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Research Paper

Crime Mapping and Analysis Using Geospatial Techniques-A Study of Shivamogga City in Karnataka State, India

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ABSTRACT: *This paper explores the feasibility and utility of Geospatial techniques to identify, analyze and mapping of places associated with criminal activity in Shivamogga city for a period of three years (2013, 2014 and 2015) in which basic satellite data of high resolution SPOT image (2015) and Survey of India topographic map No 48 O/9NW, (1:25,000) scales were used. ArcGIS 9.2 used for performing GIS tasks and ERDAS Imagine 9.2.There are twenty seven types of crimes are recorded in the city, out which six types of crimes are frequently occurring in the city. The result reveals that, the crime of cases of hurt is gradually decreasing from 2013 to 2015. Whereas the cheating is increasing from the year 2013 to 2015, the other four types are decreasing in the year 2014 and again increasing in the year 2015. To mitigate the crimes in the city, we proposed three new police stations based on closeness to places with hotspot values, distance from existing police station and closeness to the main streets.*

INDEX TERMS: *Crime analysis, Mapping, GIS and Remote sensing*
ACKNOWLEDGEMENTS: *Authors would like to acknowledge Shivamogga Police Directorate for providing data for the study and also thank Chairman and Coordinator UGC - SAP (DRS) III Department of Applied Geology Kuvempu University for all kind of support.*

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I. INTRODUCTION

The crime analysis and mapping efforts are useful, the true promise of crime mapping lies in its ability to identify early warning signs across time and space, and inform a proactive approach to police problem solving and crime prevention. Today, with the rapid advancement of technology, computer-based techniques for exploring, visualizing, and explaining the occurrences of criminal activity have been essential [1]. One of the more influential tools facilitating exploration of the spatial distribution of crime has been GIS [2]. As [3] note, it is the ability to combine spatial information with other data that makes GIS so valuable.GIS and RS uses geography and digital maps as an interface for integrating and accessing massive amounts of location based information. Geographical information system is an information system that describes the objects with location [4],[5]. GIS play an essential role in crime mapping and analysis. Geographic Information Systems (GIS) is one among the recent technological development, which can act as a decision support system to find better solutions to reduce the crime [6].

The ability to contact and procedure information quickly, whereas displaying it in a spatial and visual means allows agencies to deal out assets rapidly and more successfully. The mainly dominant beat in law enforcement is information technology. GIS not only permits consolidation and spatial analysis of the data to discover, capture and indict mistrust, but it also helps more positive measures in the course of helpful allowance of resources and better policy setting [7]. By integrating types of crime maps, the intensity of the crime is observed and it is distributed all over the region in study area [8].

1.1 SPATIAL DATA ANALYSIS TOOLS

The spatial concentration of crime in hot spots leads naturally to their representation on crime maps. Maps of crime incidents permit rapid identification of the geographic location of crime hot spots, but by themselves, they contribute little to understanding why crime is concentrated in certain locations. A crucial aspect of pattern recognition techniques such as hot spot analysis is the determination of the extent to which patterns on the map reflect “true” clusters or outliers or whether they are spurious. As well, known, simple

visual interpretation of the map is inadequate in this respect because the human mind is conditioned to find meaning and identify patterns and clusters, even when the data represented may be purely random. The use of sound cartographic principles alone does not ensure that a proper interpretation is obtained [9],[10],[11]. What is needed is a careful structuring of the visualization strategy while supplementing the visual aspects with quantitative information [12].

II. CRIME CLASSIFICATION

There are several types of crime classification; in the present study, the following classification is used:

Crime I: Security: A group of crime focuses on security, and important crime as viewpoint of security against of person. Crimes in this division are Hold up, Burglary, Shoplifting, Robbery, and Motor theft.

Crime II: Economic: A group of crime focuses on economic and important crime as viewpoint of economic against of money or property of person. Crimes in this division are auto Theft, Shoplifting, Burglary, and Fraud.

Crime III: Social: A group of crime focuses on social and important crime as viewpoint of social. Crimes in this division are Addiction, Robbery, Pick pocket and Theft from vehicle.

III. AIM AND OBJECTIVES

The main aim of the present work is to spatial analysis of crime and crime mapping for Shivamogga city police force for better management. Hence the following objects are carried out.

- Location Mapping of types of crime in Shivamogga city
- To identify the hot spots using Geo-spatial pattern recognition
- To study Urban land use patterns with crime distribution
- To Identify suitable location for new police station

IV. STUDY AREA

Shivamogga city is a district head quarter in Karnatakastate(Figure1). According to the Shivamogga City Municipal Corporation, the city has a total area of about 50 km^2 and geographically lies between 13°51'23"N to 13°59'0"N Latitude &75°29'30"E to 75°39'30" E Longitude. The city has a population of 3, 22,650 according to 2011 census. The city lies on the banks of the Tunga River. Being the gateway for the hilly region of the Western Ghats, the city is popularly nicknamed as "Gateway of Malnad". The city has a network of good roads, standard hotels and communication facilities. The Economy of the current city holds a wide industrial base in the Automobile, Information technology Business process outsourcing, Hardware manufacturing and Agriculture. There are ten police stations are located in the city, namely Doddapete, Kote, Jayanagara, TungaNagara, Women police station, Vinobanagara, Shivamogga Rural, Kumsi, Traffic East and Traffic West police stations.

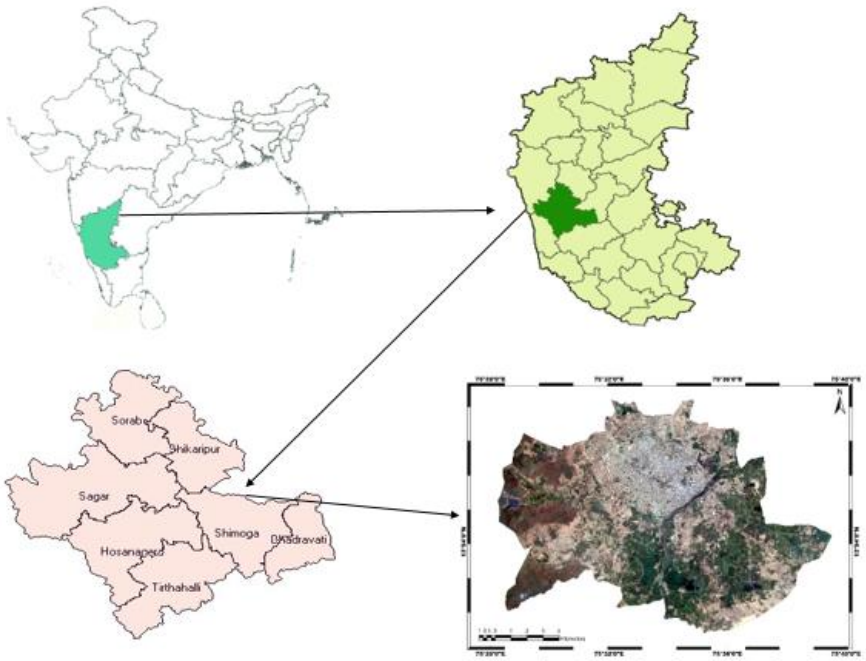


Fig.1.Location of the Study Area

V. MATERIALS AND METHODOLOGY

In this present study we have adopted various materials and methods for crime mapping and analysis for Shivamogga city are Survey of India topographic map 48 O/9NW (1:25,000). Basic satellite data of high resolution SPOT image (2015) is used for the preparation of urban land use mapping using ERDAS imagine 9.2 and ARCGIS 9.2.The present study is based on authentic data from the crime record bureau of the Shivamogga city police department over the years 2013, 2014 and 2015. The criminology detail includes property crimes such as *Robbery, Burglary, and Theft, Karnataka Police Act 1963, cases of Hurt and Cheating.* Regarding the GIS methodology adopted, it was necessary to prepare the work with a set of layers and create a theme to match the expected distribution of parishes. Thematic maps showing the number of crimes or other matrix were aggregated using colorpalettes. The Crime scene is mapped as a Point feature. The raw crime data for this study was stored in an Excel file that was convenient to analyze. The data in file comprised of columns and rows. We normalized the dataset by grouping the whole area in to 6 zones consistent with patrol allocation of the police station.

VI. RESULTS AND DISCUSSIONS

The analysis, which begins by displaying all the crimes based on their number of types of crimes existed in the Shivamogga city and the results of crime intensity, density and hotspots analysis for Shivamogga city police station jurisdiction has four circles, viz, Shivamogga Rural, Kote, Doddapet & Tunga Nagara as mentioned in the Table 1. Among these we have considered Doddapet, Kote, Jayanagar,Vinobanagar, Shivamogga Rural and Tunga Nagar police stations jurisdiction for this study and shown in Figure 3.

Table 1. Showing the police administrative structure in Shivamogga city

Sub-Divisions	Circles	Police Stations	Out Posts
Shivamogga	Doddapete	1. Doddapete 2. Traffic	Vinobanagar
	Kote	1. Kote 2, Jayanagar 3. Women	Umblebailu
	Shivamogga Rural	1. Shivamogga Rural 2. Kumsi	Ayanur
	TungaNagara	1. TungaNagara	Traffic

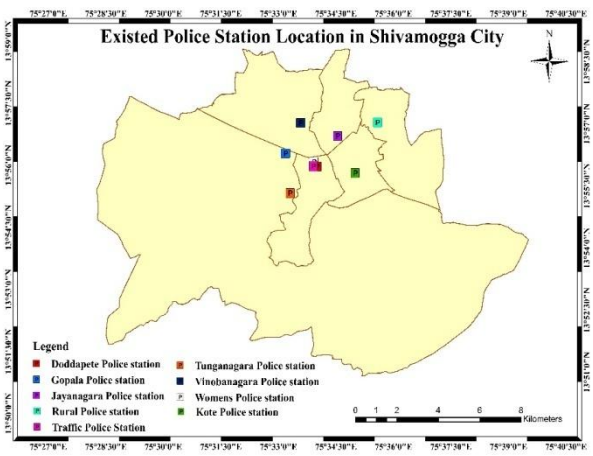


Figure3.Existed Police Station Locations of Study Area

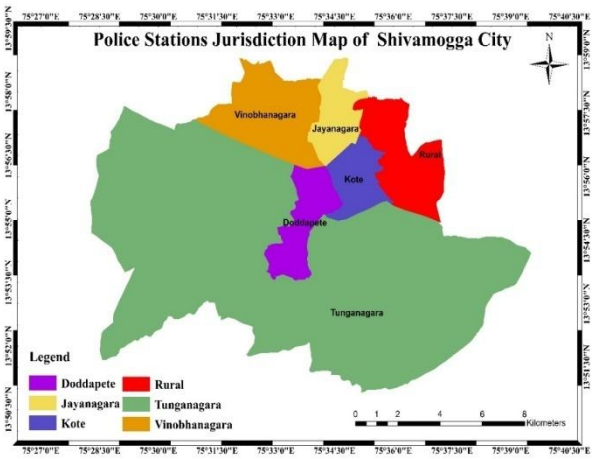


Figure4. Police Stations Jurisdiction of Shivamogga City

6.1 Crimes in Shivamogga City

In Shivamogga city there are twenty-seven types of crimes are recorded according to the data availability in the district crime record bureau and are mentioned below. Out of twenty-seven types of crimes, only six types of crimes are frequently occurring in the city remaining nineteen types are very rarely occurring and are shown in theTable2below. The six types of crimes are namely, burglary, cheating, robbery, theft, cases of hurt and Karnataka Police Act 1963.

Table 2Showing the various types of crimes usually took place in city

1. Murder	10. Unlawful Assembly	19. Other IPC Cases
2. Attempt to murder	11. Riots	20. Local & Special Laws
3. Homicide	12. Offences Against state	21. Crime against Women
4. Rape	13. Offences Promoting enmity	22. Crime against Children
5. Kidnapping and abduction	14. Criminal Breach of trust	23. Crime against SC
6. Dacoity	15. Cheating	24. Crime against ST
7. Robbery	16. Counter-feinting	25. Cases against Police
8. Burglary	17. Forgery	26. Un-Natural Deaths
9. Theft	18. Cases of hurt	27. Motor vehicle accidents
		28. Karnataka Police act

6.2 Crime Mapping and Analysis

Crime is a human phenomenon, generating data for it requires the integration of the people and the existing security outfits (police) within the geographical location where the study is carried out. Crime mapping and Analysis of crime are recognized as powerful tools for the study and control of crime, because crime maps help police identify problems at the block. The most powerful weapon in law enforcement is information technology. In present study we have done crime mapping and analysis for Shivamogga city for three temporal year's viz., 2013, 2014 and 2015 based on the availability of the data on crime in the city.

As mentioned previously, we were able to obtain data with the Location of the Crimes attached from the Shivamogga Police Directorate Unit. The Locations for the Crimes were geocoded to create a point layer for each incident. To compare the results from the Crime mapping technique to the actual locations of the incidents, a crime intensity map was created for each that showed the intensity of the estimated incidents and the actual incidents. To produce the crime intensity map from the ancillary data, a point data layer was created from the final crime raster layer. An intensity map was created using the intensity clustering method. The main purpose of this category of clustering techniques can be summarized as gaining an estimation of distribution of crime intensity across geographical areas and also visualizing the results. Regarding criminal intensity, the new administrative division gives the perception of an increase and decrease in crime numbers. However, this fact is in part related to the significance increase in area of some parishes, thus reducing the intensity of crimes. In order to understand how it would be the spatial representation of crime according to the city's [13].

6.3 Extending the Analysis

The usefulness of this approach of mapping out aggregated data can only be determined by comparing the results to a map of the actual crime locations. By using additional variables from census data that describe housing units and using transportation network data, weights could be assigned to further estimate the distribution of Crimes [13].

VII. POLICE STATIONS AND THEIR JURISDICTION

Out of ten police stations in the city, two are traffic (East & West), one women police station are included under Shivamogga sub division and one more Kumsi police station comes under rural. The police stations and their jurisdiction are shown in the Figure4. The polygon feature is used for representing the boundary. It also aids police services to realize crime management programs. Crime data set used for the present study is obtained from District Crime Records Bureau (DCRB), Shivamogga city of Karnataka and is presented in the Table 3. The crime data sets exhibits the various crimes like Theft, Robbery, Cheating, Cases of Hurt, Burglary and Karnataka police Act 1963 from 2013 to 2015. A total of 2599 cases are registered during the specific period of years. The crime intensity and analysis for all six police stations jurisdiction are prepared and are described below.

Table 3.Crime incidents recorded in the study area during 2013 to 2015

Name of Station	Year	Theft	Robbery	Cheating	Cases of Hurt	Burglary	Karnataka Police Act-1963	SubTotal	Total
	2013	51	4	24	49	20	45	193	
Doddapete Police Station	2014	41	3	22	47	29	66	208	**604**
	2015	70	8	37	33	19	36	203	
	SubTotal	**162**	**15**	**83**	**129**	**68**	**147**	**604**	
	2013	25	4	18	18	1	15	81	
Jayanagara Police Station	2014	24	2	27	17	7	17	94	**234**
	2015	15	5	12	10	5	12	59	
	SubTotal	**64**	**11**	**57**	**45**	**13**	**44**	**234**	
	2013	39	8	12	26	12	32	129	
Kote Police Station	2014	25	3	13	12	13	32	98	**321**
	2015	30	3	22	16	10	13	94	
	SubTotal	**94**	**14**	**47**	**54**	**35**	**77**	**321**	
	2013	19	8	18	108	17	46	216	
Tunganagara Police Station	2014	16	6	12	70	18	61	183	**587**
	2015	30	14	20	50	37	37	188	
	SubTotal	**65**	**28**	**50**	**228**	**72**	**144**	**587**	
	2013	25	14	16	37	17	12	121	
VinobanagaraPolice Station	2014	17	12	4	27	23	30	113	**321**
	2015	22	4	6	23	20	12	87	
	SubTotal	**64**	**30**	**26**	**87**	**60**	**54**	**321**	
	2013	20	3	5	65	12	27	132	
Shivamogga Rural police station	2014	12	3	34	84	19	46	198	**532**
	2015	21	4	51	85	13	28	202	
	SubTotal	**53**	**10**	**90**	**234**	**44**	**101**	**532**	
	Total	502	108	353	777	292	567		**2599**

7.1 Crime Analysis of Doddapete Police Station Jurisdiction

Based on the data of the crime in the Doddapete police station jurisdiction indicates that, there are six types of crimes recorded in three temporal years (2013, 2014 and 2015) along with some rare crime like cyber-crime, murder, attempt to murder and unnatural death etc., are shown in Figure5. Among six types of crimes, the theft is the more in number about 162 cases and the total number of crimes is 604 and the most number of the crimes occurs about 208 during the year 2014 which is illustrated in the Graph-1 shows that the different types of crime and their intensity.

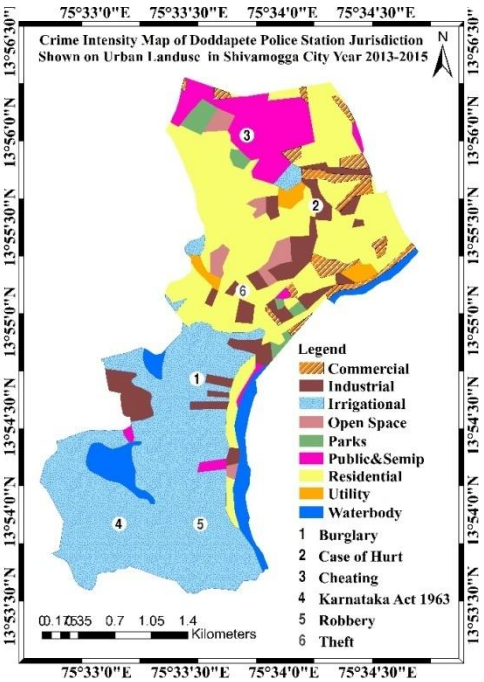
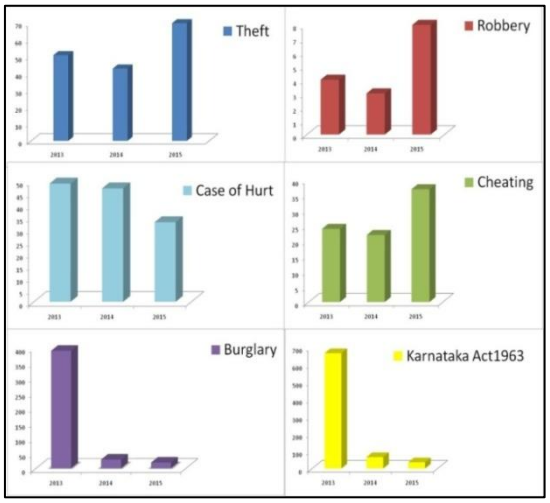


Figure5. Crime Intensity Map of Doddapete Police Station



Graph 1.Different types of crime and their intensity in the Doddapete Police Station

7.2 Crime Analysis of Jayanagara Police Station Jurisdiction

Based on the data of the crimes in the Jayanagara police station jurisdiction indicates that, there are six types of crimes recorded in the jurisdiction in three temporal years shown in the Figure 6.Reveals that theft and cheating are more in Jayanagara Police Station.

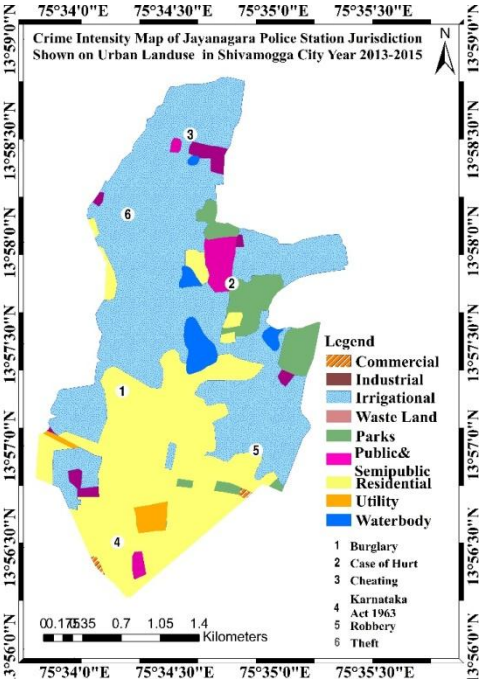
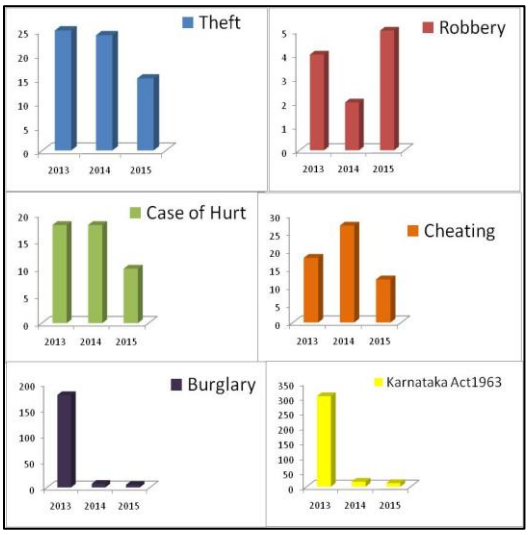


Figure 6. Crime Intensity Map of Jayanagara Police Station



Graph 2.Different types of crime and their intensity in the Jayanagara Police Station

In Jayanagara police station Jurisdiction the crime of theft is 25, 24 and 15 cases are recorded in the year 2013, 2014 and 2015 respectively. The crime robbery is 4,2 and 5 cases are recorded in the year 2013, 2014 and 2015 respectively. The crime of Cheating is 18, 27 and 12 cases are recorded in the year 2013, 2014 and 2015 respectively. The crime of cases of hurt in the year 2013, 18 in the year 2014 which decreased to 17 and again it decreases to 10 in the year 2015. The crimeofburglary01 case recorded in the year 2013, 07 in the year 2014 and 05 cases recorded in the year 2015.The crime of Karnataka police Act 1963, there are 15 cases are recorded in the 2013, 17 cases in the year 2014 and which decreases 12 cases in the year 2015 and are shown in the Graph 2.

7.3 Crimes Analysis of Kote Police Station Jurisdiction

Based on the data of the crime in the Kote police station jurisdiction, six types of crimes recorded in all the three temporal years along with some rare crime like murder, cybercrimes Dacoity are also recorded which are shown in the Figure7.

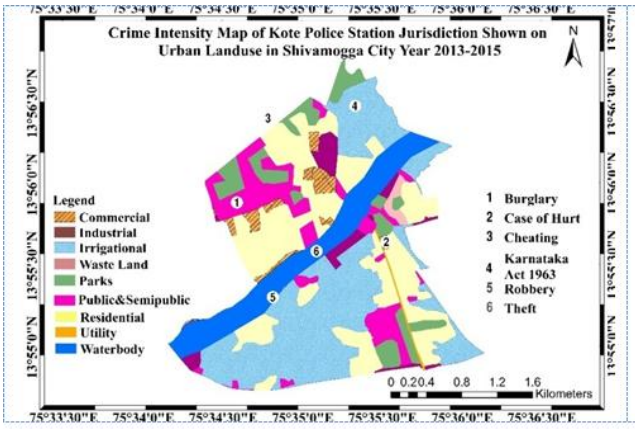


Figure7. Crime Intensity Map of Kote Police

Graph 3: Different types of crime and their intensity in the Kote Police Station

Crime intensity in Kote police station Jurisdiction it indicates that the crime of theft in is 39, 25 and 30 cases are recorded in the years 2013, 2014 and 2015 respectively. The crime of robbery cases are about 08, 03 and 03 are recorded in three temporal years. The crime of cheating is about 12, 13and 22 cases are recorded in three years. The crime of cases of hurt are about 26, 12 and 16 cases area recorded in the three specific years.

The crime of Burglary also recorded is about 12, 13 and 10 cases are recorded in these three years. The crime of Karnataka police Act 1963 is about 32, 32, and 13 cases are recorded three years of the duration , in the year 2014 which remain 32 and it decrease to 13 cases in the year 2015 shown the Graph 3

7.4 Crime Analysis of Tunganagara Police Station Jurisdiction

Based on the data of crime in the Tunganagara police station jurisdiction indicates that, there are six types of crimes recorded in all the three temporal years along with some rare crime like Homicide, Rape, Murder are also shown in the Figure8.

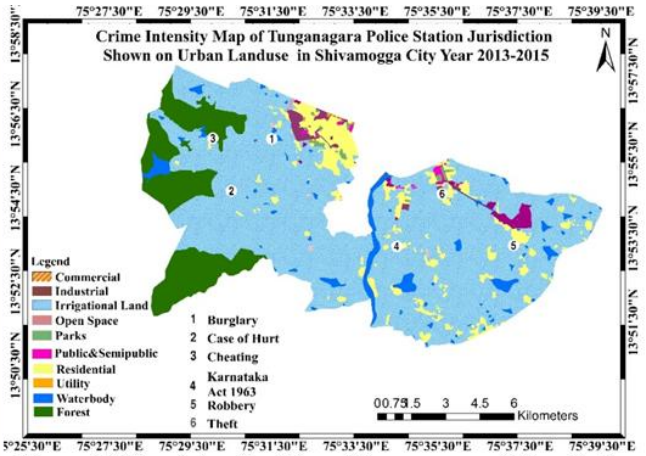
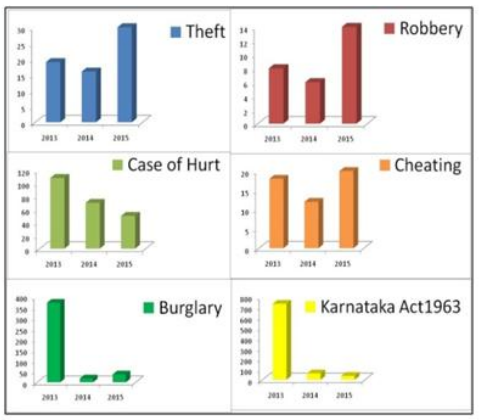


Figure 8.Crime Intensity Map of Tunganagara Police Station



Graph 4.Different types of crime and their intensity in the Tunganagara Police Station

The crime intensity in Tunganagara police station Jurisdiction it indicates that the crime of theft in the year 2013, 19 cases are recorded later 16 and 30 caser recorded in the years 2014 and 2015 respectively. The crime of robbery recorded is about 08 in the year 2013, 06 in the year 2014 and 14 in the year 2015.The crime of cheating recorded is about 18 cases are recorded in the year 2013 later 12 in 2014 and 20 cases in the year 2015. The crime o cases of hurt is about 108 cases are recorded in the year 2013 later 70 cases in 2014 and 50 cases are recorded in the year 2015. The crime of Burglary is also encountered is about 17 cases in the year 2013, later 18 cases in the year 2014 and it increases to 37 in the year 2015.The crime, Karnataka police Act 1963 cases is about 46 recorded in the year 2013, in the year 2014 it is increased 61 and gradually it is decreased to 37 in the year 2015 and are shown in the Graph 4.

7.5 Crimes Analysis of Vinobanagara Police Station Jurisdiction

Based on the data of the crime in the Vinobanagara police station jurisdiction it indicates six types of crimes recorded in all the three temporal years along with some rare crime like forgery, attempt to murder which are shown in the Figure 9.

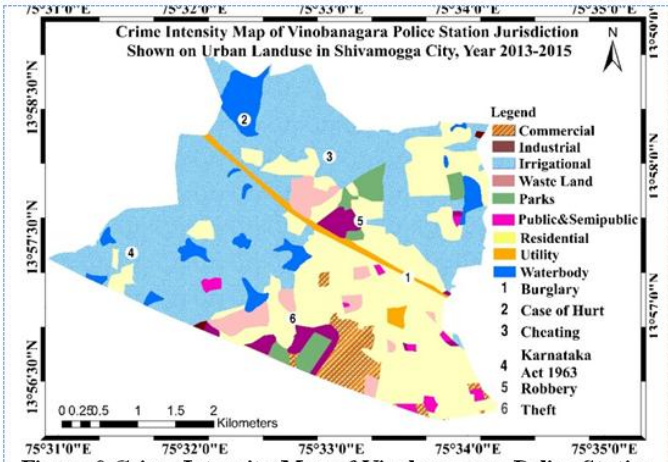


Figure 9.Crime Intensity Map of Vinobanagara Police Station

Graph 5. Different types of crime and their intensity in the Vinobanagara Police Station

Based on three temporal years data of Vinobanagara police station Jurisdiction the crime of theft recorded is about 25, 17 and 22 cases in the years2013, 2014 and 2015 respectively. The crime of robbery cases recorded about 14, 12 and 04 in the three temporal years from 2013 to 2015. The crime of cheating cases recorded about 16, 04 and 06 in three temporal years from 2013 to 2015. The crime cases of hurt recorded about 37, 27 and 23 in 2013, 2014 and 2015 respectively. The crime burglary recorded is about 17, 23 and 20 cases in three temporal years. The crime Karnataka police Act 1963 cases recorded about 12 in 2013, 30 cases in 2014 and 12 cases in the year 2015 and are shown in the Graph 5.

7.6 Crimes Analysis of Shivamogga Rural Police Station Jurisdiction

Based on three temporal years data Shivamogga Rural police station Jurisdiction the crime of theft cases recorded are 20 in2013, 12 in 2014 and 21 cases in 2015. The crime of robbery cases recorded is 03 in 2013, again 03 in 2014 and 04 cases in 2015. The crime of Cheating cases are 05 in 2013, and its increased to 34 in 204 and again it is increased to 51cases are recorded in the year 2015. The crime of cases of hurt are recorded about 65 in the year 2013 there are 65 cases are reported, 84 in the year 2014 and in the year 2015. The crime of burglary are 12 cases recorded in the year 2013, 19 in the year 2014 and 13 cases in the year 2015.The crime of Karnataka police Act 1963 cases are recorded about 27 in the year 2013, 46 in the year 2014 and 28 cases in the year 2015.

Graph 6. Showing the Crime Analysis of Rural Police Station

VIII. CRIME ANALYSIS OF SHIVAMOGGA CITY

Crime can be visualized as graduated symbols on a map. The graduated symbol view renders the data as points varying in size by the frequency of crimes at that specific location. In this way, locations with greater occurrence of crime will have a larger point or symbol. The precinct view provides a city wide view of the data and allows for comparison of crimes across the different police station jurisdictions with relative concentration or intensity of crime.

Crime type	2013	2014	2015	Total
Theft	179	135	188	502
Robbery	41	29	38	108
Cases of Hurt	303	257	217	777
Cheating	93	112	148	353
Burglary	79	109	104	292
Karnataka Police Act 1963	177	252	138	567
Total	**872**	**894**	**833**	**2599**

Table 4.Crime statistics in Shivamogga city during the year 2013 to 2015

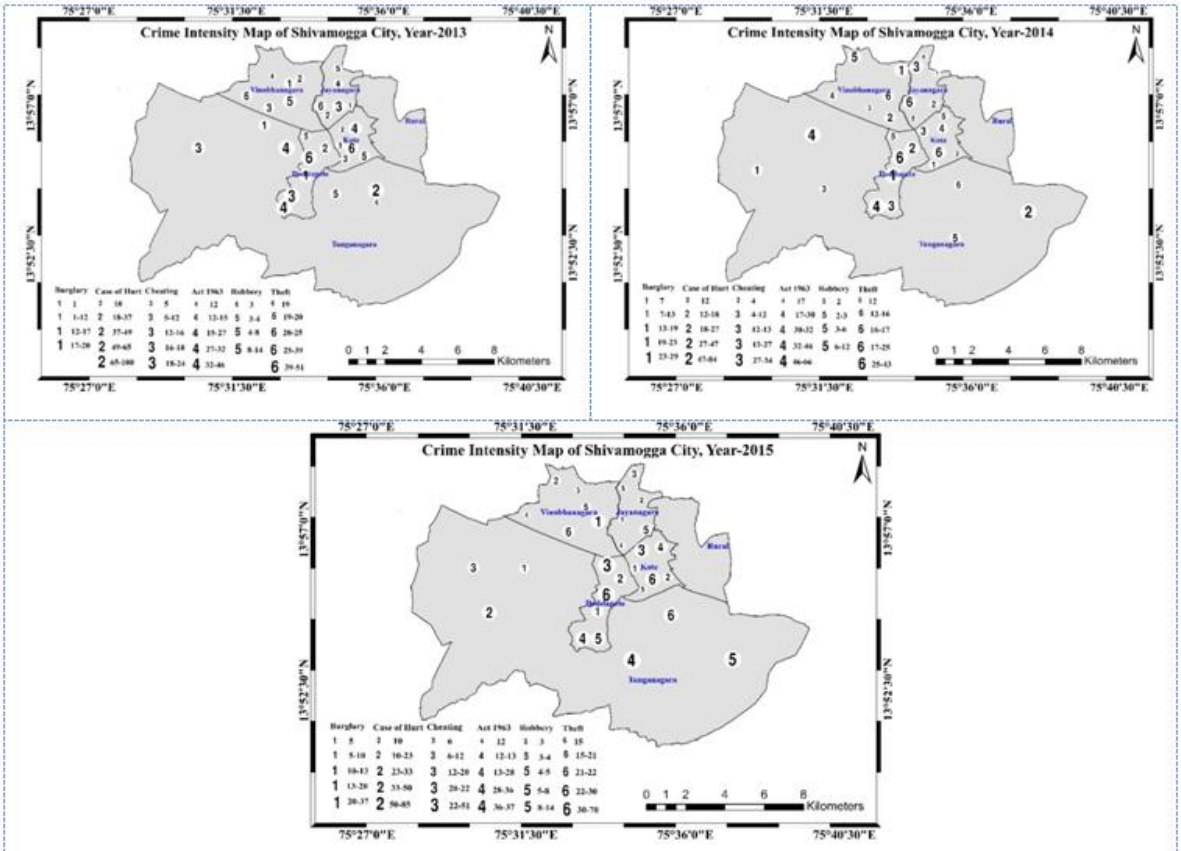


Figure10. Crime Intensity Maps of Shivamogga city in 2013, 2014 & 2015 respectively

8.1 Crime Rate Analysis for Shivamogga City

The crime map created by a spatial join between the police station locations and crime event points to determine the distribution of crimes. Knowing the total number of crime incidents for Shivamogga city. It was able to determine which police stations may be overwhelmed. This information can assist planners in determining a location for a new police station.

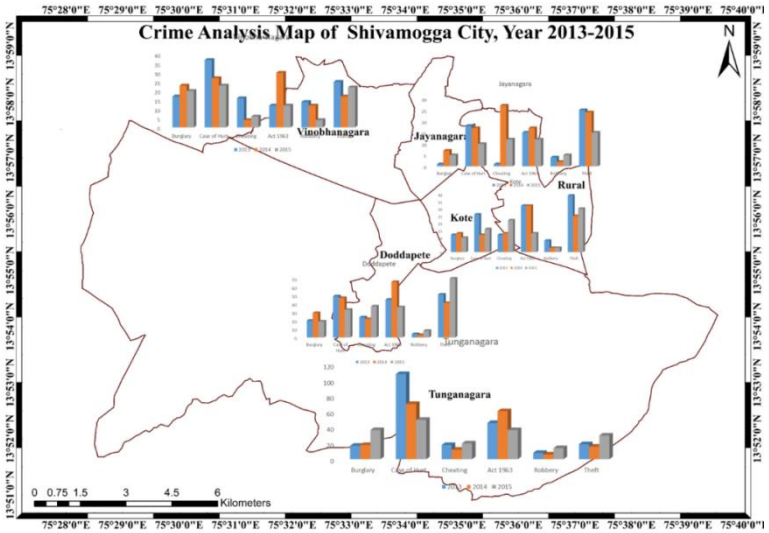
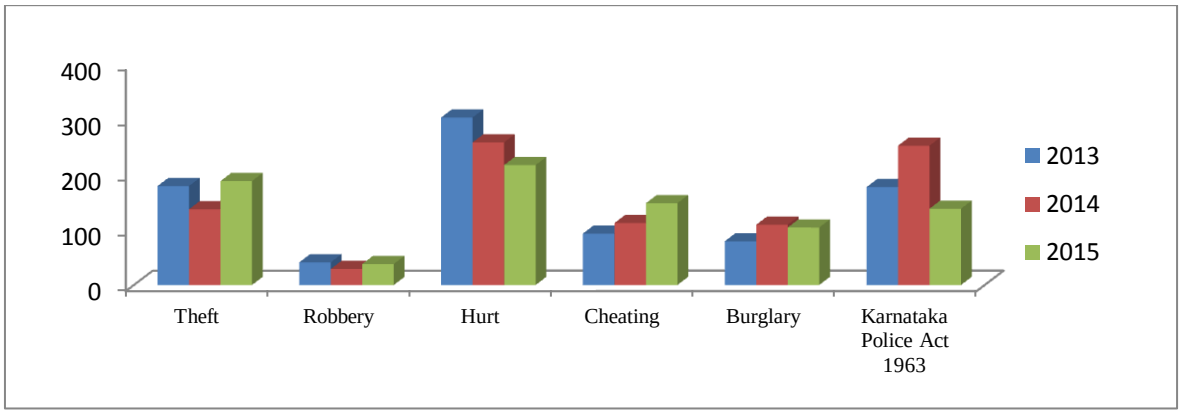


Figure 11. Crime Analysis Map of Shivamogga City from 2013 to 2015



Graph 7. Showing the Crime Analysis of Shivamogga City for the years 2013, 2014 &2015

IX. URBAN LAND USE ANDDISTRIBUTION OF CRIME PATTERNS

The relationship between crime incidents and land use

An important characteristic for the geographic analysis of crime is the understanding that crime incident does not occur in random or unpredictable locations. Rather, criminal offences occur in observable structures that are influenced by the landscape in which they occur, and the psychological factors that dictate the offender's movement. It is this maxim that makes geographic profiling as a powerful investigative tool [14]. Crime patterns can be analyzed and explained using GIS because it offers a medium criminal activities data for a better understanding of the factors that influence crime offenders and it could be used to generate a model that could predict potential crime spots. The rate of the incidents changes based on the type of the location means urban land use. This map indicates that the locations of crime incidents are more in commercial and residential areas which are shown in the Figure12.

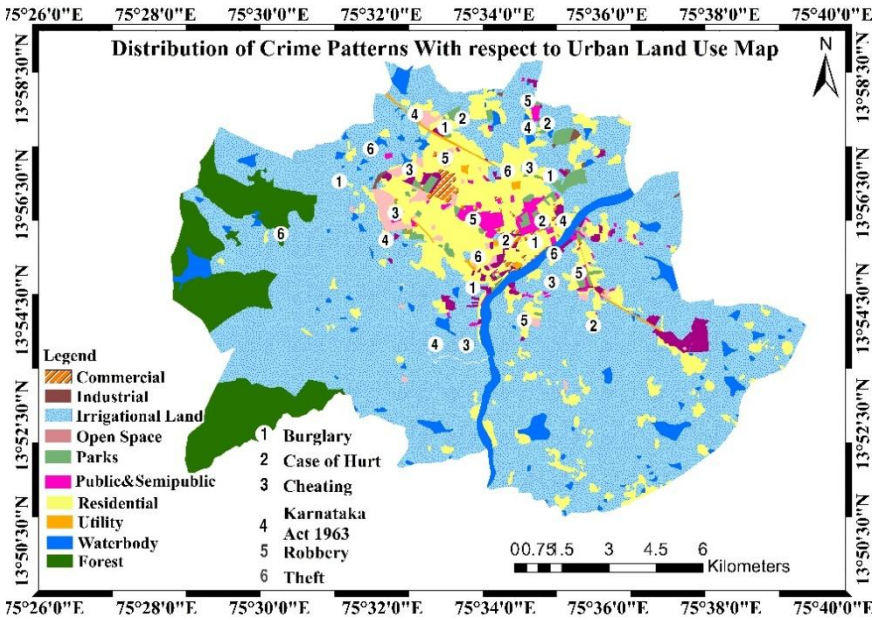


Figure12.Distribution of Crime Patterns in Shivamogga city with respect to Urban Land Use

9.1 Mitigation of Crimes In Shivamogga City

To mitigate the crime rate with the existed police stations in Shivamogga city, it may be difficult because of population increasing year by year. The crime rate with respect to cheating and Karnataka police Act 1963 are increased. Hence there is requirement of additional police stations/police out posts. Based on Closeness to places with hotspot values, distance from existing police station and Closeness to the main streets, we proposed three new police stations in the Shivamogga city for better management of crime in three locations namely Navule, Shanthinagara and MRS circle which are shown in the Figure.6.10.

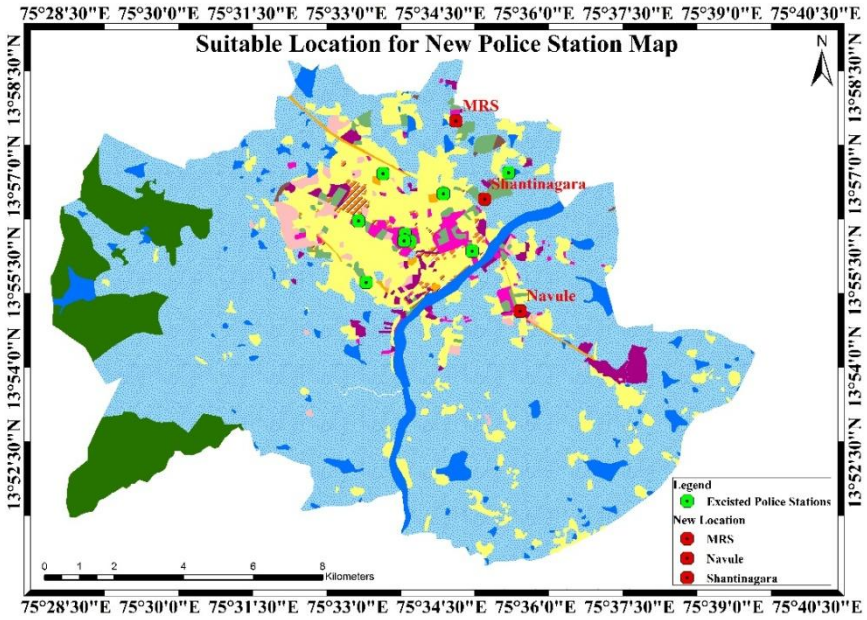


Figure13. Suitable Location for New Police Stations in the Shivamogga city

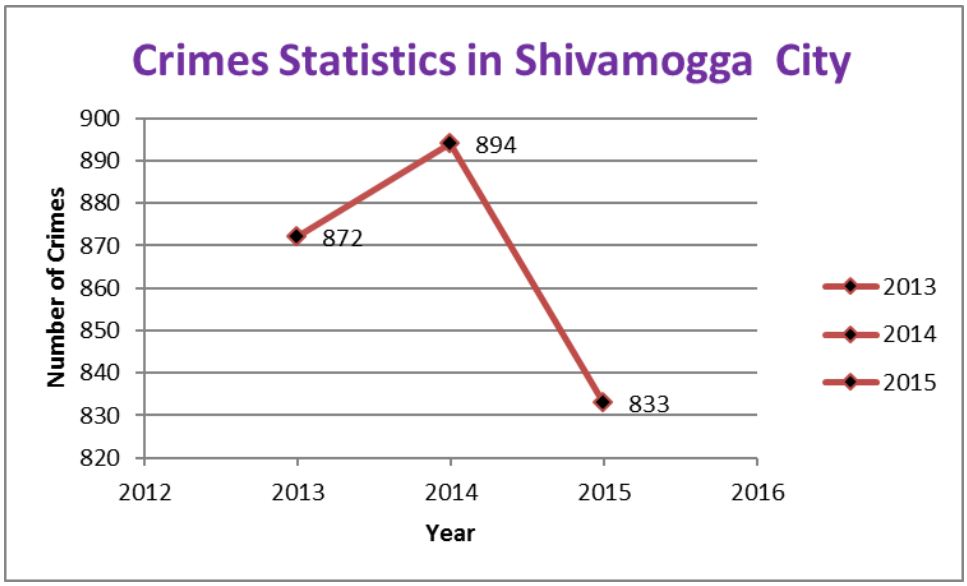


Figure 14.A line graph showing decreasing crime trend from the year 2013, 2014 and 2015.

There is a graphical fluctuation of crime record between the 2013, 2014, and 2015 years corresponding with 872, 894 and 833 respectively. This is illustrated, that there is decreasing trend shown in the graph.

X. CONCLUSION

As per district crime record bureau, twenty-seven types of crimes are recorded in the city. Out of twenty-seven types of crimes, six types of crimes are frequently occurring in the city, remaining nineteen types are very rarely occurring. The major six categories of crimes frequently occurring are Theft, Robbery, Cases of Hurt, Cheating, Burglary and Karnataka police Act 1963. The crime statistics data reveals that, the crime of cases of hurt is gradually decreasing from the three temporal years. Whereas the crime like cheating is increasing from the year 2013 to 2015. The other four types are decreasing in the year 2014 and again increasing in the year 2015. Mapping of Crime and its Analysis are used to find out the Crime Hotspot in Shivamogga City and it will help the Police personal as well as the Tourist visiting these places by providing information regarding which area is safe and where the concentration of particular crime is more. The map showing crime hotspots can help predicting the future crime occurrence and reducing crime incidence. The real time Global Positioning System (GPS) can help the patrolling team to reach the crime scene from the shortest path, which can reduce the impact of crime.

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