



# REMOTE SENSING AND GIS IN CRIME MAPPING AND ANALYSIS (A CASE STUDY OF LUCKNOW CITY)

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## **ABSTRACT**

We have come to know and work with numerous uses of Remote Sensing & GIS be its crop mapping, disaster management, positioning etc. One such beneficial use of Remote Sensing & GIS can be mapping, and analysis of crimes spread over an area.

The use of Remote Sensing & GIS for crime mapping and analysis will help in effective management of an area, controlling, curbing, and managing crime and criminals and even effectively help in law enforcement and policy or law making.

In present scenario the worldwide matter of concern is crime, criminals, and the pace at which different criminal activities are increasing. Not only crime has changed its nature but even criminals have changed their methods of committing crime with changing time and laws. The distribution of crime and criminals is uneven as a result people avoid visiting certain places or avoid moving out in night.

The criminal activities are also influenced by geospatial and temporal conditions of an area discussion of which is one of the mottos of this paper. In order to perform and complete the paper and analyse crime the method and technique of Remote sensing and GIS software is used. This paper even highlights the scope and use of mapping for administering the crime, its parameters and spread of crime in different areas.

Using Remote Sensing and GIS for mapping and analysing crime assists in crime spread, identifying crime hotspots, area wise crime impact and spread, comparative study of two or more regions criminal activities and spread. It will help in formulating laws, policies and management of crime and criminals that can be age specific, gender specific, region specific or economic status specific.

This paper will even highlight the future prospect of use of Remote Sensing & GIS and challenges that disturb the study.

## **KEYWORDS**

Remote sensing, GIS mapping, Crime epicentre, Police Commissionerate Zone, GPS, Hotspots, Kernel density, Spatio-temporal analysis..

## INTRODUCTION

Safety and better living standards are needs for all in the present world. People want to enjoy the freedom and live their lives fearlessly. But with prevailing crime and its increase day by day the human activities have been restricted. To curb and control them and to understand their nature and spread is a major concern.

Thus, the aim of this research paper is to outline the general framework, causes and spread of different criminal activities in the Lucknow city. It focuses on capturing spatio-temporal, economic and geographical analysis and spread of crime within the city. For the study of this particular topic Lucknow city has been considered as it is one of the capital cities of the most populous state in India, Uttar Pradesh which was considered to be the **crime epicentre** in India. This particular location is also chosen for study as it is undergoing a rapid transformation at present and helping in the progress of the state as well the country. Crime mapping is not a new concept but a new approach in crime analysis which plays a crucial role and act as a power tool for enhancing law enforcement and improving public safety efforts. Thus, by mapping and analysis of the city it will help out to curb the criminal activities and define the action plans to be undertaken for crime management and will set as a model for development of other areas.

For investigation Police officers used large wall maps to design their action plan for their investigation. They used to pin the crime location, important locations with respect to victim and criminals, places where such crimes have already occurred to find if it is a chain criminal offence and so on. Now with the help of crime mapping and analysis this work can be done in digitised form and can be access and operated through small handy devises.

This study of Crime mapping and analysis will provide an overview and outlook to the spread and diffusion of different criminal activities and practices in an area. It will help in detail study and analysis of particular crime, its spread and intensity with the help of maps.

It will help to map down the density and spread of criminal activities along with nature of criminal activities in specific area in comparison to other areas. It will also help to analyse the causes of spread of a particular criminal activity and its impact in a particular area.

For this research data collection will be done through different sources that will be digitised and then used in GIS software to present the output. For the mapping and analysis study QGIS software has been used here.

## STUDY AREA

Lucknow is the capital of Uttar Pradesh (Uttar Pradesh up till recently considered the crime capital of India, has now seen drastic decline in crime rate) which is known for its cuisines and nawabi manners is chosen for the study. The city has seen a vast decline in crime rate and has been recently in news for it action plans against crime and criminals or offenders.

It is a vastly emerging metropolis on India's urban map lying on the bank of river Gomti. The capital of the province of Uttar Pradesh, a fast-becoming metro city is located in originally known as Avadh region is the city, LUCKNOW. It is the administrative headquarters of Lucknow district.

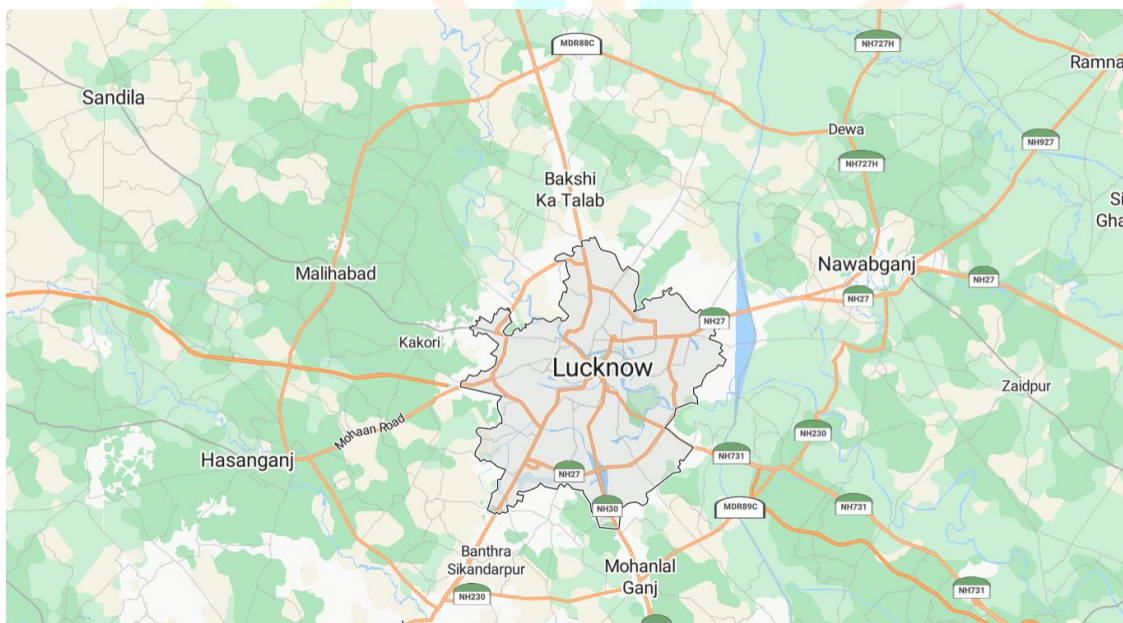


Fig 1: - Scale—5mi = 5km [lucknow city map - Bing Maps](#)

The area under study, Lucknow is divided into 5 zones according to 5 Police Commissionerate Zones divisions. These zones are further divided into 52 police stations areas according to Lucknow Police Commissionerate including two mahila thanas. 5 zones of Police Commissionerate- North Zone, East Zone, Central Zone, West Zone, and South Zone.

### **Methodology**

Methodology involved in crime mapping and analysis includes various techniques like—

- Crime analysis
- crime mapping techniques
- data collection and representation
- tools or software used

In recent times, use of remote sensing and GIS have become a popular means for obtaining data. The data obtained through remote sensing and GIS is in the form of raster and vector data. Remote sensing and GIS have become one of the prominent means for earth surface studies.

Collection of criminal data or FIR data is challenging as these are sensitive and confidential Data.

**Data collection** and manipulation of data required most brainstorming and time during our Project as there is no predefined dataset on the Internet for this problem statement, so there was need to create and collect a dataset of our own.

For research, some raw and unfiltered data could be managed which was mostly imbalance and filled with null values.

The data collected was through using location sharing feature of social media site like WhatsApp, shared by the Investigation Officers. The operators then filed the location into different spreadsheets according to the Police Stations along with other spatial and non-spatial attributes.

### **Maps:**

For the study, maps from Open Street maps were used that were provided as plugin to our GIS Software QGIS.

### **Ground Investigation:**

For the purpose of the study handheld high precision GPS (handheld GPS devices) and a Digital Camera for pictorial coverage of hotspot (where possible) was used.

## **CONCEPTUAL FRAMEWORK**

Concept of crime mapping dates back to the early 19th century. In 1829, Adriano Balbi and André Michel Guerry produced maps showing the relationships between educational levels and violent and property crime in France, which is often cited as the first instance of crime mapping.

Bentham defined Crime as, “**offences are whatever the legislature has banned/prohibited for good or for bad reasons.**” i.e. It is an activity that violates the law and does wrong to the public. Various crime theories help us to understand and visualise crime pattern in traditional ways and even guide to investigate the offence.

The art and science of Remote Sensing and GIS has spread its roots in various fields of art and sciences whether it is disaster prone area studies, agriculture and crop mapping, traffic management studies etc. In the similar way Remote sensing and GIS techniques can be used to understand and analyse crime pattern through crime mapping which can further help in enhancing law enforcement and policy framework.

Crime mapping and analysis with Remote Sensing and GIS are used to create visual representations of crime incidents. Analysts plot crime data on maps, allowing them to identify **crime hotspots**, patterns, and trends. These visualizations help law enforcement agencies understand where crimes occur and allocate resources effectively.

It enables the integration of various datasets including satellite imagery and aerial photography that enhances accuracy and gives detail of crime mapping for the creation of thematic maps and exploration of special relationships fostering and understanding of Crime patterns and trends. And by combining crime data with other geospatial information like land use, demographic transportation networks it will allow analysts to identify hotspot areas visualise crime incidence and assess their special distribution. It even analysis special data for nature of crime, crime problems and police related issues. Here kernel density estimation, nearest neighbour analysis, and special auto correction health reveal special relationships and concentration of criminal activities.

## APPLICATION OF CRIME MAPPING

- Crime mapping involved visualizing crime incidents on maps using Geographic Information Systems (GIS).
- Analysts could identify crime hotspots and patterns, aiding law enforcement in understanding where crimes occurred.
- Crime mapping can become a key component of the policing strategy.
- Police departments can use these maps to allocate resources effectively, respond to incidents, and track crime trends.
- GIS-based crime mapping supports predictive modeling by analyzing historical crime data and identifying areas at risk.
- Risk terrain modeling combines various spatial factors (e.g., land use, socioeconomic conditions, and environmental features) to predict where crimes are likely to occur.
- Law enforcement agencies can allocate resources strategically based on these predictions to prevent and respond to criminal incidents.

## CRIME MAPPING TECHNIQUE USED

Crime mapping enhances our understanding of spatial patterns and relationships. Here are some techniques:

- **Manual Pin Mapping:** Involves physically placing pins on a map to represent crime incidents.
- **Computer Mapping:** Utilizes software tools to create digital crime maps.
- **Geographic Information Systems (GIS):** A powerful tool for crime mapping, GIS integrates spatial data, allowing analysts to visualize and analyse crime patterns effectively
- **Crime Analysis Mapping:** The process of using a geographic information system in combination with crime analysis techniques to focus on the spatial context of criminal and other law enforcement activity.

## SOFTWARE AVAILABLE

### **GIS software for mapping**

GIS software, short for Geographic Information System, is a powerful technological solution that captures, manages, analyses, and interprets geographical data. It allows users to create, store, manage, query, analyse, and visualize data representing phenomena for which location is important. Few GIS softwares are listed below: -

- ArcGIS Pro
- QGIS 3
- ArcGIS Desktop
- Hexagon Geomedia
- MapInfo Professional
- Feature Manipulation Engine
- Global Mapper
- QGIS 2 etc

## SOFTWARE USED

For carrying out the mapping using Remote Sensing & GIS **QGIS software** was used. QGIS is one of the largest community efforts and open-source progress in the history of GIS. Since it is community-driven, it became wildly innovative and inventive.

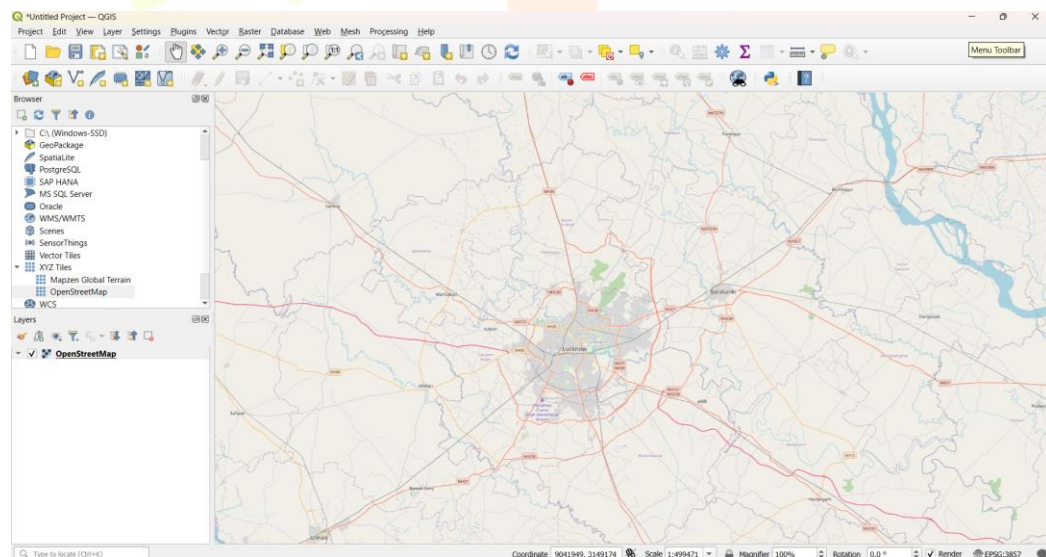
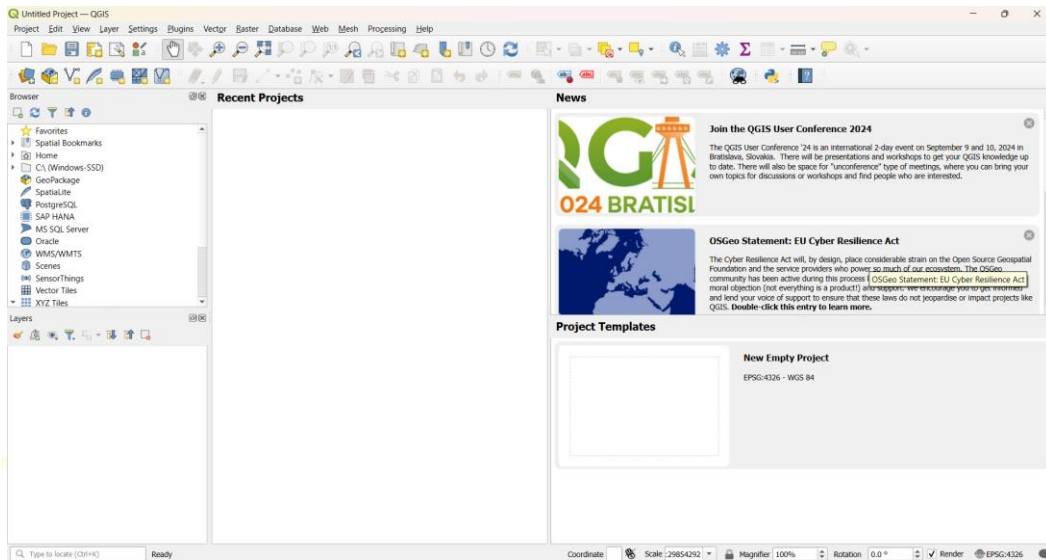


Fig 2: - qgis software map generation

### Why QGIS?

- QGIS software is used because it is a powerful open-source software,
- QGIS allows you to visualize crime data on maps, making it easier to identify patterns, trends, and hotspots
- QGIS can handle multiple data formats, including shapefiles, GeoJSON, CSV, and databases
- QGIS is highly customizable. You can tailor your maps, layouts, and symbology to meet specific requirements.
- QGIS is free and open source, making it accessible to researchers, law enforcement agencies, and community organizations

- QGIS has an active user community, forums, and documentation.

## Mapping

The Crime Mapping Project is a comprehensive analysis and visualization initiative aimed at understanding crime patterns, trends, and hotspots. In this it is done over the region of Lucknow. Crime mapping is applicable for law enforcement agencies and policymakers for allocating resources effectively and developing targeted crime prevention strategies.

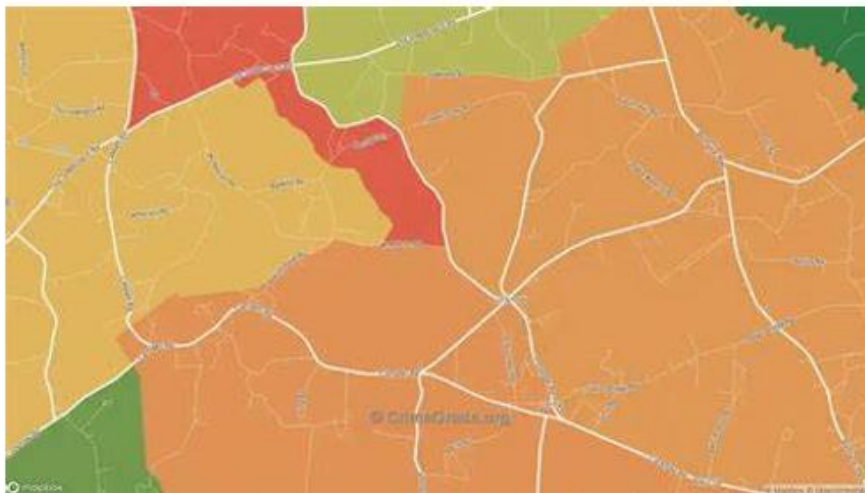
Here we have used GIS for crime mapping and its analysis for effective law enforcement and crime management. It was explored to create –

- A hierarchical system of location data collection.
- Creating database with all spatial and non-spatial data
- Creating heat map based on temporal and spatial analysis.

### Techniques Used in Crime Mapping:

- **Hotspots:** Identifying areas with high crime density or frequent criminal incidents.
- **Kernel Density:** A method that creates a smooth density surface to visualize crime hotspots.
- **Heat Maps:** Visual representations of crime intensity using colour gradients.
- **Geographic Profiling:** Investigative methodology that uses connected crime locations to determine probable offender areas

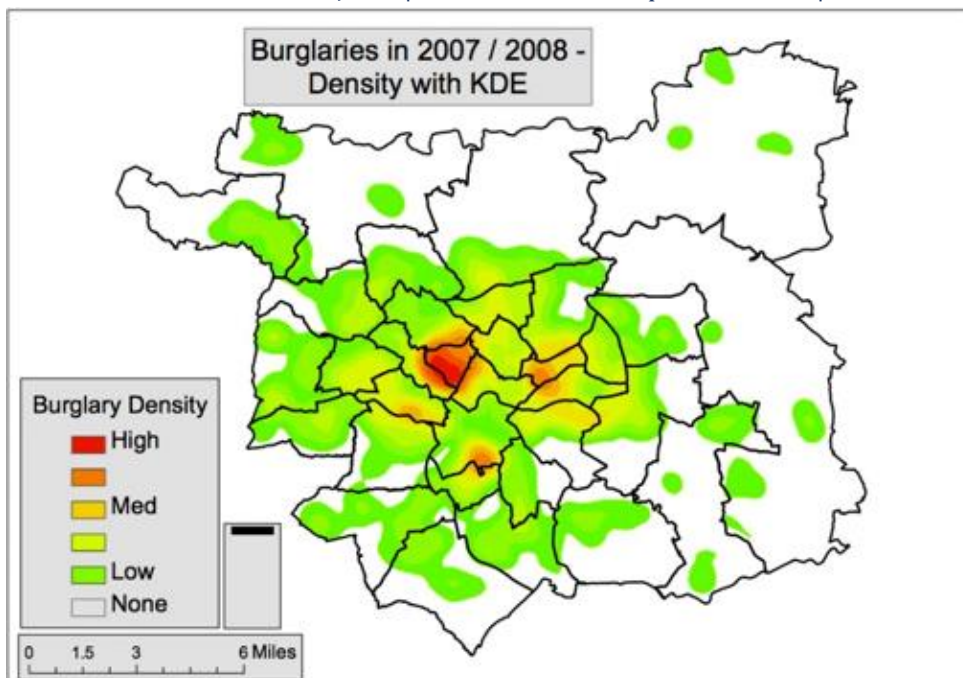
The image given below shows a QGIS map generated of a small zone of Lucknow Safe and Unsafe areas.



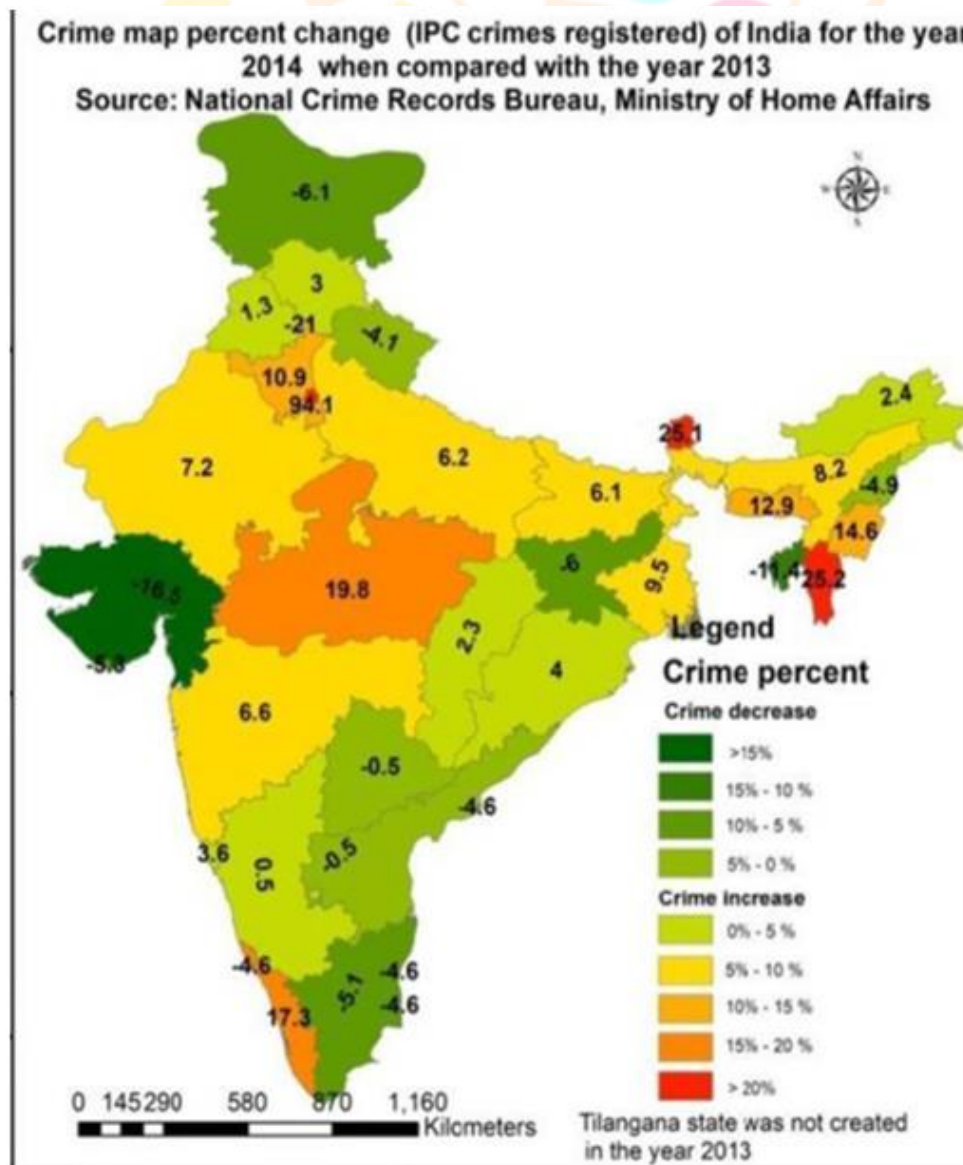
Map 5 <https://crimegrade.org/safest-places-in-lucknow-sc/>

A similar map showing the crime spread in different regions of Lucknow can be prepared using QGIS software of mapping. It can even show spread of different crimes area wise.

Research Through Innovation



Map 6 <http://surf.leeds.ac.uk/p/2016-11-15-HomeOffice-CrimeMapping.html>

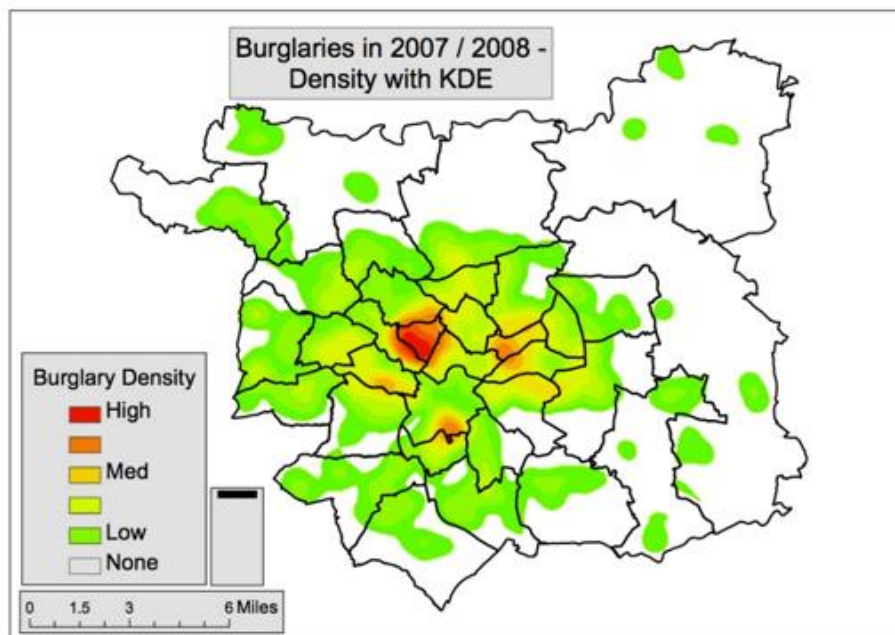


Map 7 [https://www.researchgate.net/figure/Crime-map-of-India-d-crime-map-percent-change-2014\\_fig7\\_320869704](https://www.researchgate.net/figure/Crime-map-of-India-d-crime-map-percent-change-2014_fig7_320869704)

It is a map showing Crime percent change through Crime mapping in all the states of India. Where few states have seen vast decline in crime rate, but few have seen sharp increase in criminal activities.

### **Hotspot identification**

This crime mapping through Remote Sensing & GIS will help in identifying crime hotspot areas i.e. high crime intensity areas that will help in resource allocation in the hotspot mapped area and devising separate policy for those areas. For example, while performing the study in Lucknow, and mapping the data collected the Hazaratganj and nearby area around Hazaratganj were mapped as high-risk area or hotspot for Burglaries during 2007-2008. As shown in the map below the red marked area is a hotspot region for burglary in Lucknow.



Map 6 <http://surf.leeds.ac.uk/p/2016-11-15-HomeOffice-CrimeMapping.html>

### **IMPACT, RESULT & DISCUSSION**

1. **Crime** mapping allows researchers and practitioners to explore crime patterns, offender mobility, and serial offenses over time and space. With respect to local policing, crime mapping provides the visualization of crime clusters according to types of crimes, along with validating the street knowledge of patrol officers.
2. Visualising crime data all over the region. Plotting criminal activity over maps
3. Generating and visualizing hotspot areas for a particular type of crime or different types of crimes
4. It will help law enforcement agencies and policy makers to locate resources effectively and develop target crime prevention strategies.
5. It will help in understanding Crime patrolling, and hotspot identification in any area including inaccessible areas also. Resource generation.
6. Hotspot identification will help to design special initiatives and plans to curb the crime and criminal tendencies.
7. It can help in monitoring and frequent patrolling of areas.
8. It can be used as reference data for future studies.
9. It can help in generating a comparative chart or study of different areas for spreading criminal activities
10. It helps crime officers to determine potential crime sites by examining complex unrelated criteria and displaying them all in a graphical layered spatial interface on the map.
11. It can help reduce the potential for internal violence providing better command and control.

12. It can also help locating and identifying specific crime zones that will help design and implement crime specific measures to be adopted.
13. It can help in time-to-time surveying and monitoring.
14. It can help locate habitual offenders that will help in keeping close check on their activities.

## **CONCLUSION & RECOMMENDATIONS**

Crime and criminal activities are not only a threat for an individual but for society, country, and entire world. Monitoring and controlling them is a huge challenge with a huge population.

Due to huge population and increasing economic and social disparity the day-to-day criminal activities are increasing that is resulting in lack of resource to control and curb them and handling of such large amount of data. Working with a large volume of data can post challenges when you need to understand things quickly for instant action plans.

Large storage space is required for storing huge amounts of data collected. Large number of professionals are required. Expenses are there to train them and to provide them assistance.

It will help reduce manual and paper work thus protecting the environment in a way. Loss of data and files can be prevented as all data will be digitised and can be used any time. All the data will be digitised so no storage room required, which will even prevent accidental happenings leading to loss of data.

Crime Mapping and Analysis will help to monitor the criminal activities and act as a tool of check and balance to have them under control. It can even help in studying and analysing data of different areas at the same time instantly.

This mapping of crime or criminal activities will help out the policy makers to frame or draft policies and laws according to the area, age, and gender of the human population as **crime and criminal activity varies according to area and human population and their socio-economic conditions.**

The crime mapping and analysis will help out investigators and police officers to conduct proper patrolling and checking of criminal hotspot areas, identifying areas where most criminal resides and keeping check on them, finding out causes of criminal offence and their eradication to curb crime and criminal tendencies.

Thus, we can say that use of remote sensing and GIS will act as a boom for curbing and controlling criminal activities.

This crime mapping technique can be used to large and small areas. It can be used to map the criminal data base of small regions in order to obtain detailed understanding and analysis of that particular area.

The data of different areas can be used to do comparative studies of crimes in two region and help in devising plans that could curb the crimes with respect to area with less crime rate by following their policies and laws which can be applicable in the area. Which could help in improving crime rate and ranking of areas in crime rate list

It can even help in organising applications and online portals to record crime data, to generate alert system or alarm.

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  - a. Dr. Ritu Jain- The concept for the research paper was given and administered by Dr. Ritu Jain.
  - b. Anamika Tripathi- Writing, editing, proofing, and analysis was done by Anamika Tripathi
5. **Conflict of Interest:** - No conflict between Authors. Not applicable.
6. **Data availability statement:** - Not applicable for data collection. Below mentioned are source of map undertaken.  
Map 5 <https://crimegrade.org/safest-places-in-lucknow-sc/>  
Map 6 <http://surf.leeds.ac.uk/p/2016-11-15-HomeOffice-CrimeMapping.html>
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