Cloud Publications
International Journal of Advanced Remote Sensing and GIS
2013, Volume 2, Issue 1, pp. 70-85, Article ID Tech-62
ISSN 2320 - 0243

Research Article | Open Access

Assessment of Spatial Distribution of Rural Crime Mapping in India: A GIS Perspective

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Publication Date: 28 March 2013

Article Link: http://technical.cloud-journals.com/index.php/IJARSG/article/view/Tech-62

Abstract This paper identifies the distribution of the crimes to challenge facing the police departments that pursue to implement computerized crime mapping systems. The paper highlights the importance of police departments identifying the thematic mapping creating for the rural crime areas. The Geographical Information system (GIS) also using for the how to we create for the crime maps and which mode we are giving the solution for the society or environment. GIS can be used as a tool to identify factors contributing to crime, and thus allow police to proactively respond to the situations before they become problematic. Generally, GIS includes data transfer, geocoding, data integration, system customization, and confidentiality issues are discussed in detail. Finally, we have illustrated the temporal crime incidences also implementing for the GIS analysis. This article will explore the use and possibilities of GIS by Indian Police in describing and analyzing crime action.
Keywords *Crime Data, Distribution, GIS, Spatial Analysis, Temporal Incidence, Thematic Mapping*

1. Introduction

Crime mapping is the use of geographic information to identify and analyze crime and police data. In 1990s, “crime mapping” referred to geographic analysis, even those that involved pushpins, colored dots, and paper maps. Now, however, “crime mapping” usually means the specific use of computerized GIS. Criminal investigative analysis is smaller in use which determines the aspect of crime analysis that includes activities such as geographic profile [1, 2, 3] and specific case support for crime investigations. The history of crime mapping enhanced from the supportive result [4, 5].

Computerized crime maps have recently begun to emerge as a significant tool only in crime and justice that assists police departments in strategic planning, operations and crime analysis. They may display information about the relationships between geographic areas, crime and a number of risk factors. As crime and delinquency are known to be localized processes, criminological maps have proved useful in assisting police operations and in supporting crime prevention initiatives [4]. Maps

also assist in the assessment of the regional distribution of crime. Computerized crime mapping is rapidly a developing technology that assists police departments in strategic planning. The method of investigation is to quickly view and compare patterns of the crime events. Crime has abundant references relating crime patterns to specific geographic features for example, some crimes such as robbery, snatching and pocket picking, may be particularly enhanced by the existence of commercial areas, parking places and industrial complexes [1, 6].

Criminal geographic targeting is based on study of Brantingham and Brantingham (1981) model for crime site selection and recurrence of such activities [7]. Geographic analysis of crime is strongly supported [8, 9] and the practical applications of this analysis have been demonstrated [10, 11, 12, 13]. Some areas are more prone to criminal activities than the others [14, 15] and majority of crimes are not random events, nor are they randomly distributed in terms of where they occur [16]. Spatial variability is a result of the spatially non-random distribution of people who will be motivated to be responsible for a crime and the spatially non-random distribution of causative factors that increase the chances that a person or property will be victimized [17].

Automated crime mapping applications [18, 19] shows the potential results for visual representations of the crime patterns through the spatial maps by the computer. The crime setting or place, the "where and when" of the criminal act, (Brantingham and Brantingham, 1981) describe the fourth dimension of crime, which is the primary concern of environmental criminology.

Criminological theory has two control factors for analysis,

(i) Individual
(ii) Communities

The two major questions for this theory are

(i) Why this person and not that one committed a crime?
(ii) Why is there more increased of crime in society now than before?

Brantingham and Brantingham (1994) [20] successively proved how house breaks induced crimes having the multiple effects in the neighborhoods at which they are located, raising the robbery and theft levels in the surrounding area. Crime analysis may help in the determination of multiple effects of crime and to improve the efficiency of police activity [5, 21]. The incidence of crime is affected by the presence and effectiveness of the police [22, 23, 24, 25].

Crime distribution can be identified on the maps like choropleth maps which use color pattern, shading to indicate the magnitude of a numeric variable. Isopleth map lines are the geographic distribution of a value category. Isopleth or contour maps are used to create continuous areas that connect the points which are having the same value. The contour lines are superimposed on a layer that displays the geographic boundaries. A cartogram is a variant of the choropleth map in which the two dimensional boundaries of geographic units are distorted so that the surface area of each geographic unit is proportional to the amount of the value being measured.

Crime density was used [26, 27] for investigating the associates of crime through statistical models. Furthermore, it is also possible to employ GIS to calculate density of crime in a more accurate way under certain circumstances.

2. Objective

The present study is to produce crime distribution maps based on the following dimensions of the criminal instances in Coimbatore rural police jurisdiction.

i. Allocation of police stations
ii. Boundary of police stations
iii. Crime rate and density in a specific area
iv. Trend of crime in a given time frame
v. Top five prominent crime types
vi. To prepare the thematic map of crime distribution incidences
vii. To measure the crime data in statistical analysis crime rate
viii. To summarize the temporal incidences in the particular areas in Coimbatore rural police jurisdiction.

3. Study Area

Coimbatore is popularly famous as 'The Manchester of South India'. Coimbatore district of Tamilnadu has geographic area of 105.60 Square Kilometer. Coimbatore rural division is situated between 10° 68" and 11°16" Northern latitude and 76.68° and 77.15° Southern longitude in the extreme west of Tamil Nadu near Kerala. The study area for this expression is India, in the State of Tamilnadu; Coimbatore coordinates rural zones which have been identified by the Development of Police as an area with the high number of crime hits. Coimbatore rural police jurisdiction area has been divided into two sub-division namely Perur.and Periyanaickenpalayam. Totally, fourteen police jurisdictions namely Sirumugai, Mettupalayam, Pillur, Karamadai, Periyanaickenpalayam, Thudiyalur, Vadavalli, Thondamuthur, Alandurai, Karunya, Perur, Madukarai, Podanur and Kinathukadavu.

4. Data Preparation and Methodology

The Crime incidence data is collected from the Superintendent of Police Office (SPO) and the Population data from Census of India for the preparation of the spatial crime map for the present two subdivisions and fourteen police stations in the Coimbatore rural jurisdictions with the help of software ArcGIS 9.1. The methodology includes the use of the digitized map of the rural jurisdictions in Coimbatore. The attribute data table of this area consisted of SPO name, jurisdiction to which it belongs, crime incidence data, the population size of the area under the SPO, the number of police stations and the number of subdivisions in each constituency.

The population density of each SPO area was calculated based on population/ area in sq. kms. This value was used as a factor to prepare crime map of the population level for crime incidence in Coimbatore rural division. Maps are prepared thematically to identify the crime areas based on the data available for the population and natural breaks. The population based on the were identified three classes namely highly populated, moderately populated and lowly populated.

5. Crime Incidences in Rural Police Jurisdiction

5.1. Thematic Map of Crime incidences in Rural Police Jurisdiction

Thematic mapping is the process of representing the geographical database on the attribute data available and the value, size, color, represents the data on the map. Thematic maps can be used to highlight individual features or illustrate a series of features. Thematic mapping involves data classification methods, which is known as the most common method for map manipulation. Generally, five data classification methods are available: equal interval, frequency levels, mean and standard

deviation, natural breaks and a user defined. Equal interval uses a constant class interval in classification. Equal frequency, also called quantile, divides the total number of data values by the number of class and ensures that each class contain the equal proportion of area. Mean and standard deviation sets the class breaks at the units of standard deviation above or below the mean. The method of natural breaks uses a computing algorithm to minimize differences between data values in the same class and to maximize differences between classes. For the present study, natural break classification methods were chosen to prepare maps.

5.2. Distribution of Crime Incidences

As mentioned earlier, the study area boundary is digitized and used for creating the distribution of mean crime incidences in Coimbatore city. There are fourteen police stations Sirumugai, Mettupalayam, Pillurdam, Karamadai, Periyanaickenpakayam, Thudiyalur, Vadavalli, Perur, Thondamuthur, Alandurai, Karunya, Madukarai, Podanur and Kinathukadavu. The jurisdictions having low moderate geographical area are Thondamuthur, Vadavalli, and Podanur present in the rural police division limits and under the superintendent of police.

The mean criminal incidences (2003-2006) of Coimbatore rural police division were used for the preparation of thematic maps. For this present study, natural break classification was used to classify the criminal incidence data for thematic mapping.

It was observed that out of the fourteen jurisdictions in Coimbatore rural police jurisdiction, one jurisdiction was classified as high incidence jurisdiction (Thudiyalur), five jurisdictions were classified as moderate jurisdictions Mettupalayam, Karamadai, Periyanaickenpakayam, Vadavalli and Podanur as area two jurisdictions were identified as moderate (Sirumugai and Perur) in the low incidence area, and the remaining six jurisdictions were identified (Pillurdam, Thondamuthur, Alandurai, Madukarai, Karunya and Kinathukadavu) as very low incidence areas.

The total area of the Coimbatore rural police boundary covers about 142.35 Sq.kms. The high incidence area covers nearly 16.97 Sq.kms and the calculated percentage of that area covered is 11.92% .The moderate incidence area occupies 57.64 Sq.kms and the percentage is 40.48%. The low incidence area covers 17.41 Sq.kms (12.22%) and the remaining very low incidence area covers 51.36 Sq.kms (36.08%). However, the increasing number of incidences depends on the density of the population rather than the area occupied. Therefore, a density based thematic map was prepared.

5.3. Temporal Crime Incidences

The collected crime incident for four years are calculated from the basic records and represented in the temporal observation Table 1. The rate of crime incidents for the reported cases is decreased with effect of this thematic preparation of the crime areas. But the trend was not uniform for crime records. It is increasingly and decreasingly reported from the SPO action to the instruction.

For the year 2003-2006, auto vehicle crime thematic map was prepared and presented as Map 1 by using Natural breaks classification. The thematic map was classified into very low, low, moderate and high incidence areas. The very low incidence jurisdictions are Pillur, Thondamuthur, Karunya, Thondamuthur and Kinathukadavu. The low incidences were observed in Perur and Madukarai. The moderate incidence was observed in Sirumugai, Karamadai, Periyanaickenpakayam, Vadavalli and Podanur and the remaining high incidence was observed in Mettupalayam and Thudiyalur of the Coimbatore rural jurisdiction.

The thematic map of 2003-2006 for grave crime is represented as Map 2. It shows a more or less similar pattern to that of the auto crime map. In addition to these maps, the house breaking day (HB

day) thematic map shows the increasing tendency of crime incidences in the areas than the previous type. Similarly, the moderate incidence areas were also found to decrease to low crime from six to five police stations. There is not much variation on the mean crime incidences. The pattern of criminal distribution was found to differ while studying the thematic map presented in House breaking night crime Map 4, i.e., the high incidence areas are found in the central part of the Coimbatore rural division that is Thudiyalur, Mettupalayam and Podanur.

The Map 5 of Murder for gain (MF gain) Mettupalayam, Periyanaickenpakayam, Thudiyalur and Podanur, shows moderate incidences and the remaining areas show high, low and very low incidences. The temporal Map 6 of Murder crime shows more or less the same pattern as pocket picking. The high incidence area was Thudiyalur and the remaining areas showed very low, low and moderate incidences as shown in Map 7. Unfortunately, a criminal incidence data of Robbery showed very low incidence in Sirumugai and other no incidence area are presented in Map 8. (Map 1, Map 2, Map 3, Map 4).

However, in snatching crime, very low incidence areas increased to nine as represented in Map 9. High incidence areas decreased to one in Snatching. The low incidence area decreased whereas the moderate and high incidences decreased among the jurisdictions. The summary of the temporal changes of crime incidences in different jurisdictions of Coimbatore rural police jurisdiction was prepared and presented in the temporal observation. From the temporal observed that there is no jurisdiction in crime spread among and between the jurisdictions except in Thudiyalur jurisdiction.

The remaining jurisdictions shows the following pattern of distribution,

(i) Very low and Low incidences are interchanged in some jurisdictions spatially and temporally.
(ii) Low incidence areas changed to Moderate incidence areas
(iii) High incidences areas are distorted to moderate incidence area and
(iv) Very low incidence areas are altered to low incidence area.

From the above observations, it is concluded that the criminal broadcast in Coimbatore rural division is mixed, which is influenced by the local environment. Control measures of the respective jurisdictions or stations are rather than a uniform outbreak as the observations carried out in other crime countries as in Iceland, Sweden, and other. Therefore, the conceptual study is required for effective measures to control criminal incidences at regional level in Coimbatore rural jurisdiction. (Map 5, Map 6, Map 7, Map 8, Map 9).

5.4. Thematic Map Prepared Using Geographical Area

From the results of Map 10, it is observed that two jurisdiction which has a large geographical area are Thudiyalur and Mettupalayam. The jurisdictions having moderate geographical areas are Sirumugai, Periyanaickenpakayam, Madukarai and Kinathukadavu. The jurisdictions having low geographical areas are Pillur dam, Karamadai and Podanur. The five jurisdictions recorded to have a very low geographical area are Vadavalli, Thondamuthur, Perur, Alandurai and Karunya below 142.35 Sq.kms.

The population distribution of the study area was collected for each Police station and represented as Map 11. From this map, it is found that Coimbatore jurisdiction has the highest recorded population in Karamadai. Thudiyalur jurisdiction has moderate area. The other jurisdictions Sirumugai, Mettupalayam, Periyanaickenpakayam Alandurai, Podanur, Madukarai and Kinathukadavu have low distributed population. The remaining five jurisdictions have low and very low distributed population.

Based on the population density of the SPO area, a characteristic was introduced in the following equation to establish a relationship between population and crime incidence. The crime rate at that particular area was calculated based on the following equation and as

$$\text{Crime rate} = \frac{\text{Number of crime in the area}}{\text{Population of the area}} \times 100000$$

For each jurisdiction area, a thematic map of crime distribution Coimbatore was prepared. Natural breaks classification method was used to classify the area into high, moderate, low and very low incidence zones. The population density of each jurisdiction was calculated based on the population by total geographical area of the jurisdictions and represented as Map 12. The highest population density in Coimbatore jurisdiction was recorded of the rural area Vadavalli. (Map 10, Map11)

Moderate density of population was recorded at Mettupalayam, Periyanaickenpakayam, Thudiyalur and Podanur. Low density of population was recorded at Sirumugai, Karamadai and Perur. The remaining jurisdictions were very low populated. The average percentage of the crime cases was calculated for four years by using the obtained values. The crime density based on population was calculated and used as a crime factor for preparing the population density on a crime map for Coimbatore rural police jurisdiction (Map 12) (Table 1).

6. Conclusion

The resultant map clearly indicates the major crime prone areas in Coimbatore rural police jurisdiction. The crime incidence map clearly visualized the regions where efforts are to be maintained for crime control. These areas require necessary funds and suitable measures. Effective suggestions, put forward are

i. In-depth study of these areas has been taken by integrating the population wise data, heavy forces of crime controlled in the surrounding areas.

ii. Crime mapping techniques are not widespread in police forces and Home affairs office and remains to be explored to be fullest extent. It provides major availabilities at the local level for greater utilization of GIS for crime analysis.

iii. Crime analysts and problem-solvers also use computer maps to identify emerging patterns of crime activity for the using of Police department.

iv. Many police officials want to have available effective representations of crime location patterns. For analytical and decision making purposes, useful representations of hot spots and other location information are needed. Simulations are becoming more important as visualization techniques become more sophisticated.

v. We propose that different police agencies need different types of crime mapping systems. Moreover, even within a police agency, different police functions will most likely demand different types of applications.

vi. However, this research is necessary to evaluate the above mentioned techniques for executing the map with a particular interval because accurate population data is critical for the assessment of human population density on crime rate and attribution of risk to crime incidences.

vii. Therefore, we suggest that police departments need to identify the primary end-user from the outset, and then prioritize the customization of crime mapping systems accordingly.

viii. The new technology that features mapping representations would be helpful to police, especially in the study of crime patterns in large buildings and underground structures. In general, geographic presentation is an area with vast potential for developing new types of maps and charts that can aid police authorities.

ix. Finally, the map also serves as a guide for crime affairs/surveyors/officers in identifying the proper study for environment international trials and also as assistance for the population who would be benefitted from the new interventions.

From the field work investigation, interviews and data obtained from the primary and secondary sources one could find that the high crime rate as well as different kinds of crime occur more frequently in the poorer sections of the society like that in slum prone areas, areas lacking street lights and other adequate facilities for daily living and areas having low literacy rates.

Figures

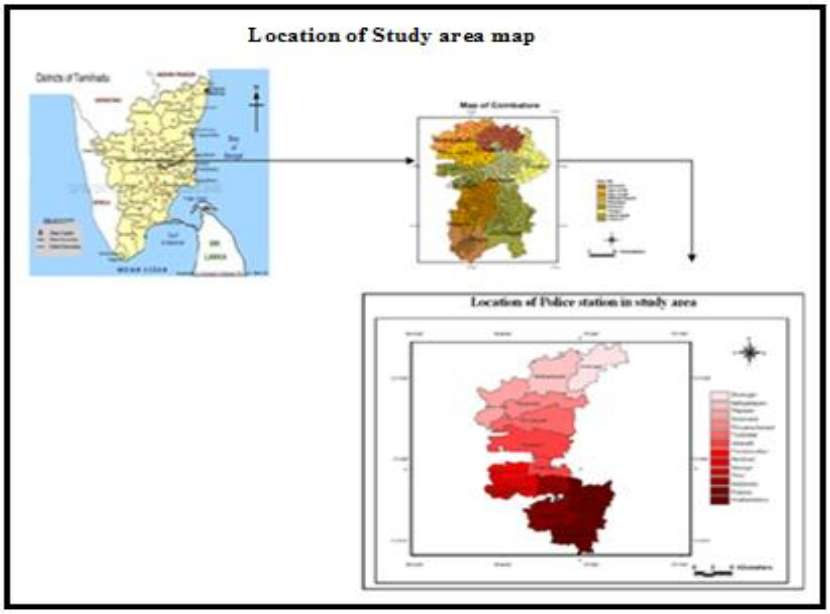

Figure 1: *Location of Study Area*

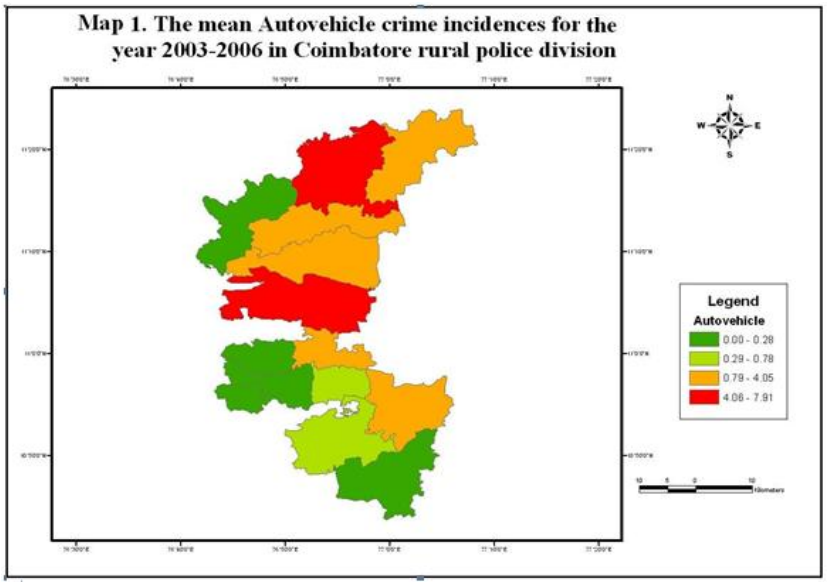

Figure 2: *The Mean Auto Vehicle Crime Incidences for the Year 2003-2006 in Coimbatore Rural Police Division*

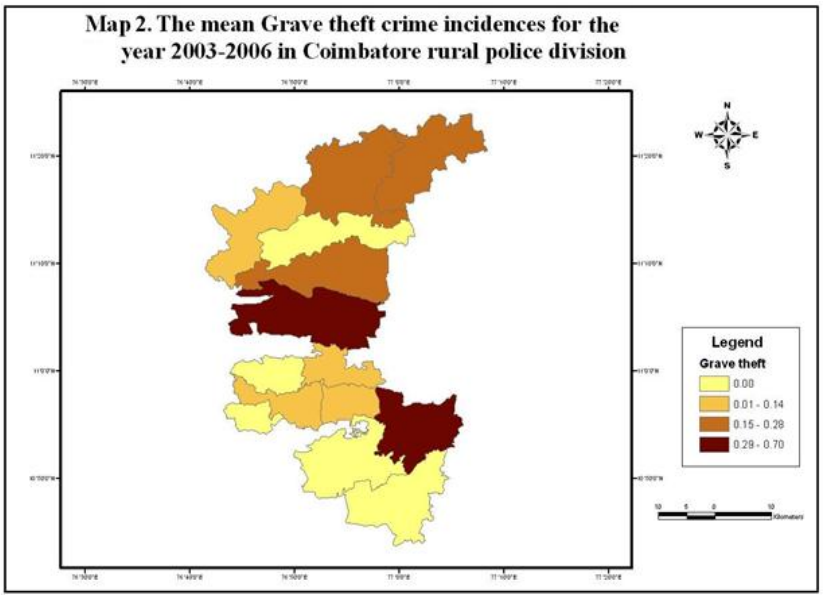

Figure 3: *The Mean Grave Theft Crime Incidences for the Year 2003-2006 in Coimbatore Rural Police Division*

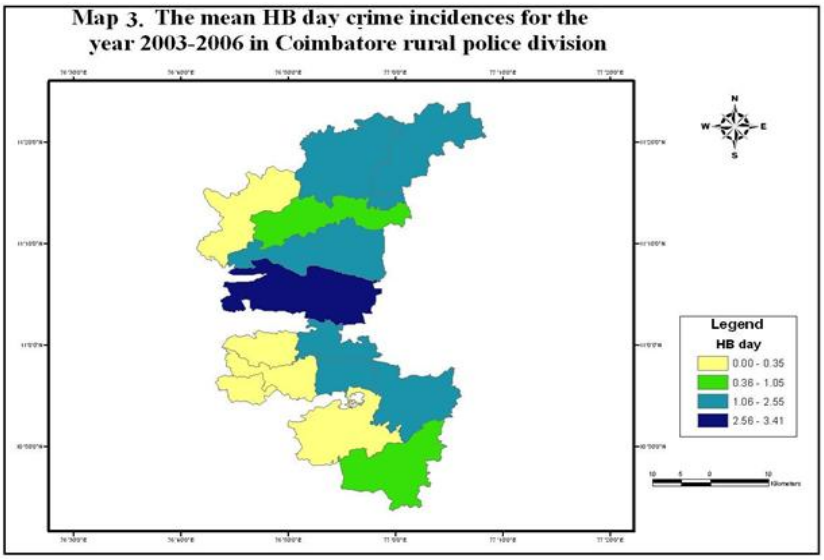

Figure 4: *The Mean HB Day Crime Incidences for the Year 2003-2006 in Coimbatore Rural Police Division*

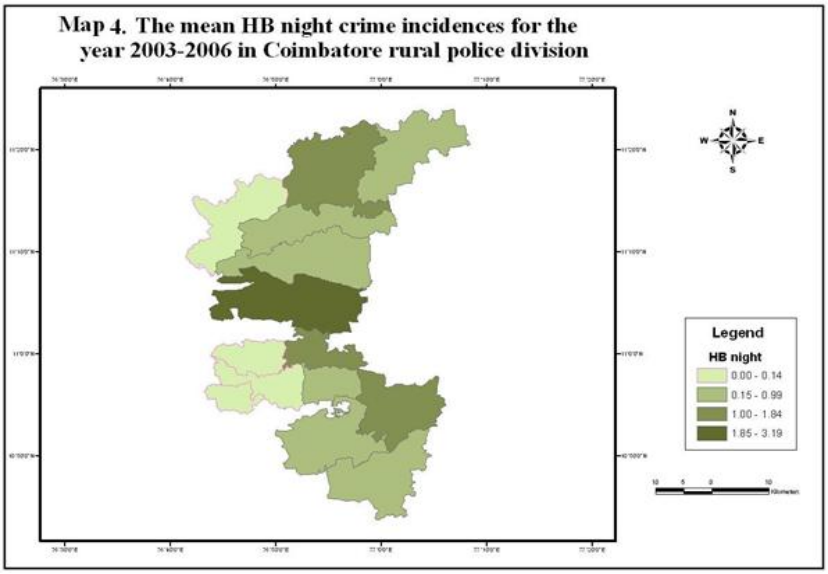

Figure 5: *The Mean HB Night Crime Incidences for the Year 2003-2006 in Coimbatore Rural Police Division*

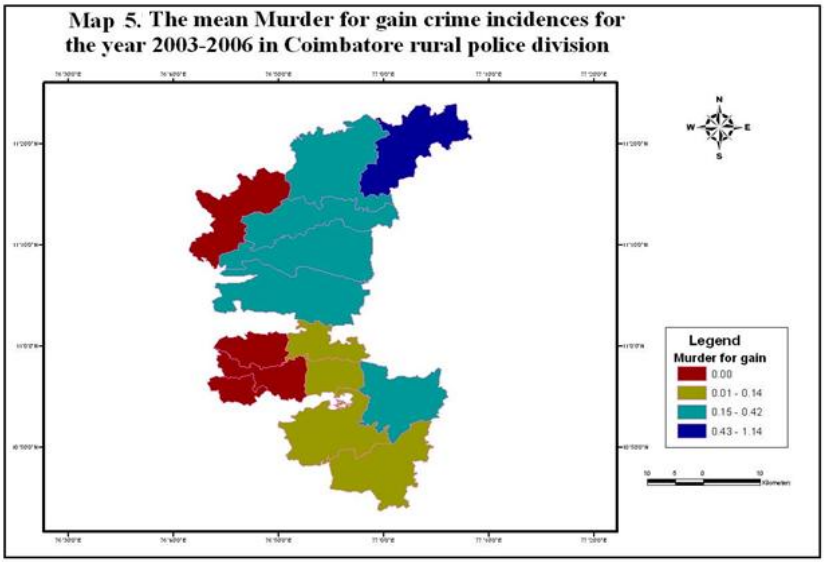

Figure 6: *The Mean Murder for Gain Crime Incidences for the Year 2003-2006 in Coimbatore Rural Police Division*

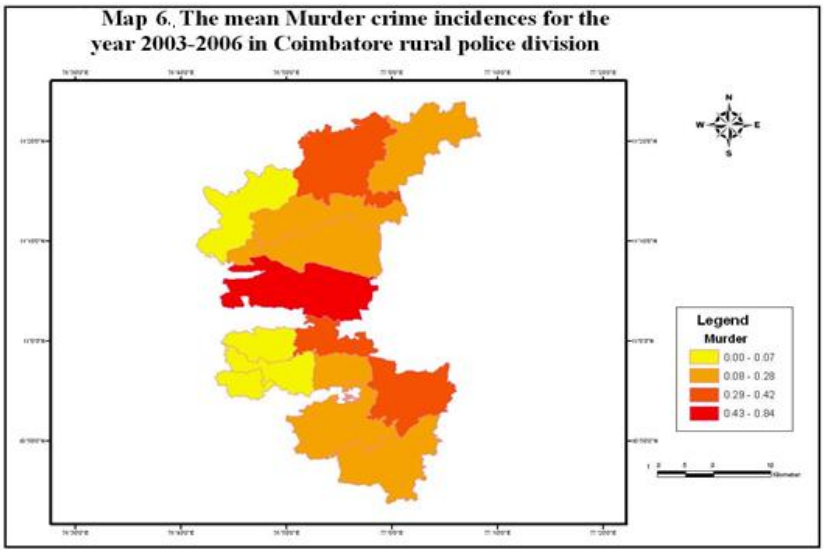

Figure 7: *The Mean Murder Crime Incidences for the Year 2003-2006 in Coimbatore Rural Police Division*

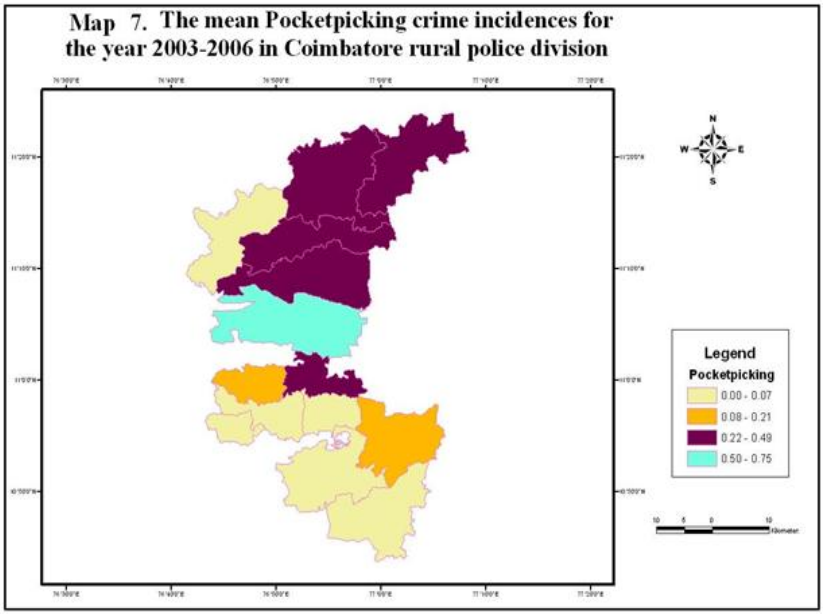

Figure 8: *The Mean Pocket Picking Crime Incidences for the Year 2003-2006 in Coimbatore Rural Police Division*

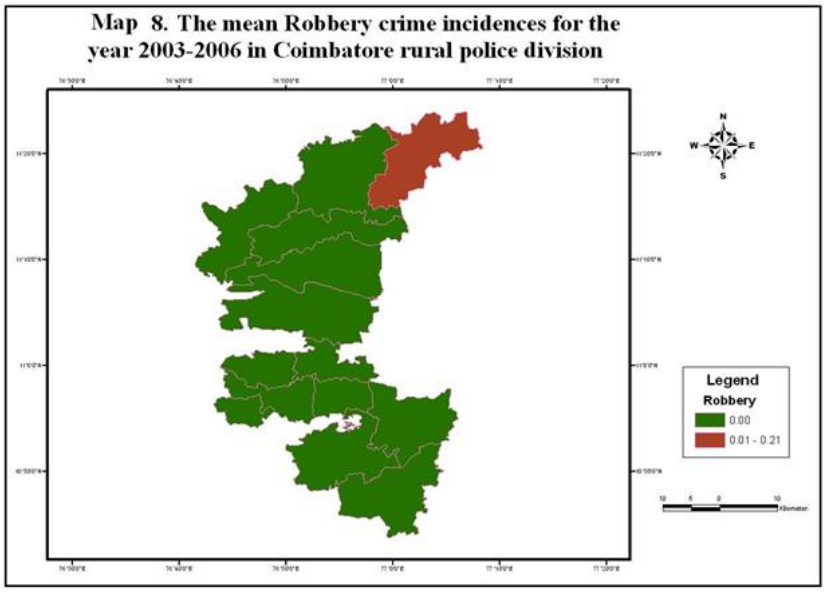

Figure 9: *The Mean Robbery Crime Incidences for the Year 2003-2006 in Coimbatore Rural Police Division*

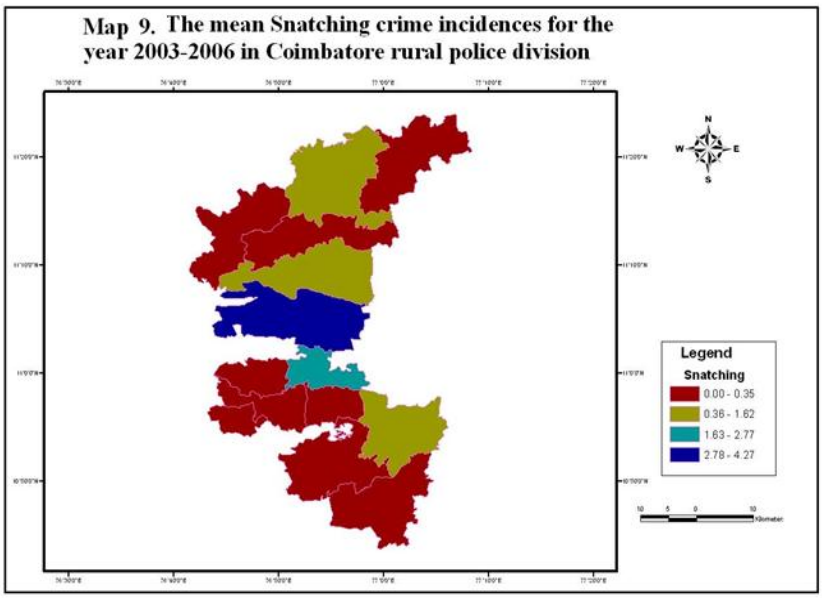

Figure 10: *The Mean Snatching Crime Incidences for the Year 2003-2006 in Coimbatore Rural Police Division*

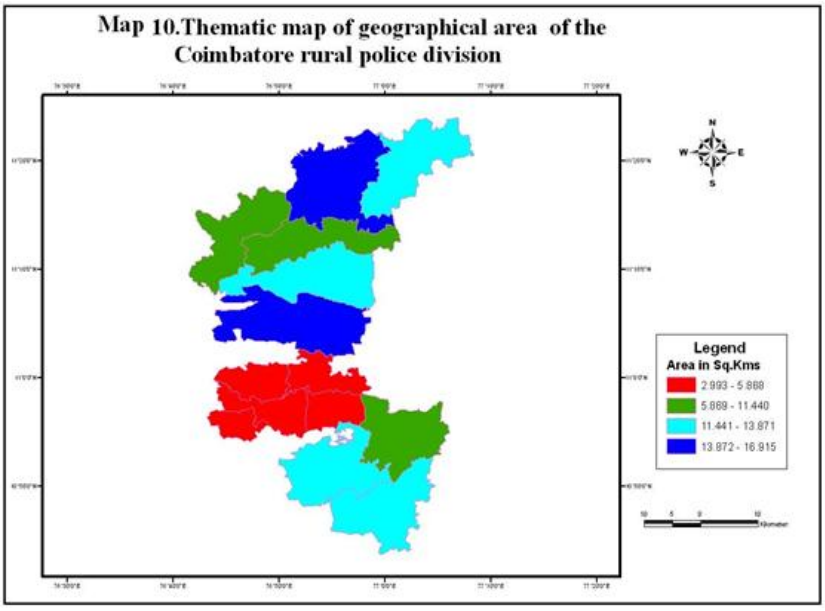

Figure 11: *Thematic Map of Geographical Area of the Coimbatore Rural Police Division*

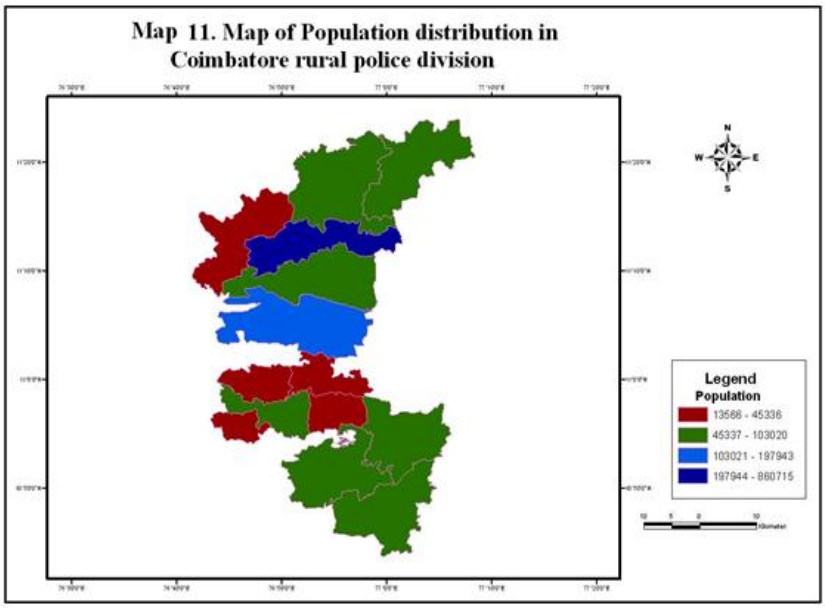

Figure 12: *Map of Population Distribution in Coimbatore Rural Police Division*

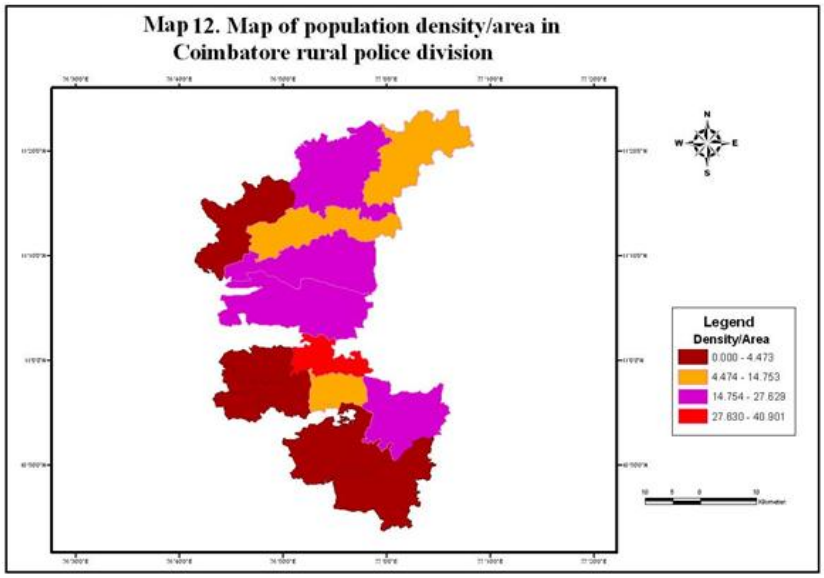

Figure 13: *Map of Population Density/Area in Coimbatore Rural Police Division*

Table

Table 1: *Temporal Observation / Changes of Recorded Crime Incidences in the Police Jurisdictions of Coimbatore Rural of India (2003-2006)*

Police Jurisdiction	Auto	Grave	HB Day	HB Night	MF Gain	Murder	Pocket Picking	Robbery	Snatching
Sirumugai	**	***	***	**	***	**	**	***	*
Mettupalayam	***	***	***	***	****	***	****	***	**
Pillur dam	*	**	*	*	*	*	*	*	*
Karamadai	**	*	**	**	***	**	***	***	*
PN palayam	**	***	***	**	****	**	***	***	**
Thudiyalur	****	****	****	****	****	***	****	***	****
Vadavalli	**	**	***	***	***	****	**	****	***
Thondamuthur	*	*	*	*	*	*	*	**	*
Alandurai	**	**	*	*	*	*	*	*	*
Karunya	*	*	*	*	*	*	*	*	*
Perur	*	**	***	**	**	**	*	**	*
Madukarai	*	*	**	*	****	**	*	*	*
Podanur	**	****	****	***	***	***	***	**	**
Kinathukadavu	*	*	*	**	***	**	**	*	*

Very low	6	5	5	5	4	4	6	5	9
Low	6	4	2	5	1	6	3	3	3
Moderate	1	3	5	3	5	3	3	5	1
High	1	2	2	1	4	1	2	1	1

Key

* Very low incidences
** Low incidences
*** Moderate incidences
**** High incidences

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