iJRASET

International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 Issue: IX Month of publication: September 2026

DOI: https://doi.org/10.22214/ijraset.2026.84872

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue IX Sep 2026- Available at www.ijraset.com

Smart Women Safety Prediction and Alert System

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***Abstract:* Women's safety is a major concern, especially in urban areas where risks can vary with location, time, and previous incidents. Most existing safety applications mainly focus on emergency assistance rather than identifying risky areas in advance. This paper presents a web-based Smart Women Safety Prediction & Alert System that combines Machine Learning, GIS, incident analysis, and emergency alerts. K-Means clustering is used to identify incident hotspots, while Logistic Regression predicts Low, Medium, and High risk levels. The system provides Incident Reporting, Safety Map, Safe Route, Nearby Police, Emergency Contacts, and Quick SOS features. Using 12,000 incident records, the system generated 10 clusters, and the Logistic Regression model achieved 84.42% accuracy. PostgreSQL with PostGIS, React.js, and Flask were used for system development. The proposed system combines safety prediction, location-based analysis, and emergency support in a single web platform.**
***Keywords:* Women Safety, Machine Learning, Risk Prediction, Safety Hotspot Detection, GIS, Emergency Alert System.**

I. INTRODUCTION

Women's safety is an important social concern, as incidents such as harassment, stalking, and assault can occur in public places and during travel. Smartphones, GPS, and location-based applications are widely used for emergency support through SOS alerts and location sharing. However, most existing systems mainly respond after an emergency occurs and provide limited information about possible risks in advance.

The use of Machine Learning (ML), and Geographic Information Systems (GIS) can help identify potentially risky areas using incident data. Historical incidents can be analyzed based on location and time to identify patterns and hotspots, while GIS can display this information on a map. The Smart Women Safety Prediction & Alert System is a web-based platform developed to provide safety prediction and emergency support. K-Means clustering is used to identify incident hotspots, while Logistic Regression predicts risk levels as Low, Medium, or High.

A. Objectives

The main objectives of the proposed system are:

1. To collect and incorporate user-reported incident data into the existing incident records, enabling the safety information to be updated and supporting the generation of Low, Medium, and High risk levels.
2. To provide users with the safest available route from their current location to a selected destination by considering the safety information of the areas along the route.
3. To help users identify nearby risky areas for a selected location by providing location-based safety and incident information.

II. RELATED WORK

Several studies have explored the use of Artificial Intelligence (AI), Machine Learning (ML), GPS, GIS, and emergency alert technologies to improve women's safety.

Ara and Rajeshwari [1] proposed an AI-based women safety and alert system that provides SOS alerts, location tracking, and emergency communication. The system also uses previous alert information to identify unsafe areas. However, it does not provide community-based incident reporting or dynamic risk prediction. Sinha et al. [2] developed a women safety system using GPS tracking, wearable devices, biometric monitoring, and emergency communication. The system supports voice-based SOS and emergency assistance. Vasantha et al. [3] proposed an AI-powered safety system using predictive crime alerting, computer vision, GPS, and emergency response. These systems mainly focus on emergency detection and monitoring. Lokesh et al. [4] presented a women safety analytics system using YOLO, SSD, CNN, crowd density analysis, and lone-woman detection to identify possible threats. Although the system provides proactive monitoring, it does not combine incident reporting with dynamic risk scoring and safer route support.

Indalkar et al. [5] reviewed technologies used for women's safety, including GPS tracking, geofencing, wearable devices, AI, and emergency alerts. The study also discussed challenges such as GPS limitations, privacy, internet dependency, and false alarms. Satya Sree et al. [6] proposed *Safe Path*, which provides safe route suggestions, live location tracking, SOS alerts, and emergency contacts. The system uses crime, GPS, and traffic information for route suggestions. However, it does not provide community-based incident reporting or a continuously updated risk model.

Shankar et al. [7] developed a Machine Learning-based women safety application using audio sensing, geolocation, cloud storage, and emergency alerts. The system can detect distress through audio patterns and send emergency information. Prakruthi et al. [8] discussed a location-based women safety system using scream analysis, Machine Learning, GPS, community awareness, and wearable technologies. The approach mainly focuses on detecting emergency situations rather than predicting risk from incident location and time patterns.

Eranpurwala et al. [9] proposed a women safety application for safe route prediction using GPS, crime data, user reviews, and route safety analysis. The system provides safer routes based on location and time. However, it has limited support for community-based incident reporting and dynamic risk analysis. Agarwal et al. [10] proposed SafeRoutes, which uses K-Means clustering, Gaussian Mixture Models, heatmap generation, and GPS-based route safety analysis. The study shows the usefulness of clustering and route analysis for women's safety. However, it mainly depends on historical crime data and does not include community-based incident reporting.

Overall, the reviewed studies cover areas such as emergency alerts, GPS tracking, AI-based threat detection, safe route prediction, Machine Learning, and hotspot analysis. However, most systems focus on specific safety functions rather than combining them into one platform. The proposed Smart Women Safety Prediction & Alert System combines incident reporting, hotspot identification, risk prediction, GIS-based safety information, safer route support, nearby police identification, and emergency assistance in a single web-based platform.

A. *Research Gap Analysis*

Many studies have addressed women's safety using SOS alerts, GPS tracking, emergency communication, AI-based threat detection, and safe route prediction. These systems provide useful support for personal safety and emergency situations.

However, most existing systems focus on specific features and do not combine incident reporting, hotspot identification, risk prediction, safety maps, safer routes, nearby police information, and emergency assistance in one platform.

The literature review shows a need for a system that provides both safety prediction and emergency support. The proposed Smart Women Safety Prediction & Alert System addresses this gap by combining Machine Learning, GIS-based analysis, incident reporting, route support, and SOS assistance in a single web-based platform.

Table I
Research Gap Analysis For Women Safety

Existing Research Area	Major Contribution	Identified Gap
AI-Based Women Safety Systems	Provides intelligent alerts and emergency support.	Limited risk prediction and incident reporting.
GPS and Emergency Alert Systems	Provides GPS tracking, SOS alerts, and emergency notifications.	Mainly focuses on emergency situations.
AI-Based Threat Detection	Detects possible threats using AI, ML, audio, or images.	Limited location-based risk analysis.
Safe Route Prediction Systems	Provides safer routes using location and crime data.	Limited use of user-reported incidents.
Clustering-Based Safety Analysis	Identifies hotspots using clustering and maps.	Limited emergency support and incident reporting.
Existing Women Safety Research	Covers different safety and emergency features.	Most features are developed separately.
Proposed System	Combines incident reporting, hotspot identification, risk prediction, GIS, Safe Route, Nearby Police, and SOS.	Provides an integrated approach in one web-based platform.

Based on the analysis, the main gap is the lack of an integrated system that combines safety prediction with emergency support. The proposed system addresses this gap by bringing these features together in a single web-based platform.

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III. SYSTEM ARCHITECTURE

The proposed Smart Women Safety Prediction & Alert System focuses on providing a structured platform for location-based safety prediction, incident analysis, and emergency assistance. The system consists of four major components:

A. Incident Data and Risk Prediction Module

This module manages historical incident data and user-reported incidents. The collected data is processed to identify patterns based on location and time. K-Means clustering is used to identify incident hotspots, while Logistic Regression is used to predict the risk level of a location as Low, Medium, or High.

B. GIS and Safety Analysis Module

This module performs location-based safety analysis using geographic information. It supports hotspot visualization, safety map generation, nearby risky location identification, safe route processing, and identification of nearby police stations based on the selected location.

C. User and Emergency Management Module

This module provides user registration, login, incident reporting, emergency contact management, and access to safety information. Users can report incidents and view their submitted reports. The system also provides a two-click SOS mechanism for emergency situations.

D. Database and Alert Service Module

This module manages the storage of user information, incident records, risk scores, emergency contacts, and SOS alerts using PostgreSQL with PostGIS. During an SOS activation, the system identifies the nearest police station, retrieves the user's emergency contacts, and sends SMS notifications through the configured alert service.

The architecture connects these components through the web application and backend services to provide an integrated approach to women safety prediction, location-based analysis, and emergency assistance.

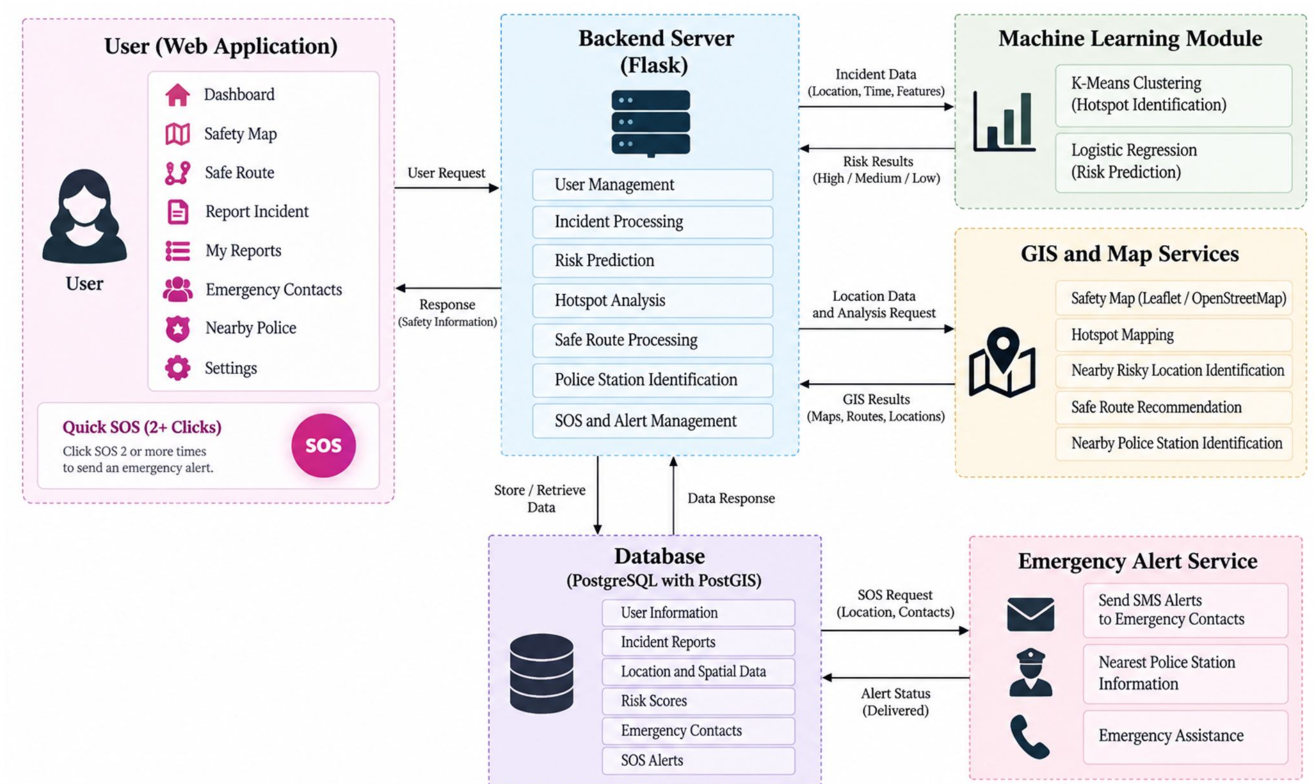

Fig. 1. System Architecture of Women Safety Prediction & Alert System

IV. METHODOLOGY

The methodology of the proposed Smart Women Safety Prediction & Alert System includes incident data preparation, feature engineering, hotspot identification, risk prediction, GIS-based analysis, route processing, and emergency alert processing.

A. Requirement Analysis

The system was designed to provide both safety information and emergency support. The main features include user registration, login, incident reporting, Safety Map, Safe Route, Nearby Police, Emergency Contacts, and Quick SOS. PostgreSQL with PostGIS is used to store user, incident, spatial, risk, emergency contact, and SOS information.

B. Incident Data Collection and Preprocessing

The system uses historical incident data and user-reported incidents. The historical dataset contains incident type, date, time, location, latitude, longitude, and description information. The historical dataset contained 12,000 records with no missing values or duplicate incident IDs. After preprocessing, all 12,000 records were retained for further analysis.

C. Feature Engineering

Six features are used for risk prediction**:** latitude, longitude, month, day of the week, hour, and cluster incident count. These features represent the location, time, and incident concentration required for risk analysis.

D. Hotspot Identification Using K-Means Clustering

K-Means clustering is used to group incident locations and identify areas with higher incident concentration. The number of clusters was set to 10, and the resulting cluster counts were used for further risk analysis.

E. Risk Labeling

Risk levels are assigned based on the concentration of incidents in each cluster using quantile-based thresholds. The system classifies locations into Low, Medium, and High risk levels, with a night-time adjustment also considered. The resulting dataset contained 1,802 Low-risk, 7,569 Medium-risk, and 2,629 High-risk records.

F. Risk Prediction Using Logistic Regression

Logistic Regression is used to predict the risk level of a selected location using the prepared features. The model predicts Low, Medium, or High risk. The model was trained using 9,600 records and evaluated using 2,400 test records. During implementation, the model achieved approximately 84.42% accuracy.

G. GIS-Based Safety and Location Analysis

PostGIS is used for managing spatial information, while Leaflet/OpenStreetMap is used for map visualization. The Safety Map displays risk information and hotspots based on location. Geographic coordinates are stored using SRID 4326.

H. Safe Route and Nearby Police Station Processing

The Safe Route feature processes the selected source and destination locations while considering nearby risky areas to support safer route selection. The Nearby Police feature uses geographic distance to identify the nearest police station based on the selected location.

I. Emergency Contact and SOS Alert Process

Users can add and manage emergency contacts through the application. The Quick SOS feature uses a two-click mechanism. When activated, the Flask backend processes the user's location, identifies the nearest police station, retrieves emergency contacts, and sends SMS notifications through Twilio. The SOS event and its status are also stored in the PostgreSQL database.

V. SYSTEM IMPLEMENTATION STEPS

The implementation of the proposed system follows these stages:

1) Set up the PostgreSQL with PostGIS database for storing users, incidents, risk data, emergency contacts, and SOS information.
2) Collect and preprocess incident data by cleaning the records and removing duplicates.

3) Store user-reported incidents in the database.
4) Prepare the required features using location and time information.
5) Apply K-Means clustering to identify incident hotspots.
6) Assign Low, Medium, and High risk levels based on incident concentration and time.
7) Train and integrate Logistic Regression for risk prediction.
8) Implement GIS features including Safety Map, Safe Route, and Nearby Police.
9) Implement Emergency Contacts and Quick SOS with SMS alerts and SOS record storage.
10) Integrate all components into the complete web application using the frontend, backend, ML, GIS, database, and alert services.

VI. EXPERIMENTAL RESULTS

The implemented Smart Women Safety Prediction & Alert System was tested using historical incident data and the developed web application. The historical dataset contained 12,000 records, with no missing values or duplicate incident IDs. After preprocessing, all 12,000 records were retained for further analysis. K-Means identified 10 incident clusters, and the Logistic Regression model achieved approximately 84.42% accuracy on the test dataset. The risk analysis resulted in 1,802 Low-risk, 7,569 Medium-risk, and 2,629 High-risk records. The system generated 10 risk records in the PostgreSQL database. The web application was also tested for Report Incident, Safety Map, Safe Route, Nearby Police, and Quick SOS features.

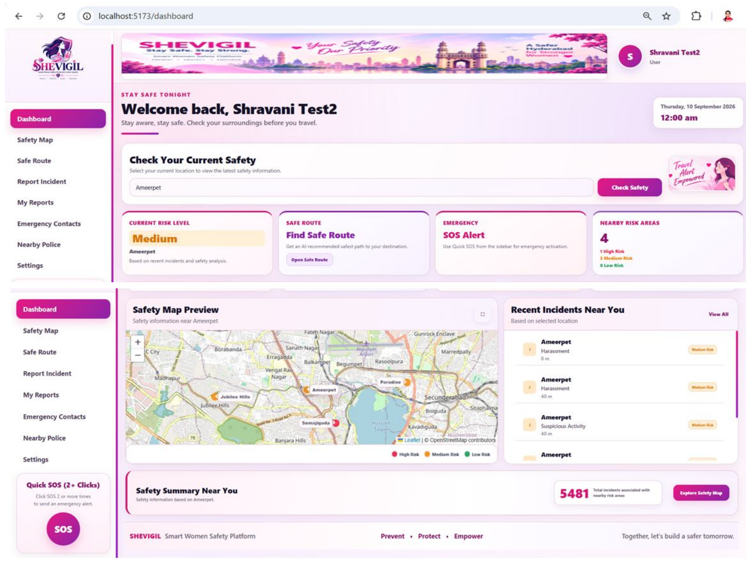

Fig. 2. User Dashboard

The dashboard provides access to the main safety features, including Safety Map, Safe Route, Report Incident, My Reports, Emergency Contacts, Nearby Police, and Quick SOS.

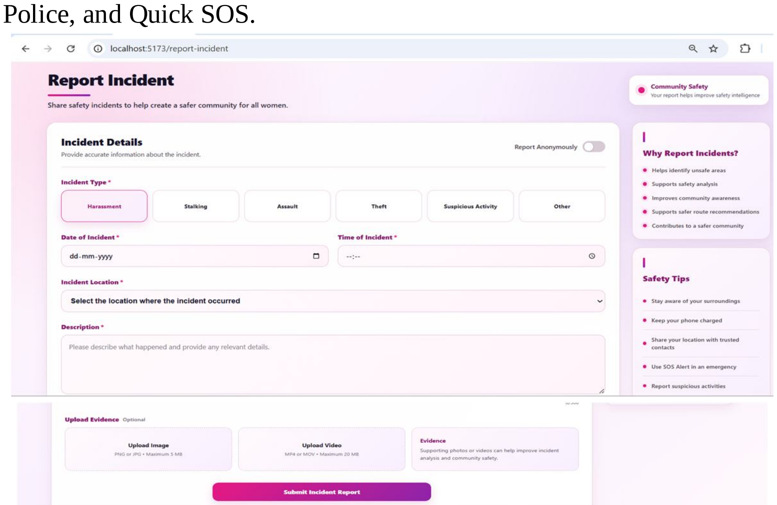

Fig. 3. Report Incident Interface

This interface allows users to submit incident details and location information. The submitted incidents are stored in the database.

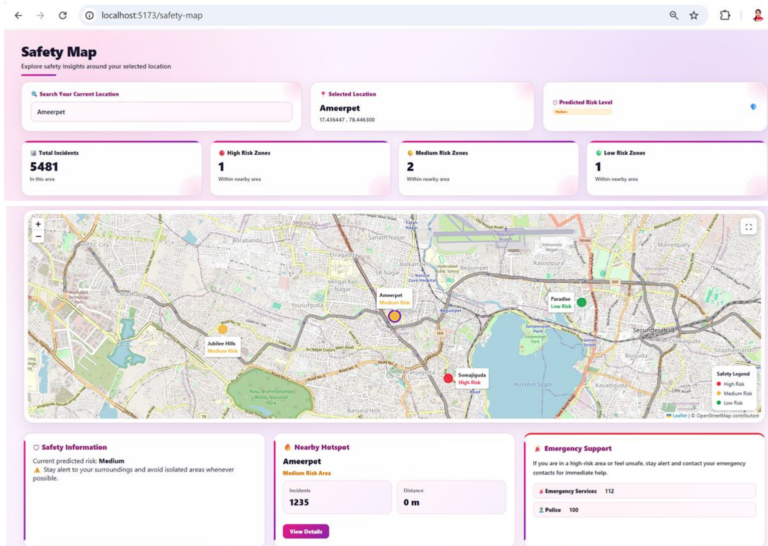

Fig. 4. Safety Map

The Safety Map displays location-based risk and incident information to help users understand the safety conditions of an area.

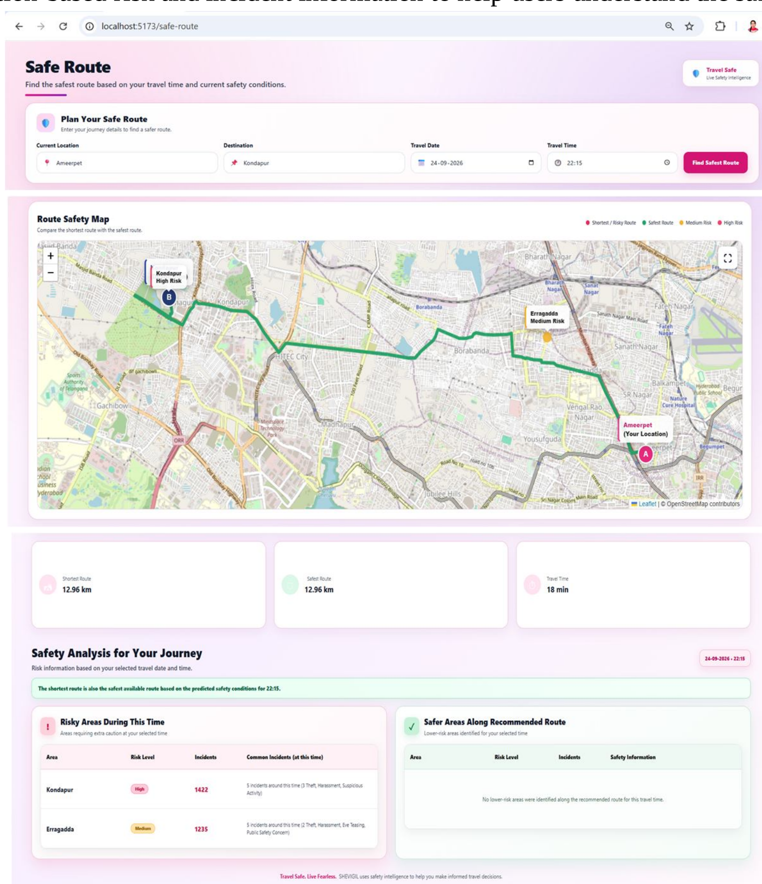

Fig. 5. Safe Route Interface

The Safe Route feature provides route information for the selected source and destination while considering the available safety information.

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
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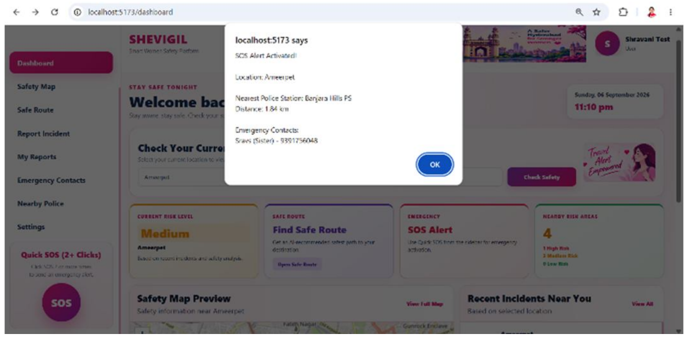

Fig. 6. SOS Alert Result

The Quick SOS feature was tested using the two-click mechanism. The system successfully stored the SOS event, identified the nearest police station, and sent an SMS notification to the registered emergency contact.

Overall, the results show that the system successfully combines risk prediction, hotspot identification, GIS-based safety analysis, and emergency assistance in a single web-based platform.

VII. FUTURE SCOPE

The proposed Smart Women Safety Prediction & Alert System provides a foundation for location-based risk analysis and emergency assistance. Although the current system integrates incident reporting, machine learning-based risk prediction, GIS analysis, safe route support, nearby police identification, and SOS alerts, several enhancements can be considered in future versions.

1) Larger and Updated Datasets: The system can use larger and regularly updated incident datasets from different locations to improve the accuracy of risk analysis and prediction.
2) Improved Risk Prediction: Advanced machine learning techniques can be explored to improve risk prediction and provide more accurate safety information.
3) Mobile Application Support: A dedicated mobile application can be developed to provide easier access to the Safety Map, Safe Route, emergency contacts, and SOS features.
4) Emergency Service Integration: The system can be extended to connect with police and other emergency services so that important emergency information can be forwarded directly to the appropriate authorities.
5) Real-Time Safety Data: Real-time and verified external data sources can be integrated to provide more updated information about incidents and changing safety conditions.
6) Cloud Deployment and Scalability: The system can be deployed on cloud infrastructure to support more users and larger datasets and can be extended to other cities and regions.

These enhancements can help make the system more scalable, accurate, and useful for practical safety applications.

VIII. CONCLUSION

This research presented the design and implementation of a Smart Women Safety Prediction & Alert System that combines machine learning, GIS-based analysis, incident reporting, and emergency alert services within a web-based platform. The system integrates K-Means clustering for identifying incident hotspots and Logistic Regression for predicting location-based risk levels as Low, Medium, and High.The implementation demonstrated that historical and user-reported incident data can be used to provide safety-related information through the Safety Map, while the Safe Route and Nearby Police features provide additional location-based support. The system also allows users to report incidents and manage emergency contacts, making the platform useful for both safety analysis and user assistance.

The Logistic Regression model achieved an accuracy of approximately 84.42%, and the K-Means clustering process generated 10 incident clusters from the 12,000-record dataset. The emergency module was also successfully integrated with the application through the two-click Quick SOS mechanism. During testing, the system identified the nearest police station, retrieved the registered emergency contacts, sent the configured SMS notification, and stored the SOS event in the PostgreSQL database.

Overall, the developed system provides a practical approach to combining risk prediction, hotspot identification, GIS-based safety analysis, and emergency assistance in a single platform. The implementation provides a foundation that can be further improved using larger datasets, updated safety information, mobile application support, and integration with additional emergency services.

IX. ACKNOWLEDGMENT

The authors express their sincere gratitude to Amirishetty Rajeshwar, Associate Professor, Department of Computer Applications, School of Informatics, Aurora Higher Education and Research Academy (Deemed-to-be University), for his valuable guidance, encouragement, and support throughout the development of this research work. The authors also thank the Department of Computer Applications for providing the necessary academic support and resources to complete this study successfully.

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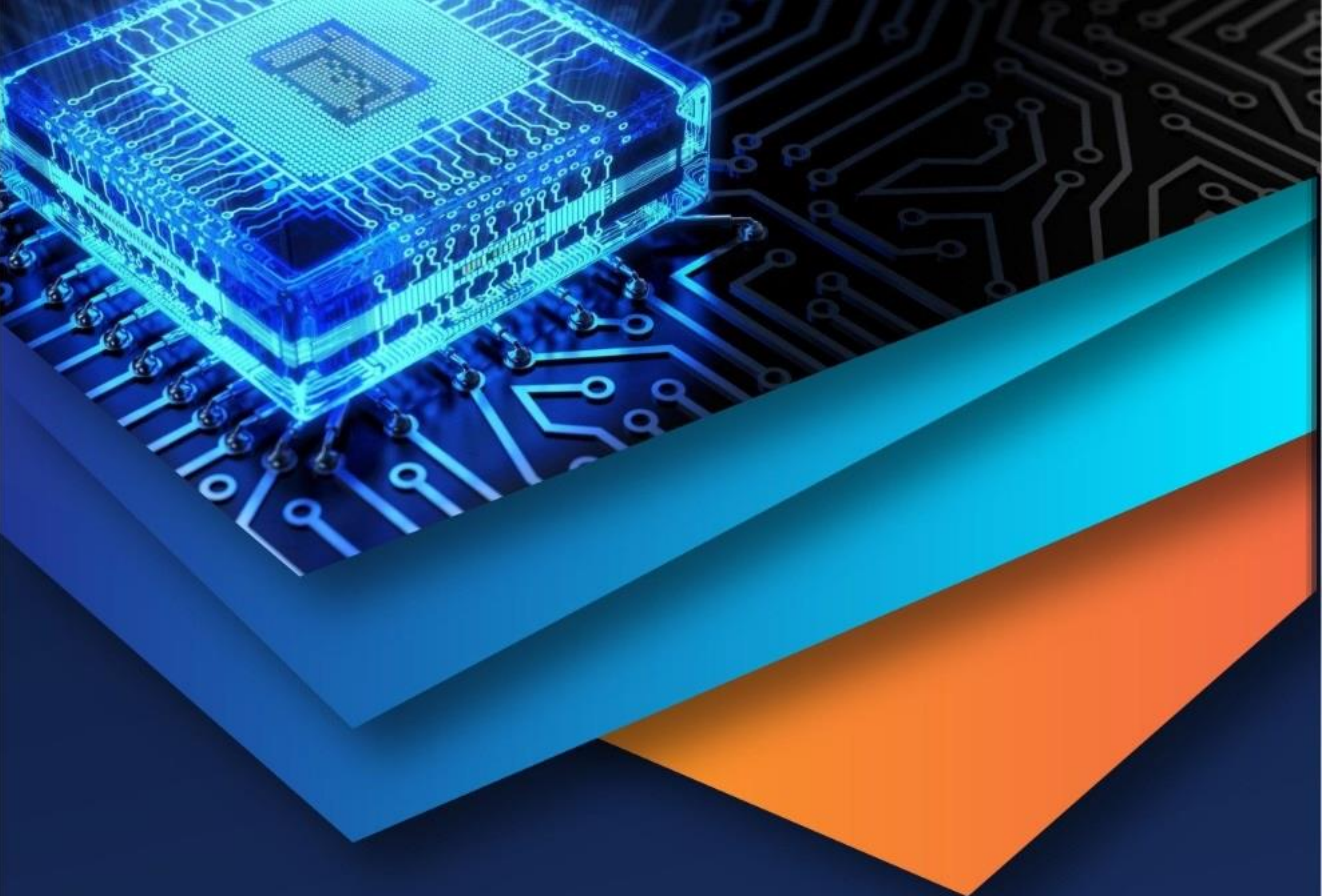

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