The Use of Geographic Information System (GIS) in Predictive Policing

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Abstract—In the contemporary landscape of law enforcement, policing strategies are rapidly evolving in response to changing crime patterns and increasing criminal sophistication. Predictive policing has emerged as a vital tool for preventing crimes before they occur, though its effectiveness has fluctuated with the advancement of technology. This research underscores the continued importance of refining predictive policing methods to effectively tackle modern crime challenges. Geographic Information System (GIS) technology is pivotal in this regard, offering robust tools for the visualization, storage, management, and analysis of geospatial data. By integrating GIS tools with crime mapping, statistical analysis, and law enforcement expertise, predictive policing can forecast high-risk areas and times for potential criminal activities. The research highlights the benefits of these technologies through initiatives such as India's Predictive Policing for Women's Safety, which aims to reduce violence against women. The study concludes that refining predictive policing and GIS integration is crucial for improving public safety.

Index Terms—Predictive Policing, Geographic Information System (GIS), Crime Mapping, Crime Prevention, Law Enforcement, Geospatial Data Analysis, Women safety.

I. INTRODUCTION

Policing has changed dramatically in recent years as crime patterns have rapidly evolved. To stay up with these changes, we need more effective methods for preventing crimes before they occur. Predictive policing is necessary for this aim. While this approach was traditionally used, its value has lessened as a result of increased reliance on technology. However, as crime patterns evolve and criminals become more skilled, studying and developing predictive policing is critical to effectively addressing these difficulties.

Geographic Information System (GIS) technologies are of core relevance to the visualization, storage, management, and analysis of geospatial data. They are of particular significance in the new field of predictive policing, which employs crime mapping, statistical modelling, and law enforcement experience to forecast the locations and time of likely criminal activity. With the budget constraints of most police agencies, predictive policing software can significantly enhance law enforcement effectiveness. By employing GIS-based crime analysis, agencies can position officers tactically in higher-risk areas, thus enhancing crime prevention efforts and optimizing resource deployment.[1]

Objectives:
1. To understand the effective utilization of GIS for predictive policing by law enforcement agencies.
2. To know about the use of GIS technology for women's safety by Indian Police.
3. To asses a case study on the implementation of crime mapping analytics and predictive policing by Delhi Police.

Meaning and Scope

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[1] U.S. Department of Homeland Security, Science and Technology Directorate. (2013). The geographic information software and predictive policing application note. Retrieved from: https://www.dhs.gov/sites/default/files/publications/GIS-Predictive-Policing-AppN_0813-508_0.pdf. Last accessed on 26-08-2024.

The phrase "geographic information system" involves a wide range of associated technology. Geographic Information System (GIS) is "a computer technology which combines geo-graphic information (the locations of man-made and natural earth surface features) and other kinds of data (names, classes, addresses, and more) in order to produce visual maps and reports." GIS operates on the premise of geographic location for linking unrelated sets of information and offers a systematic way of obtaining and handling location-based information that is central to governmental objectives.[2]

II. DISCUSSION

Predictive policing, enhanced by Geographic Information System (GIS) technology, represents a powerful evolution in crime prevention strategies. By analysing historical data and real-time information, predictive policing forecasts high-risk areas and times, allowing for proactive interventions and optimized resource allocation. GIS adds value by visualizing and analyzing geospatial data, creating detailed crime maps, and improving the accuracy of predictions. Challenges include potential biases in historical data, the need for accurate and comprehensive data, and financial constraints for many police departments. Addressing these issues requires careful management, ongoing data refinement, and possibly public-private partnerships to support technology adoption.
Programs like India's Predictive Policing for Women's Safety highlight the practical benefits of integrating GIS with targeted crime prevention efforts. To maximize effectiveness, continuous development and adaptation of these technologies are essential for enhancing public safety.

Use of geographic information technologies to aid law enforcement agencies:
Geographic Information Systems (GIS) is such a powerful tool for performing spatial analysis, but it does not have a agreed definition. Basically, GIS makes it easier to collect, store, analyze, and visualize geographic data, thus enabling the user to generate maps and access statistical information. GIS

utilization will only be successful if there are a number of essential elements, i.e., personnel (e.g., officials, managers, and technicians), computer software and hardware, data, and protocols. However, the actual potential of GIS lies in geographic reasoning—the process of asking spatial questions, organizing data, and interpreting geographic patterns. The union of GIS and geographic reasoning renders crime mapping a very useful tool for analysts performing crime analysis.

A GIS system is able to manipulate various kinds of geographic data, mainly raster data and vector data. Raster data consist of aerial photography, scanned maps, and satellite data, and are used as background layers but not as background for structured attribute data. Vector data consist of points, lines, and polygons and are widely used in crime mapping. An example is street centerline data, used to depict road networks, which is typically used as a base map to analyze crime. GIS also maintains attribute data within tables where each record corresponds to a geographic entity. Points are used to represent crime events, lines to represent street segments, and polygons to represent precinct boundaries. Attribute data can be updated and examined on its own separate from the map and is therefore a crucial component of crime analysis.
Police forces typically accept crime incident data from reports and input it into a database prior to selectively mapping it onto GIS. Geocoding, which puts crime locations into a GIS street database, is one of the most important steps in mapping. The database includes street names and address ranges for every city block, so crime locations can be identified even without exact addresses. Once a crime incident is input into GIS, it will be displayed as a point in the proper geographic location, and a corresponding record is held in the database. Every type of crime has a symbol assigned so that the analyst can easily identify patterns. Burglaries, robberies, and assaults, for instance, may each be represented by a different icon or color. Figurative symbols such as a gun, knife, or broken house are employed by some forces to symbolize specific crimes, while most employ geometric

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[2] O'Looney, J. (2000). Beyond maps: GIS and decision making in local government. United States: ESRI Press.

symbols such as circles, squares, and stars in several colors to differentiate crimes by several time periods.

With GIS, police can detect hotspots of crime, examine patterns, and design effective public safety interventions. The integration of spatial analysis and crime data allows the police to respond reactively, better preventing crime and allocating resources.

Importance of Data Integration and Real-Time Communication for Timely Responses:
Data integration and real-time communication play a crucial role in ensuring swift disaster response. Below are some key aspects highlighting their importance.

Comprehensive Situational Awareness:
Data integration entails combining information from numerous sources, such as sensors, satellite imaging, weather forecasts, and social media feeds. By combining these disparate databases in real time, emergency management authorities can get a full understanding of catastrophic situations. This comprehensive understanding facilitates improved decision-making and a more effective and coordinated response.

Early detection and rapid response:
 Real-time data integration enables early discovery of catastrophic events. Authorities can detect unexpected trends and abnormalities, as well as trigger thresholds that have been violated, signifying the start of a crisis, by continuously monitoring different data streams. Real-time communication enables for the quick broadcast of this information to important stakeholders, resulting in a faster response Communication, customized messaging, two-way communication, and integration with other technology can all be used to send out timely alerts and warnings, activate evacuation plans, and mobilize emergency services. Using these tools, emergency management agencies may ensure that critical information reaches the public quickly and efficiently, allowing for a more

informed and responsive approach to disaster management. [3]

Aiding crime analysis
The most common method is having a crime analyst use GIS to examine the space and time facets related to a string of crimes, as well as detect patterns, trends, and anomalies. In the majority of police forces, crime analysts view GIS as a significant yet not essential resource. They will often create only subset reports about the crimes or construct crime maps reacting to given types of occurrences, i.e., serial robbery or rape. The departments take liberal use of GIS due to it being fairly a new advancement within policing. Besides, geocoding of every crime event, or indeed all large crime, is challenging an operation to do, and appropriate resources at several agencies aren't being rendered in order to support maintenance.[4]

Overview of Predictive Policing Models and Their GIS Applications in Crime Prevention:
1. Hot Spot Analysis: AI algorithms analyze crime data to pinpoint places with a higher risk of crime. Law enforcement can then direct resources toward these hotspots, increasing patrols and monitoring to dissuade criminal activity.
2. Crime Trend Analysis: AI algorithms may find patterns and trends in crime data to predict potential escalation or reoccurring crimes in specific places. This knowledge permits proactive intervention and tailored preventative strategies.
3. Identifying Repeat Offenders: AI can examine data to identify individuals who have committed multiple crimes. This information enables law enforcement to closely monitor high-risk individuals and intervene before they commit additional crimes.
4. Resource Optimization: AI algorithms optimize resource allocation, including patrol routes and staffing, by prioritizing crime-prone regions and times. This guarantees that law enforcement agencies make the best possible use of their resources.

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[3] Geospatial Technology for Natural Resource Management. (2024). United States: Wiley.
[4] *GIS in Law Enforcement: Implementation Issues and*

Case   Studies. (2002). United

Kingdom: Taylor & Francis. Last Accessed on: 12/09/2024.

III. PREDICTIVE POLICING FOR WOMEN'S SAFETY USING GIS TECHNOLOGY BY INDIAN POLICE

The Predictive Policing for Women Safety initiative in India, includes software and a control centre, will analyse and dynamically update a database to monitor crime against women. This output will assist field police officers by providing dynamic crime hotspots. This program enables effective patrolling points and routines for field police vehicles. This software bundle will include several components.

1. GIS Ecosystem: The GIS ecosystem includes three segments: input, processing, and output. Data inputs include digital maps, satellite images, and demographic/socioeconomic/crime data. GIS software can process large amounts of data in real-time. The result will include dynamic crime thematic maps and targeted vulnerability/patrolling routes.
2. Core AI engine: The core AI engine integrates data from various sources and formats to generate geographic, tabular, and document outputs.
3. Mobile Applications: Input and output

Input: A dedicated program in an open domain collects threat scores for different places and persons, as well as trustworthy data from social media networks.

Output: Inform police personnel for necessary action and let establishing daily patrol routes.

4. CAD (Computer Aided Dispatch): software is needed for vehicle scheduling and field feedback/reporting.

In addition to the software, frequent surveys are conducted among women living in vulnerable parts of the field. This survey informs the design of questions used to generate threat scores and predictive assessments for regions and individuals. Women, particularly those experiencing domestic violence and physical abuse, often refrain from reporting their issues, making it crucial to address them. To assess domestic violence and physical abuse, a complete survey is including indications rather than direct questions.[5]

Predictive Tools to Cater Policing for Women's Safety:

In the quest to make cities safer and more accessible, developing a fully-fledged crowdsourcing tool for gathering data is critical. The tool will gather and analyze various inputs, from social media comments and special online portals to offline trust points that gather offline feedback, especially from women and girls who have been known to be limited in accessing digital spaces. Through the use of Geographic Information Systems (GIS), accurate geospatial coordinates can be charted, facilitating the detection of dangerous zones with great accuracy. GIS map analysis is central to this endeavour, as it provides for the visualization, interpretation, and spatial analysis of crime data. For example, the National Geoportal, built and hosted by ISRO, provides flexible features including satellite imagery visualization, enhanced data analysis facilities, and download of free data, which can greatly aid the identification and tracking of areas prone to crime.

Fusion of various data sources, e.g., Crime and Criminal Tracking Network & Systems (CCTNS) database, Emergency Response Support System (ERSS) 112/100 dial systems, traffic offense records, CCTV analytics, and online police reports, enhance the predictive model. GIS maps can superimpose these sets to detect spatial patterns, e.g., crime hotspots and cold spots, and monitor their dynamic evolution with time. For instance, hotspots can be identified as areas frequently reporting street harassment, stalking, or bullying, whereas cold spots can be identified as those areas with lower criminal activity after interventions. This geographic analysis assists law enforcement agencies in more efficiently deploying resources and planning focused interventions. In addition, GIS maps may include real-time information from social media updates, face analytics, and automatic number plate recognition (ANPR) systems, creating a complete and current picture of crime patterns.

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[5] Retrieved from: Predictive policing for women safety:
https://bprd.nic.in/uploads/pdf/202203031148045524 485PredictivePolicingforWomen.pdf Last accessed on 26-08-2024. Last accessed on 02/03/2025.

GIS map analysis
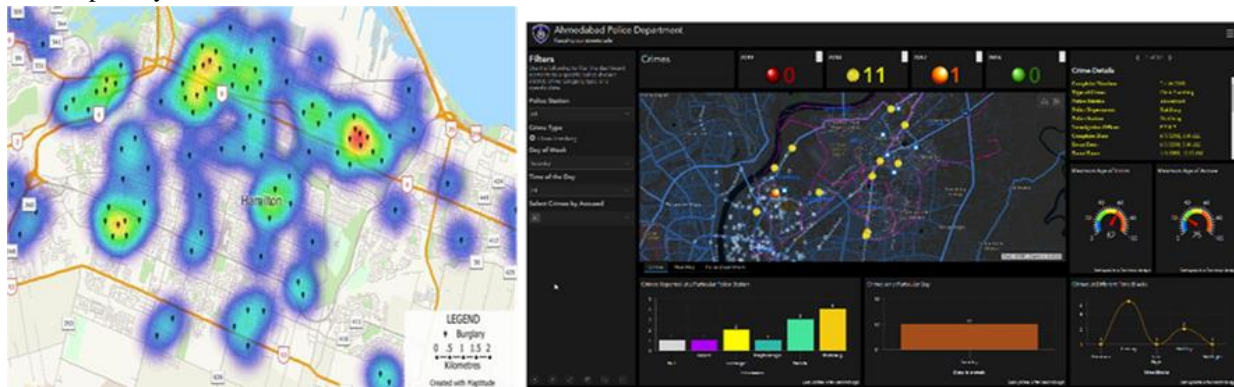
Source:https://bprd.nic.in/uploads/pdf/202203031148045524485PredictivePolicingforWomen.pdf Last accessed on 26-08-2024. Last accessed on 02/03/2025

The physical trust points' role, aided by NGOs and social workers, is also important within this system. The trust points allow for proper, grassroots-level data to be collected, especially in poor neighbourhoods where digital connectivity might not be present. By incorporating such data into GIS maps, the predictive model gets stronger, with the ability to detect early warning signs of crime and create proactive interventions. Finally, GIS-based map analysis not only increases the precision of crime mapping but also empowers communities by offering a technical paradigm that guarantees confidentiality, inclusivity, and real-time responsiveness, setting the stage for safer and more secure public spaces.[6]

IV. CASE STUDY: IMPLEMENTATION OF CMAPS BY DELHI POLICE FOR PREDICTIVE POLICING

Introduction

As technology has advanced, so too have crime prevention and law enforcement. With CMAPS (Crime Mapping Analytics and Predictive System), a cutting-edge program that combines geographical mapping and real-time crime data, the Delhi Police have adopted a data-driven strategy. The application, advantages, and difficulties of CMAPS in strengthening crime prevention tactics in the nation's capital are examined in this case study.

Background

Delhi, which is 1,483 square kilometres in size and has 13 police districts, has a high crime rate and needs efficient policing techniques. Prior to now, crime mapping was done by hand at 15-day intervals, which limited the ability to respond in real time. CMAPS, which uses real-time data from the Dial 100 helpline and ISRO's satellite images for crime hotspot detection, was adopted in response to the demand for a more dynamic and predictive approach.

Implementation of CMAPS:

CMAPS represents crime trends by combining geospatial analytics with emergency call data. A major improvement over the previous method, the software updates its data every three minutes. The Delhi Police can proactively deploy resources according to the predictive analytics built into CMAPS, which forecasts possible crime scenes using statistical models.

Key Features of CMAPS:

1. Real-time crime mapping: To pinpoint hotspots, 100 dialed calls are placed on geographic maps.
2. Predictive policing: By using statistical models to identify criminal hotspots, preventative actions can be taken.
3. Data-Driven Decision Making: CMAPS assists in linking crime incidences to certain locations, such as bars, which have been connected to an increase in robbery cases.
4. Improved Response Time: Quick police action is guaranteed by the three-minute update cycle.

Impact on Policing:

By implementing a proactive approach to crime prevention instead of a reactive one, CMAPS has completely transformed Delhi's police force. Better

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[6] Ibid.

resource allocation and increased public safety have resulted from the capacity to anticipate and prevent crimes. Law enforcement can carry out focused interventions, including heightened patrols and surveillance, by identifying crime-prone regions.

Challenges and limitations:

Despite its benefits, CMAPS has drawbacks, including issues with data veracity, system reliance on technology infrastructure, and privacy. Integration with other law enforcement databases and ongoing police training are also necessary for successful implementation.[7]

In conclusion:

Delhi Police's approach to crime prevention has undergone a paradigm shift with the implementation of CMAPS. CMAPS has improved situational awareness by utilizing real-time data and predictive analytics, which enables strategic decision-making in law enforcement. Even though there are still difficulties to overcome, integrating technology into crime prevention is an essential first step toward effective urban law enforcement.

Key Impacts of Predictive Policing Technologies

Fig. 2 Postulated impacts of predictive policing in 2025

Source**:**https://www.google.co.in/books/edition/Policing_in_the_Era_of_AI_and_Smart_Soci/SufxDwAAQBAJ?hl=en&gbpv=0

- Predictive policing technologies are by 2025 affecting law enforcement, although controversies continue regarding whether the benefits seen are the result of the technology or other causes. These technologies have brought about major societal changes, as discussed below.

- Ethical Impacts, Predictive systems are resented by veteran officers, who see them as eroding their expertise, without acknowledging the transition from street crime to cyber and financial crime. Increased accountability, such as bodycams, has subjected police actions to greater scrutiny. Civil

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[7] https://www.hindustantimes.com/delhi/delhi-police-is-using-precrime-data-analysis-to-send-its-men-to-likely-trouble-spots/story-

hZcCRyWMVoNSsRhnBNgOHI.html Feb 27, 2017 06:38 PM IST, Last accesed on 14/09/2024.

rights organizations claim that predictive policing violates basic rights, debating whether responding to an 80% accurate algorithm is a violation of due process. On the other hand, not responding is said to be a violation of victims' rights.

- While predictive policing has assisted in making discriminatory stop-and-searches public, it has also entrenched certain biases. Debates in the public sphere have resulted in tighter controls on explain ability and the creation of autonomous inspection bodies. Media attention has also shifted to corporate accountability, especially on the part of tech behemoths holding back vital information on criminal activity.

- Legal frameworks fail to keep up with technological developments. Most lawmakers are not technically versed, hindering regulation. Although the GDPR continues to be applicable, data aggregation erodes anonymity. The Police Directive enables LEAs to investigate without permission, though bans on automated decision-making are too unenforceable. The general disobedience of some GDPR aspects has reduced legal compliance among individuals and companies.

- Social Impacts, Criminals utilize technology quicker than police can counter. Predictive policing works against street crime, but organized and white-collar crime (e.g., money laundering, fraud, hacking) continue to adapt.

- Public awareness of predictive policing is low, buried under information overload and disinformation. Surveillance is normalized, and people adjust behaviour to evade suspicion, even in legal activities.[8]

V. CONCLUSION

Predictive policing, supported by Geographic Information System (GIS) technology, is essential for adapting to evolving crime patterns and improving pre-emptive crime prevention. GIS enhances predictive policing by providing tools for effective data visualization, management, and analysis. This integration allows law enforcement to forecast high-risk areas and optimize officer deployment. Initiatives like India's Predictive Policing for Women's Safety program demonstrate the practical benefits of GIS in addressing specific issues such as violence against women. Continued refinement of predictive policing methods, underpinned by GIS, is crucial for enhancing crime prevention and operational efficiency in modern law enforcement.

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[5] Retrieved from: Predictive policing for women safety: https://bprd.nic.in/uploads/pdf/202203031148045524485PredictivePolicingforWomen.pdf Last accessed on 26-08-2024. Last accessed on 02/03/2025.

[6] Ibid.

[7] https://www.hindustantimes.com/delhi/delhi-police-is-using-precrime-data-analysis-to-send-its-men-to-likely-trouble-spots/story-hZcCRyWMVoNSsRhnBNgOHI.html Feb 27, 2017 06:38 PM IST, last accesed on 14/09/2024.

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