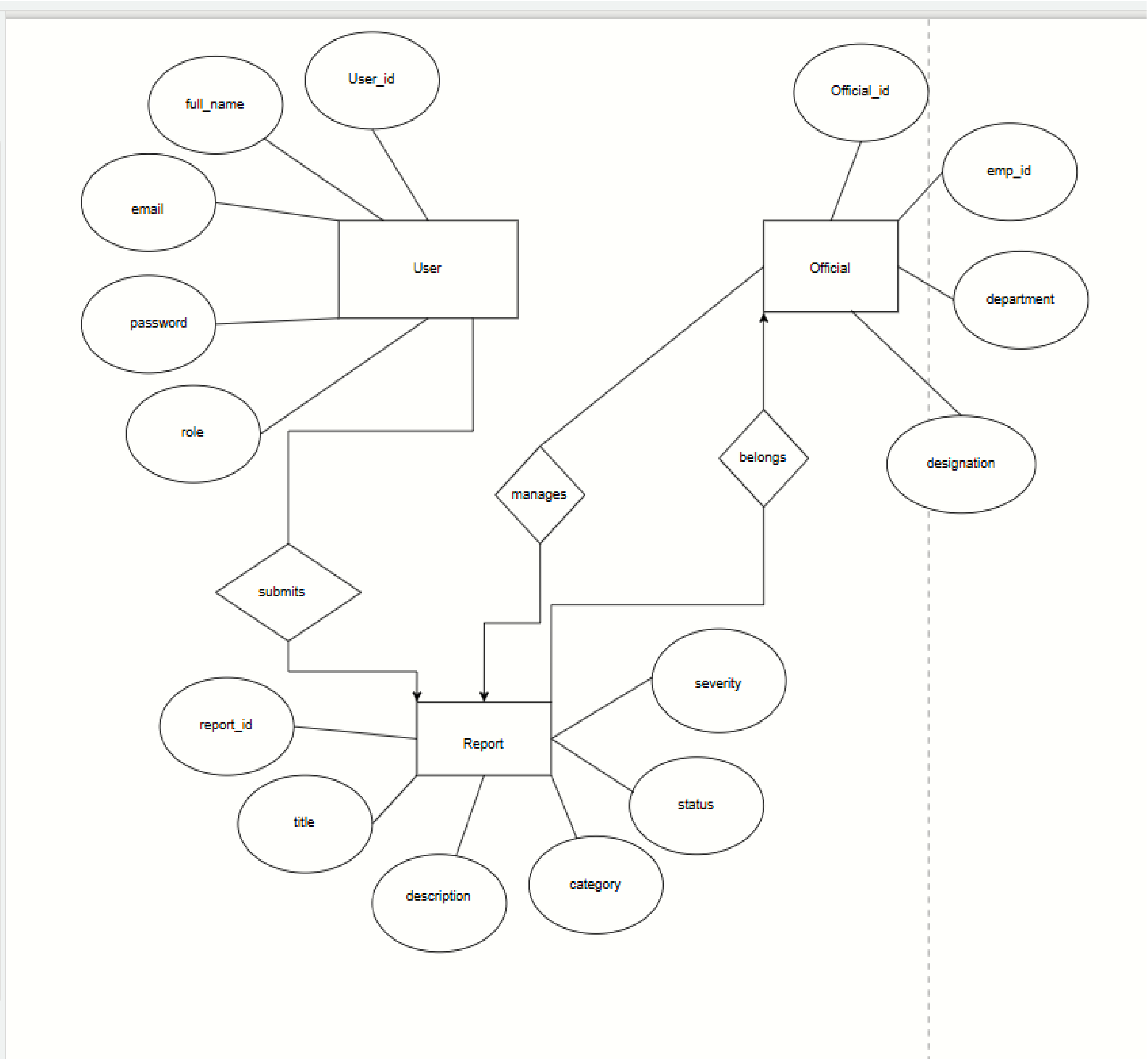
The **Use Case Diagram** illustrates the interaction between the main actors — *Citizen*, *Official*, and *Administrator* — and the *RoadSense.ai* system. It defines the key functionalities accessible to each user, such as reporting road issues, managing zones, updating issue statuses, and monitoring analytics. This diagram provides a high-level view of system requirements and the relationships between users and their respective actions within the platform.

3.2 ML Flow Diagram: -


RoadSense.ai - Machine Learning Flow Diagram
Data Collection
Data is collected from citizen reports, including location, category, severity, timestamps, and resolution time.
Data Preprocessing
Data cleaning, removal of duplicates, handling missing values, and conversion into structured format.
Feature Extraction
Extract features like issue type, frequency, location density, and seasonal trends for model training.
Model Selection & Training
Select appropriate ML model (e.g., Random Forest or Regression) and train it using historical report data.
Model Evaluation
Evaluate accuracy and performance using metrics like precision, recall, and F1-score.
Prediction Phase
Use trained model to predict future road issue hotspots and expected severity.
Visualization & Analytics
Predicted results visualized on interactive map dashboard and statistical charts for decision-making.

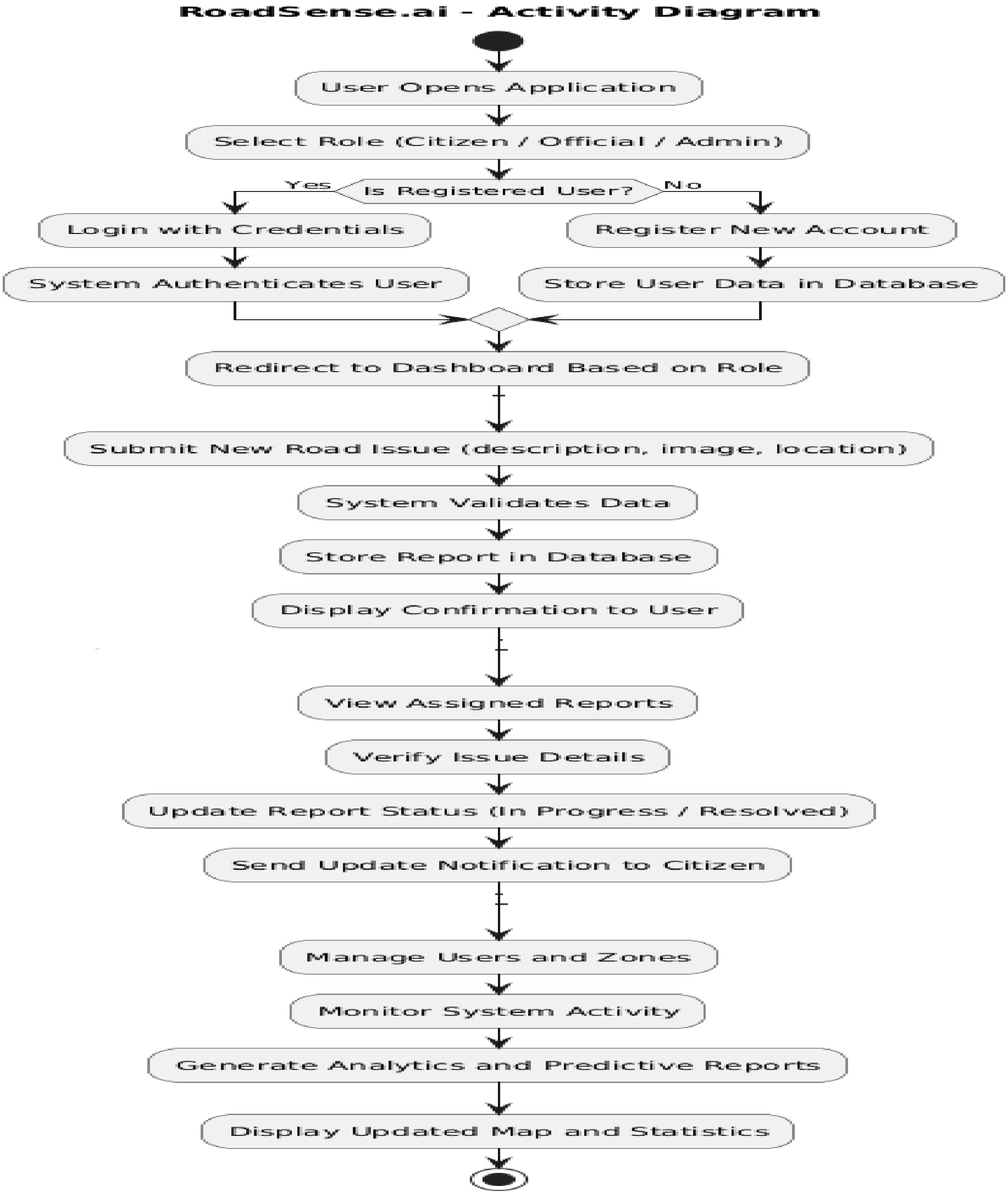
The **Machine Learning Flow Diagram** explains the end-to-end process of predictive analytics used in *RoadSense.ai*. It begins with data collection from user-submitted reports, followed by preprocessing, feature extraction, model training, and evaluation. The trained model generates predictions for potential road issue hotspots, which are visualized on the analytics dashboard. This diagram highlights the role of machine learning in proactive maintenance planning.

3.3 ER Diagram:



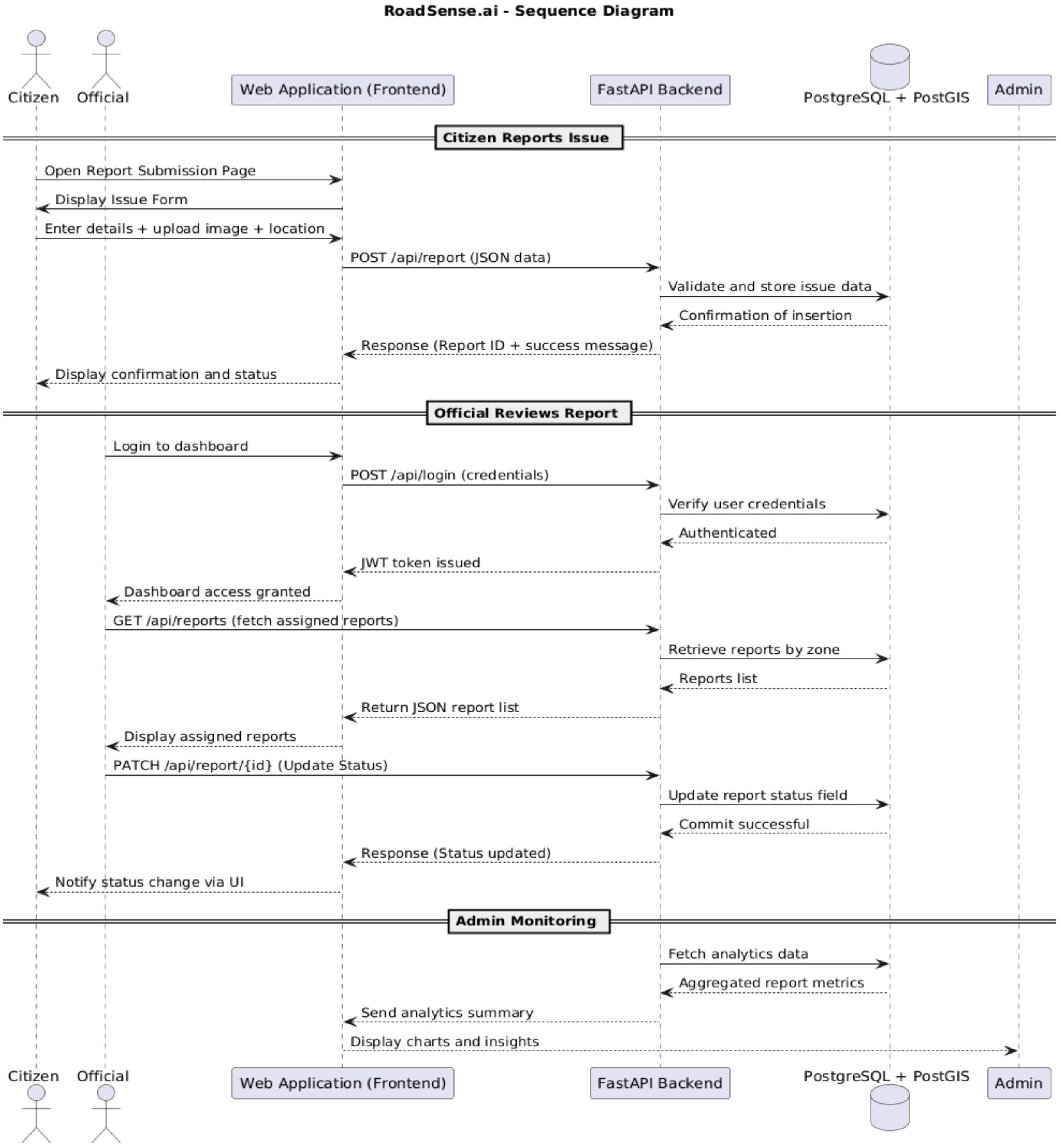
The **Entity Relationship Diagram** defines the logical structure of the database used in *RoadSense.ai*. It showcases entities such as *User*, *Official*, *Zone*, *Report*, *Feedback*, and *Prediction*, along with their attributes and relationships. This diagram establishes how data flows between entities and ensures data integrity and efficient database design.

3.4 Activity Diagram:

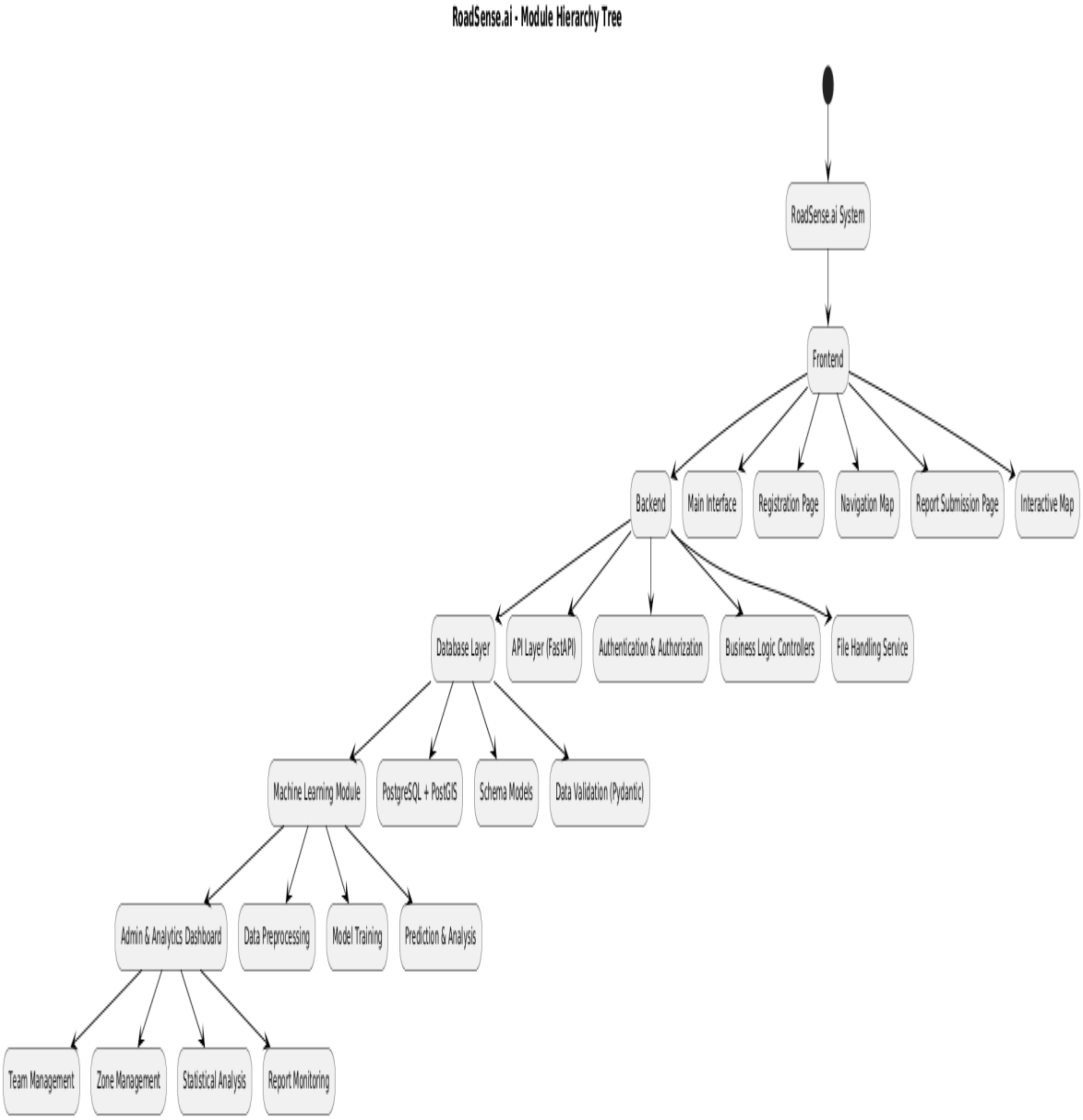

RoadSense.ai - Activity Diagram
User Opens Application
Select Role (Citizen / Official / Admin)
Yes
Is Registered User?
No
Login with Credentials
Register New Account
System Authenticates User
Store User Data in Database
Redirect to Dashboard Based on Role
Submit New Road Issue (description, image, location)
System Validates Data
Store Report in Database
Display Confirmation to User
View Assigned Reports
Verify Issue Details
Update Report Status (In Progress / Resolved)
Send Update Notification to Citizen
Manage Users and Zones
Monitor System Activity
Generate Analytics and Predictive Reports
Display Updated Map and Statistics

The **Activity Diagram** represents the workflow of activities within the *RoadSense.ai* system. It depicts the sequence of operations, beginning with user login or registration, followed by report submission, verification by officials, and issue resolution. The diagram highlights the parallel activities among different user roles and demonstrates the logical flow of control throughout the application's lifecycle.

3.5 Sequence Diagram :


RoadSense.ai - Sequence Diagram
Citizen
Official
Web Application (Frontend)
FastAPI Backend
PostgreSQL + PostGIS
Admin
Citizen Reports Issue
Open Report Submission Page
Display Issue Form
Enter details + upload image + location
POST /api/report (JSON data)
Validate and store issue data
Confirmation of insertion
Response (Report ID + success message)
Display confirmation and status
Official Reviews Report
Login to dashboard
POST /api/login (credentials)
Verify user credentials
Authenticated
JWT token issued
Dashboard access granted
GET /api/reports (fetch assigned reports)
Retrieve reports by zone
Reports list
Return JSON report list
Display assigned reports
PATCH /api/report/{id} (Update Status)
Update report status field
Commit successful
Response (Status updated)
Notify status change via UI
Admin Monitoring
Fetch analytics data
Aggregated report metrics
Send analytics summary
Display charts and insights
Citizen
Official
Web Application (Frontend)
FastAPI Backend
PostgreSQL + PostGIS
Admin

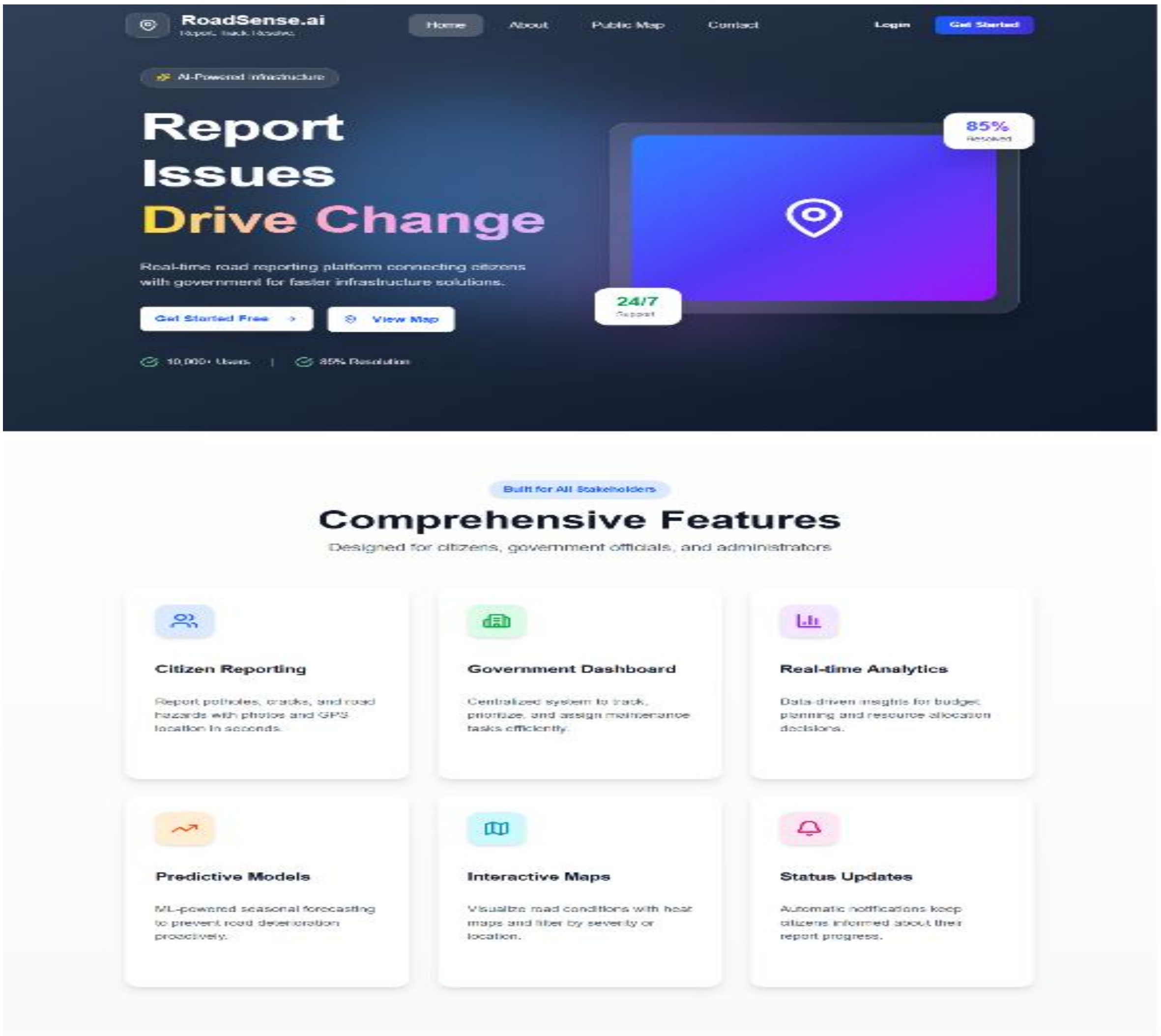
3.6 Module Hierarchy Diagram :



The **Module Hierarchy Diagram** outlines the structural organization of the *RoadSense.ai* system into various modules and submodules. It depicts the relationship between core layers such as the frontend, backend, database, and machine learning components. The diagram helps in understanding system modularity, inter-module dependencies, and how each part contributes to the overall functionality of the application.

4.User Interface Design & Business Logic :

4.1 Landing Page :



Report Issues Drive Change

Real-time road reporting platform connecting citizens with government for faster infrastructure solutions.

Comprehensive Features

Designed for citizens, government officials, and administrators

Citizen Reporting

Report potholes, cracks, and road hazards with photos and GPS location in seconds.

Government Dashboard

Centralized system to track, prioritize, and assign maintenance tasks efficiently.

Real-time Analytics

Data-driven insights for budget planning and resource allocation decisions.

Predictive Models

ML-powered seasonal forecasting to prevent road deterioration proactively.

Interactive Maps

Visualize road conditions with heat maps and filter by severity or location.

Status Updates

Automatic notifications keep citizens informed about their report progress.

Business Logic

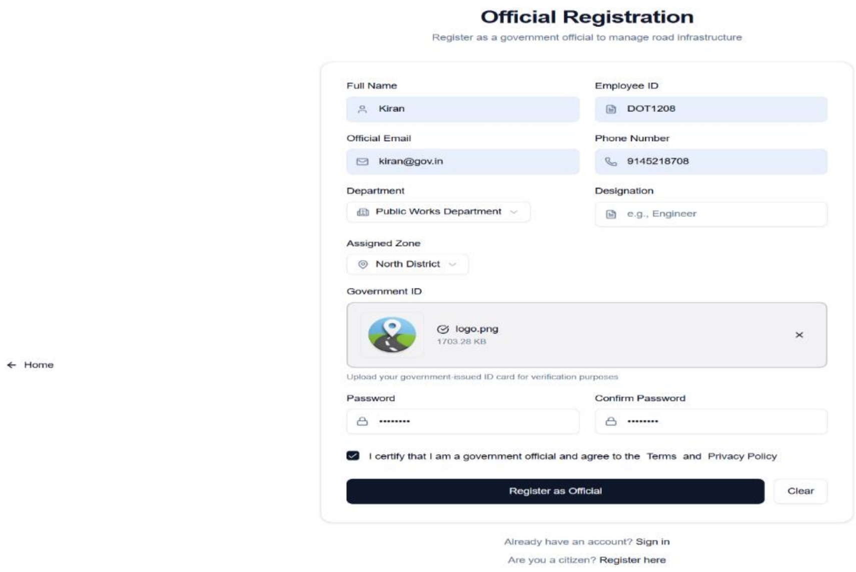
```
 @app.post("/api/register/citizen")
def register_citizen(user: schemas.CitizenRegister, db: Session = Depends(get_db)):
    # Check for existing account
    existing_user = db.query(models.User).filter(models.User.email == user.email).first()
    if existing_user:
        raise HTTPException(status_code=400, detail="Email already registered")

    # Hash password and create new user
    hashed_password = auth.get_password_hash(user.password)
    new_user = models.User(
        full_name=user.full_name,
        email=user.email,
        password_hash=hashed_password,
        role=models.UserRole.CITIZEN,
        is_active=True
    )
    db.add(new_user)
    db.commit()
    db.refresh(new_user)
    return {"message": "Registration successful", "user_id": new_user.id}

@app.post("/api/login")
def login(credentials: schemas.LoginRequest, db: Session = Depends(get_db)):
    user = auth.authenticate_user(db, credentials.email, credentials.password)
    if not user:
        raise HTTPException(status_code=401, detail="Invalid email or password")

    # Create JWT token
    access_token = auth.create_access_token(data={"sub": user.email})
    return {"access_token": access_token, "token_type": "bearer"}
```

Registration



← Home

Official Registration

Register as a government official to manage road infrastructure

Full Name: Kiran

Employee ID: DOT1208

Official Email: kiran@gov.in

Phone Number: 9145218708

Department: Public Works Department

Designation: e.g., Engineer

Assigned Zone: North District

Government ID: logo.png 1703.28 KB ×

Upload your government-issued ID card for verification purposes

Password: ••••••••

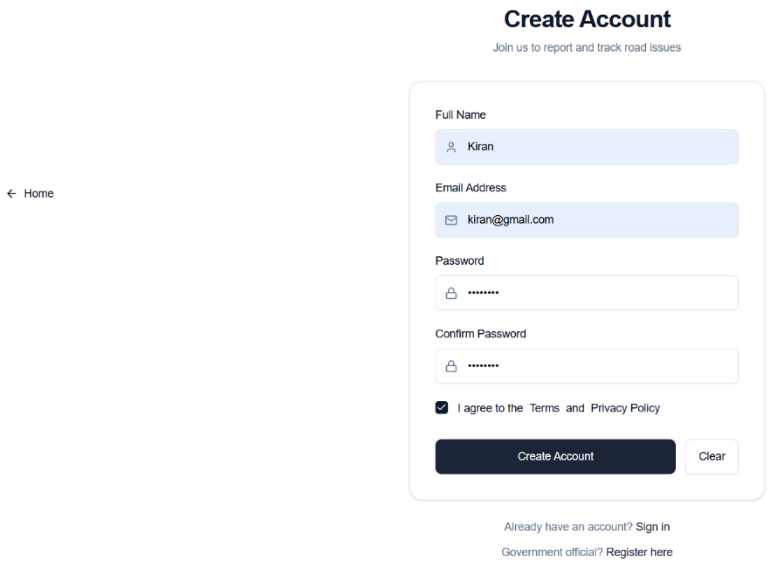
Confirm Password: ••••••••

☑ I certify that I am a government official and agree to the Terms and Privacy Policy

Register as Official | Clear

Already have an account? Sign in

Are you a citizen? Register here



← Home

Create Account

Join us to report and track road issues

Full Name: Kiran

Email Address: kiran@gmail.com

Password: ••••••••

Confirm Password: ••••••••

☑ I agree to the Terms and Privacy Policy

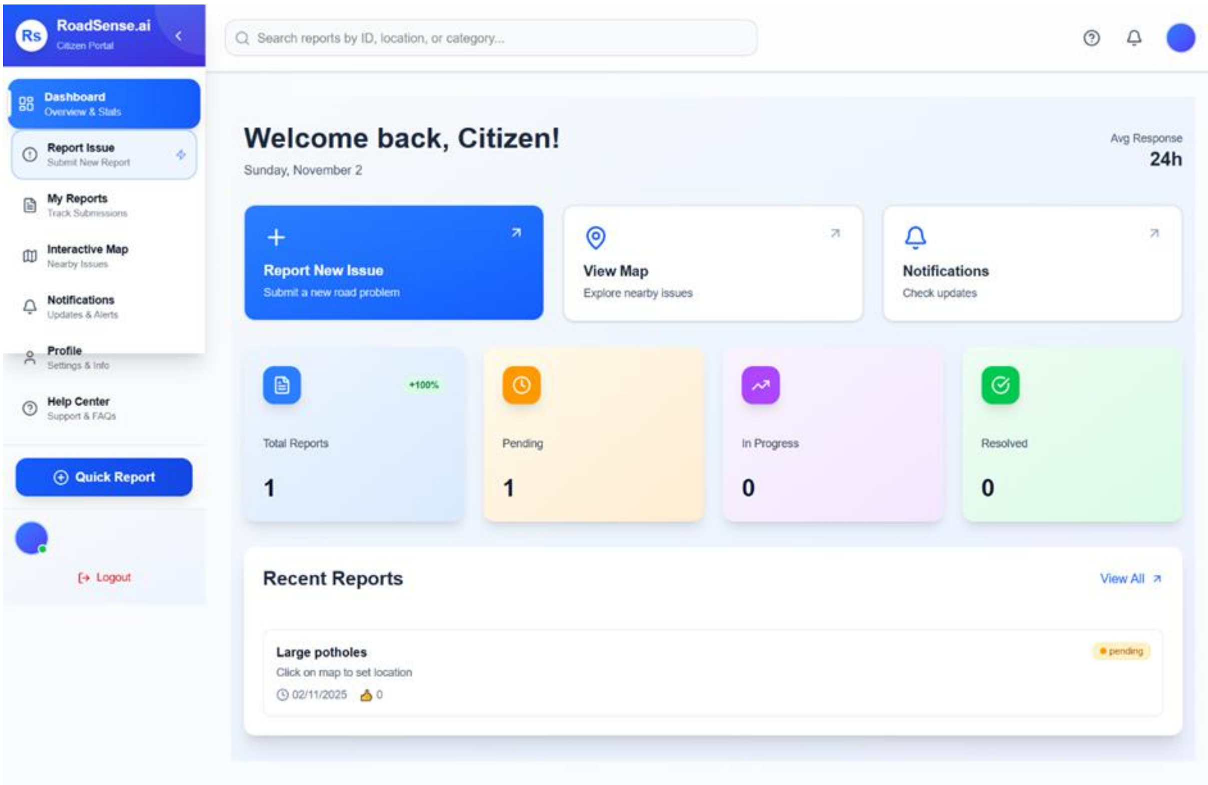
Create Account | Clear

Already have an account? Sign in

Government official? Register here

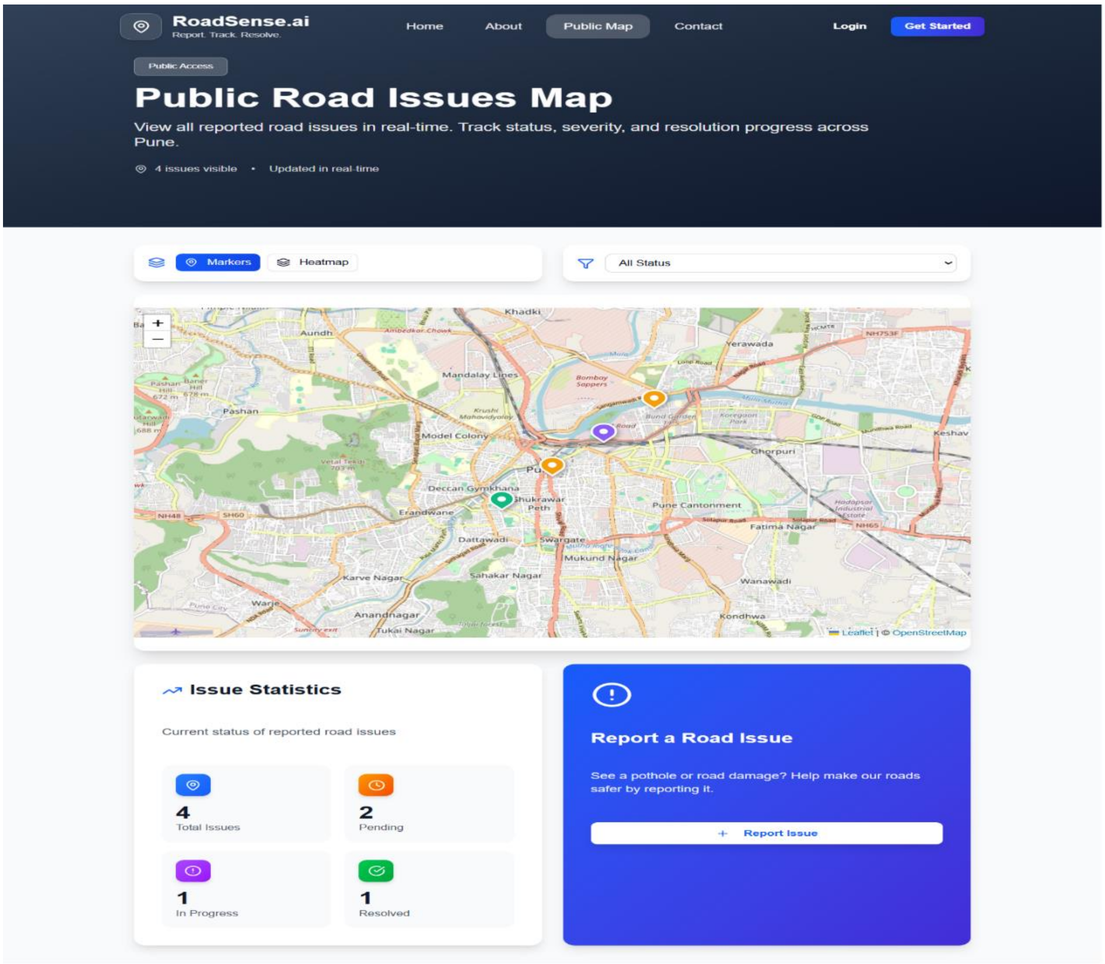
The **Registration Page** allows new users to create an account on the platform. Citizens can register by providing basic personal details and login credentials, while officials are required to submit additional information such as employee ID, department, and a verified government ID document. Input validation, file upload verification, and password hashing ensure data accuracy and security. Once registered, users can log in and access their respective dashboards based on their assigned roles

4.2 Main Dashboard :



The M**ain Navigation Page** of *RoadSense.ai* serves as the central access point for all user roles—citizens, officials, and administrators. It provides an intuitive interface that allows users to navigate between key modules such as report submission, issue tracking, analytics, and user profile management. The design focuses on simplicity and accessibility, ensuring that users can easily locate features relevant to their role. From this page, citizens can quickly submit new issues, officials can monitor and resolve assigned cases, and administrators can oversee system performance and predictive insights. This centralized navigation enhances user experience and streamlines interaction across the platform.

Public Map :



Public Road Issues Map

View all reported road issues in real-time. Track status, severity, and resolution progress across Pune.

4 issues visible • Updated in real-time

Issue Statistics

Current status of reported road issues

4 Total Issues

2 Pending

1 In Progress

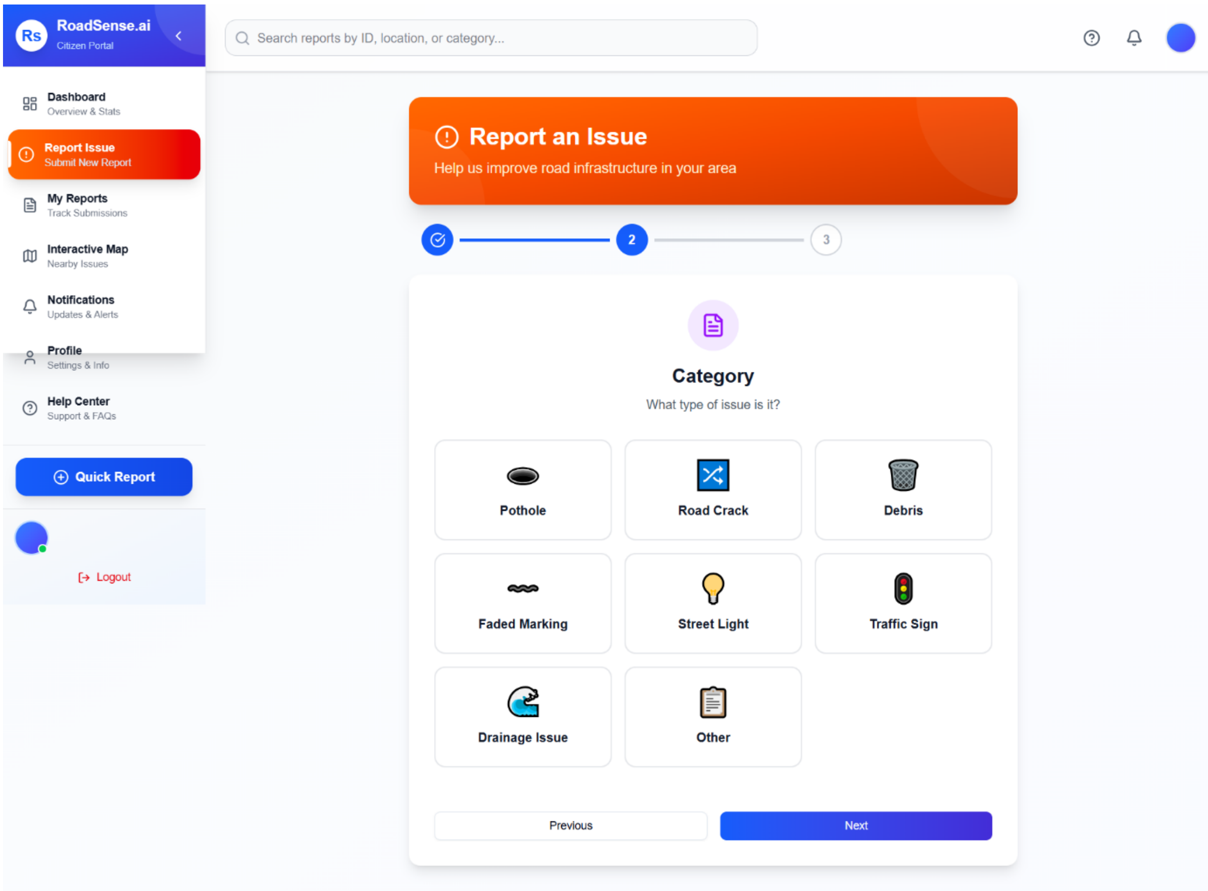
1 Resolved

Report a Road Issue

See a pothole or road damage? Help make our roads safer by reporting it.

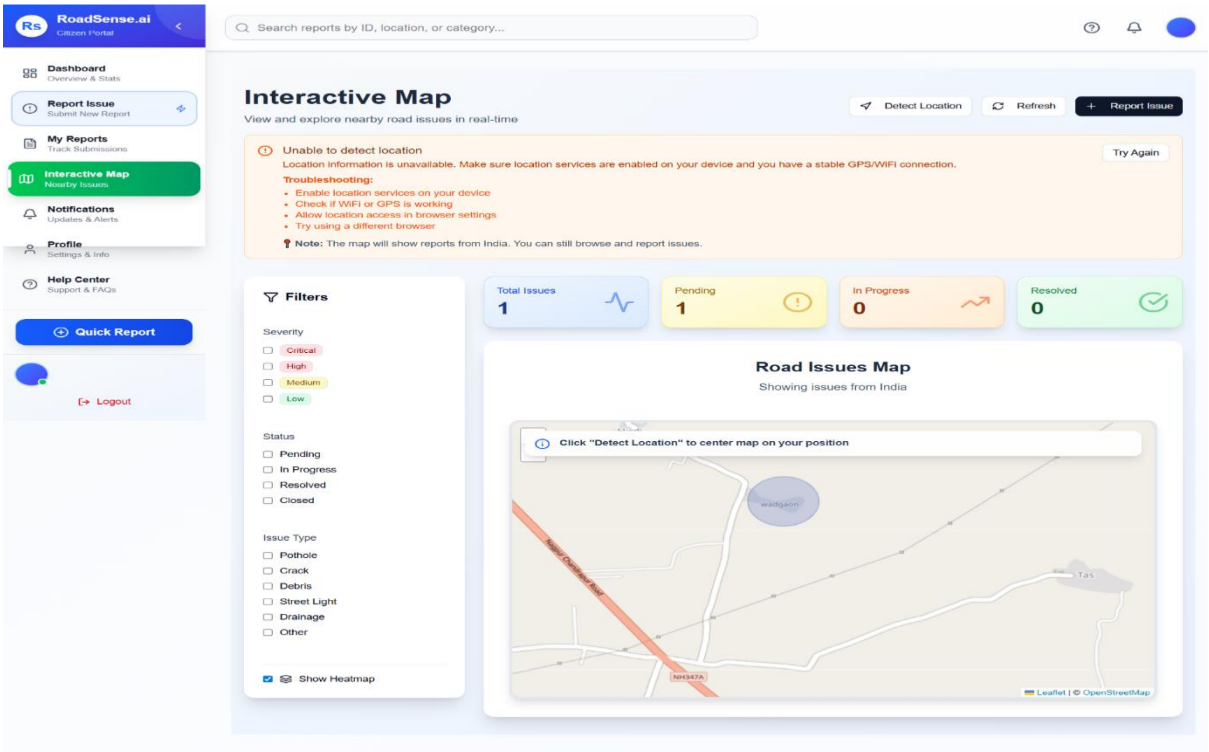
The **Public Map Page** provides an interactive geospatial view of reported road issues. Built using PostGIS and integrated mapping APIs, it visualizes real-time reports on a map interface with markers representing each issue's location and status. Users can zoom into specific zones, filter issues by category or severity, and view detailed information by clicking on a marker. This page enhances situational awareness and helps officials identify high-density problem areas at a glance.

4.3 Submitting New Report:



The **Report Submission Page** enables citizens to lodge new road issue reports quickly and accurately. The form includes fields for title, description, location (auto-fetched via GPS), and image uploads for visual evidence. On submission, the data is validated, geocoded, and stored in the database. The system assigns priority and severity levels, ensuring that issues are categorized efficiently for faster resolution.

4.Interactive Map :



Interactive Map

View and explore nearby road issues in real-time

Unable to detect location

Location information is unavailable. Make sure location services are enabled on your device and you have a stable GPS/WIFI connection.

Troubleshooting:

- Enable location services on your device
- Check if WiFi or GPS is working
- Allow location access in browser settings
- Try using a different browser

Note: The map will show reports from India. You can still browse and report issues.

Severity

- □ Critical
- □ High
- □ Medium
- □ Low

Status

- □ Pending
- □ In Progress
- □ Resolved
- □ Closed

Issue Type

- □ Pothole
- □ Crack
- □ Debris
- □ Street Light
- □ Drainage
- □ Other

☑ Show Heatmap

Total Issues	Pending	In Progress	Resolved
1	1	0	0

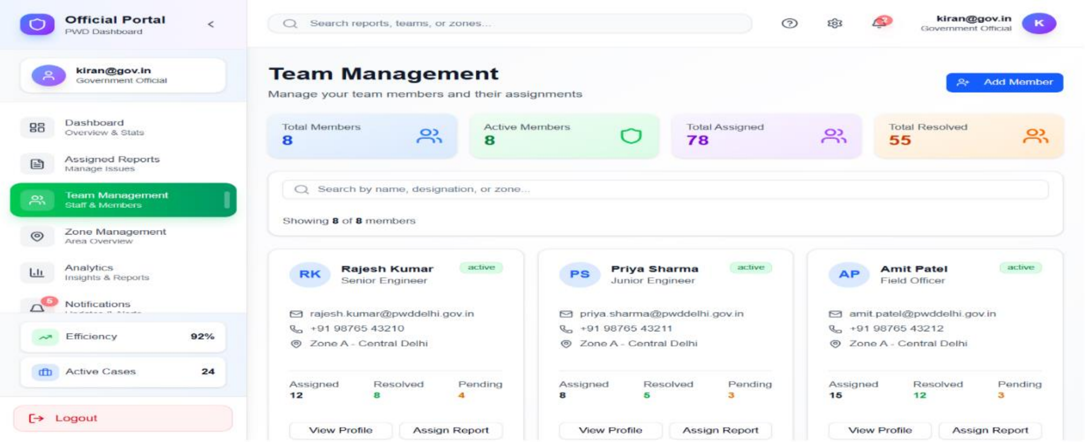
Road Issues Map

Showing issues from India

Click "Detect Location" to center map on your position

The **Interactive Page** provides citizens an interactive geospatial view of reported road issues

4.5 Team & Zone Management Pages :



Team Management

Manage your team members and their assignments

Total Members	Active Members	Total Assigned	Total Resolved
8	8	78	55

Search by name, designation, or zone...

Showing **8** of **8** members

RK **Rajesh Kumar** active
Senior Engineer
rajesh.kumar@pwddelhi.gov.in
+91 98765 43210
Zone A - Central Delhi

Assigned	Resolved	Pending
12	8	4

View Profile | Assign Report

PS **Priya Sharma** active
Junior Engineer
priya.sharma@pwddelhi.gov.in
+91 98765 43211
Zone A - Central Delhi

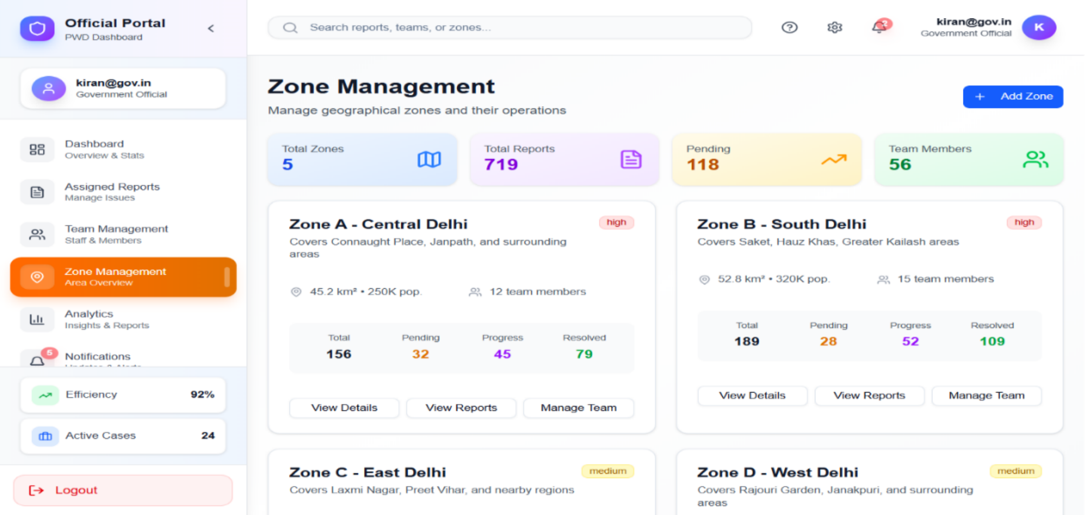
Assigned	Resolved	Pending
8	5	3

View Profile | Assign Report

AP **Amit Patel** active
Field Officer
amit.patel@pwddelhi.gov.in
+91 98765 43212
Zone A - Central Delhi

Assigned	Resolved	Pending
15	12	3

View Profile | Assign Report



Zone Management

Manage geographical zones and their operations

Total Zones	Total Reports	Pending	Team Members
5	719	118	56

Zone A - Central Delhi high
Covers Connaught Place, Janpath, and surrounding areas
45.2 km² • 250K pop. 12 team members

Total	Pending	Progress	Resolved
156	32	45	79

View Details | View Reports | Manage Team

Zone B - South Delhi high
Covers Saket, Hauz Khas, Greater Kailash areas
52.8 km² • 320K pop. 15 team members

Total	Pending	Progress	Resolved
189	28	52	109

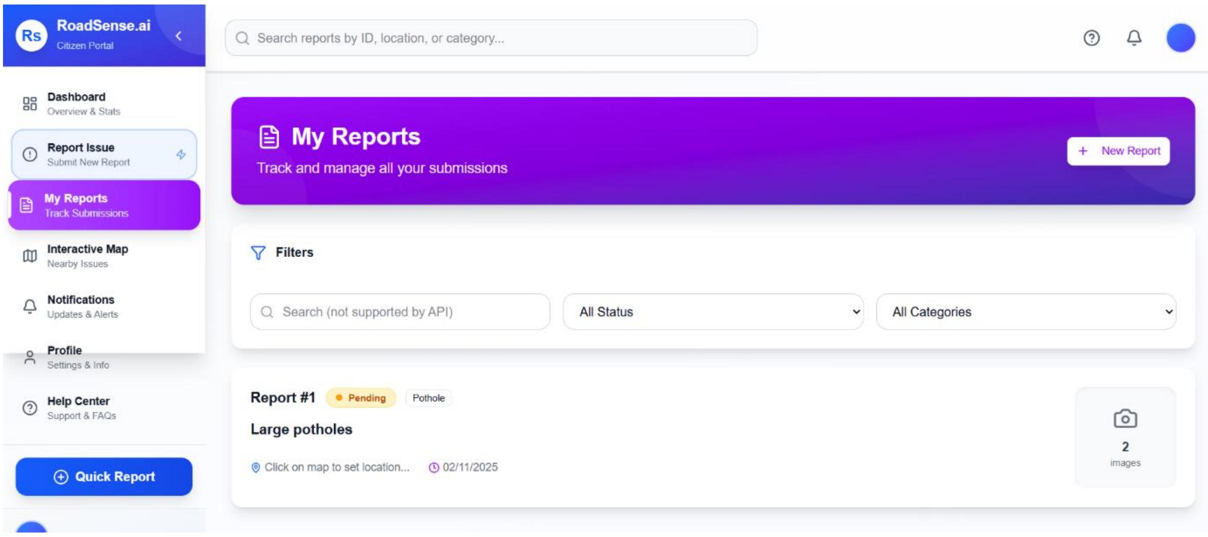
View Details | View Reports | Manage Team

Zone C - East Delhi medium
Covers Laxmi Nagar, Preet Vihar, and nearby regions

Zone D - West Delhi medium
Covers Rajouri Garden, Janakpuri, and surrounding areas

The **Team Management Page** allows administrators to create and manage official teams responsible for different zones. Each team can be assigned specific members, supervisors, and operational areas. The **Zone Management Page** complements this by providing tools to define geographic zones, upload boundary data, and link reports or teams to specific locations. Together, these pages ensure organized workflow distribution and clear jurisdictional accountability.

4.6 My Report Page:



My Reports

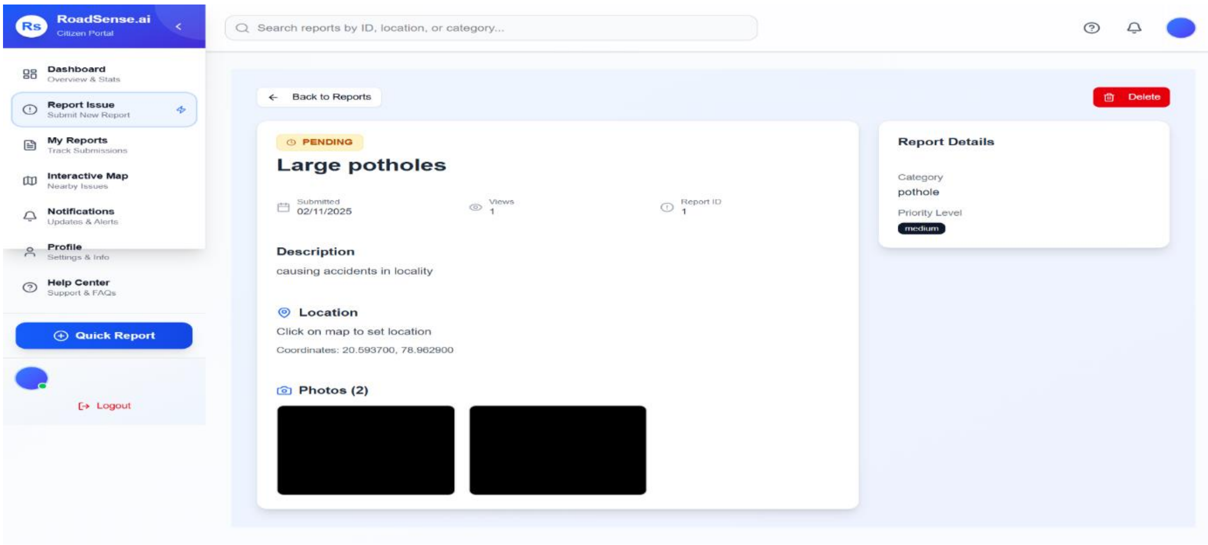
Track and manage all your submissions

Report #1 Pending Pothole

Large potholes

Click on map to set location... 02/11/2025

2 images



PENDING

Large potholes

Submitted 02/11/2025

Views 1

Report ID 1

Description

causing accidents in locality

Location

Click on map to set location

Coordinates: 20.593700, 78.962900

Photos (2)

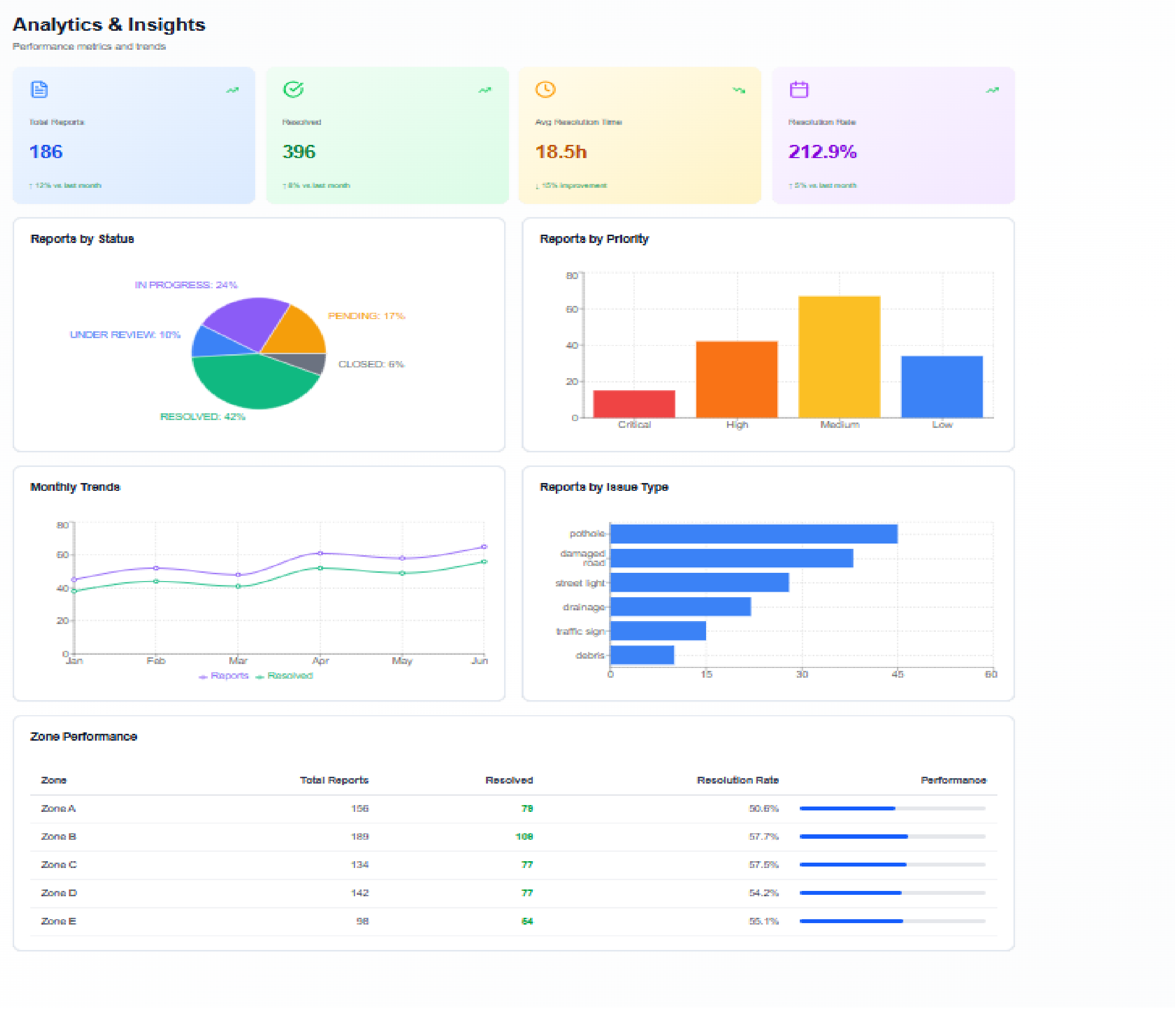
Report Details

Category: pothole

Priority Level: medium

The **Current Reports Page** displays all ongoing and recent issue reports in a structured format. It provides filtering and sorting options based on location, severity, and status. Officials can update progress, add comments, or mark reports as resolved. Citizens can track their submitted reports, view updates, and provide feedback on completed tasks. This page ensures transparency and maintains effective two-way communication between citizens and authorities.

Comprehensive Analysis of Complaints:



Analytics & Insights

Performance metrics and trends

Total Reports
186
↑ 12% vs last month

Resolved
396
↑ 8% vs last month

Avg Resolution Time
18.5h
↓ 15% improvement

Resolution Rate
212.9%
↑ 5% vs last month

Zone Performance

Zone	Total Reports	Resolved	Resolution Rate	Performance
Zone A	156	79	50.6%	
Zone B	189	109	57.7%	
Zone C	134	77	57.5%	
Zone D	142	77	54.2%	
Zone E	98	54	55.1%	

The **Analysis and Statistics Page** presents visual insights and analytical summaries derived from the system’s database and machine learning models. It includes charts, heatmaps, and predictive graphs showing issue trends, resolution rates, and high-risk areas. The page enables administrators to monitor performance metrics and plan preventive maintenance based on data-driven predictions. This analytical component transforms raw report data into actionable intelligence for smarter city management.

5.Conclusion:

The *RoadSense.ai* project successfully demonstrates how geospatial intelligence, data analytics, and citizen participation can be integrated to create a smart, responsive, and data-driven road maintenance system. The platform bridges the communication gap between citizens and civic authorities by providing a unified digital medium for road issue reporting, monitoring, and resolution. Through its user-friendly interface, citizens can easily report issues with precise geolocation and visual proof, while officials can efficiently manage and resolve complaints through their dashboards.

By using **PostgreSQL** integrated with **PostGIS**, the system efficiently stores and analyzes spatial data, enabling accurate mapping of issues and region-specific decision-making. Furthermore, the inclusion of a **machine learning module** enhances predictive capabilities, allowing authorities to anticipate recurring issues based on historical patterns and seasonal variations. This predictive maintenance approach helps optimize resources, reduce repair delays, and prevent infrastructure degradation.

The modular architecture of *RoadSense.ai*, built on **FastAPI** and **SQLAlchemy**, ensures scalability, security, and performance. The project's structured database schema supports data integrity and provides a solid foundation for future upgrades such as IoT sensor integration and computer vision-based pothole detection. The combination of analytical dashboards and intelligent mapping tools transforms raw civic data into actionable insights, fostering transparency and accountability in road management.

In conclusion, *RoadSense.ai* stands as a practical example of how technology can empower urban governance and community engagement. It not only simplifies road issue management but also embodies the broader vision of smart city infrastructure — one that is efficient, participatory, and sustainable. Future improvements could include integration with municipal APIs, AI-based damage classification, and automated maintenance scheduling to further enhance the platform's efficiency and social impact.

6. References:

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