Role of Geospatial Technology in Crime Mapping & Analysis: A Case Study of District Kasur, Punjab, Pakistan

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C rime is a social stigma that needs to be addressed beyond talks. The use of geospatial information technology has become well recognized within the fields of forensic sciences and criminology, especially in the developed world. The current study is an attempt to analyze the distribution and trends of various crime types, including rape, murder, baby kidnapping, vehicle theft, and dacoity in district of Kasur Punjab, Pakistan during the year 2021. (Police station wise crime data) was collected from the District Police Office (DPO), Kasur and interpolation technique was applied and several maps were generated, including crime type, crime rate, and crime density with in study area and statistical illustrations were down users Microsoft Excel software suite. Murder crimes were found highest in the vicinity of Sadar Kasur police station whereas lowest in the vicinity of City Pattoki police station. Alla abad police station reported the highest rape crimes, whereas the lowest crime rate was found in the jurisdiction of Theh Sheikham. Kidnapping were highest in Sadar Kasur and Kot Radhakishen police stations' vicinity, while it was found to be the lowest in the The Sheikham police station's jurisdiction. Ganda Singh Wala, Kangan Pur, and Sadar Chunian had the lowest number of vehicle theft, whereas the city Pattoki and Sadar Kasur police stations recorded the highest dacoity crime. The present study suggests that the use of geospatial technology within the study area and beyond by the law enforcement departments can effectively enhance crime control and can help to maintain law and order situations.
Keywords: Crime Analysis, Geographical Information System, Crime Mapping, Daysmetric maps.

Introduction

Crimes in Pakistan have been growing for a long and minimizing their occurrences has become a great challenge for law enforcement agencies, especially in context of the rapidly growing population in the country. The law enforcement/ security agencies and police departments in Pakistan have state-of-the-art modern equipment/ technology to cater to this issue however the ratio of security/ police personnel to the population densities in various jurisdictions, disabling them to handle the crime issues therefore it is a need to manage this issue by analyzing crime pattern recognition.

The traditional method of crime detection, monitoring, and management has failed to be fully effective in curbing the present crime scenario [1]. Crime as a social & spatial phenomenon needs suitable prevention with information technology to decrease the intensity, for example, crime mapping risk distribution using Geographical Information System (GIS) [2] [3].

A spatial decision support system like GIS, along with other advanced technologies, is essential to discover better results in the context of uprising crime rate and crime density. This also helps in assessing the spatial pattern of data related to criminology for better understanding its causes on local, regional, and national scales for security specialists [4]. GIS is a key tool to deliver the information compulsory to the organizational staff to investigate and make a rapid conclusion by providing the final result with spatial as well as graphic information permitting the law implementation agencies to understand where crimes are occurring, where the high density of the crimes are and where the crime rate is high [5]. GIS can also be utilized as a tool in analyzing & making a decision in the safety field, particularly in crime and mapping analysis [6].

In Australia and the United States, for instance, crime study using GIS has increased over time to perform crime mapping, including spatial analysis processes of crime to obtain information about crime trends, patterns, and dynamics relating to time, location, and target [7][8]

Balogun et al. [8] mapped crime hotspot areas insufficient security outfit areas of overlap requiring constant patrol in the City of Benin using buffer analysis. With the emergency of geographic data and its positive use as an instrument for crime analysis & forecasting, the study of current crime data to identify spatial crime tends has emerged as a new study area however, in Europe, this reality is still recent [9][11].

Each crime event is important in time, space, human activity, and pattern [10]. In Indonesia, the investigation of crime analysis and mapping using GIS usually inputs data to be concentrated in specific places, even close to spaces with extreme crime risk [11].

Policymakers in police sectors can utilize more complicated maps to observe trends in criminal activity, and maps may be invaluable in settling criminal cases [4][12]. Successful GIS products to be utilized in crime mapping includes the time needed to collect information and ensure that information is solid for crime analysis [13]. A map containing trends of criminal activity in high-density areas and temporal information has a lot of value for strategy makers of the police sectors [14].An attempt has been made to map crime trends in District Kasur, using primary & secondary datasets.

Study Area

District Kasur has been selected as the study area for the present research (figure 1). Kasur is located in the Punjab province of Pakistan, It is located on geographical coordinates of 31.11556° N latitude and 74.44667° E longitude and is situated at a distance of about 55 km towards the south of Lahore district, the capital of Punjab province. The district is bounded by India on the South and East through the river Setluj, Lahore district on the North, district Sheikhupura on North West, and district Okara lies to its South West. It has covered an area

of 3,995 Km^2 and is divided into four tehsils, i.e., Kasur, Pattoki, Chunian, and Kot Radha Khisn. [15].
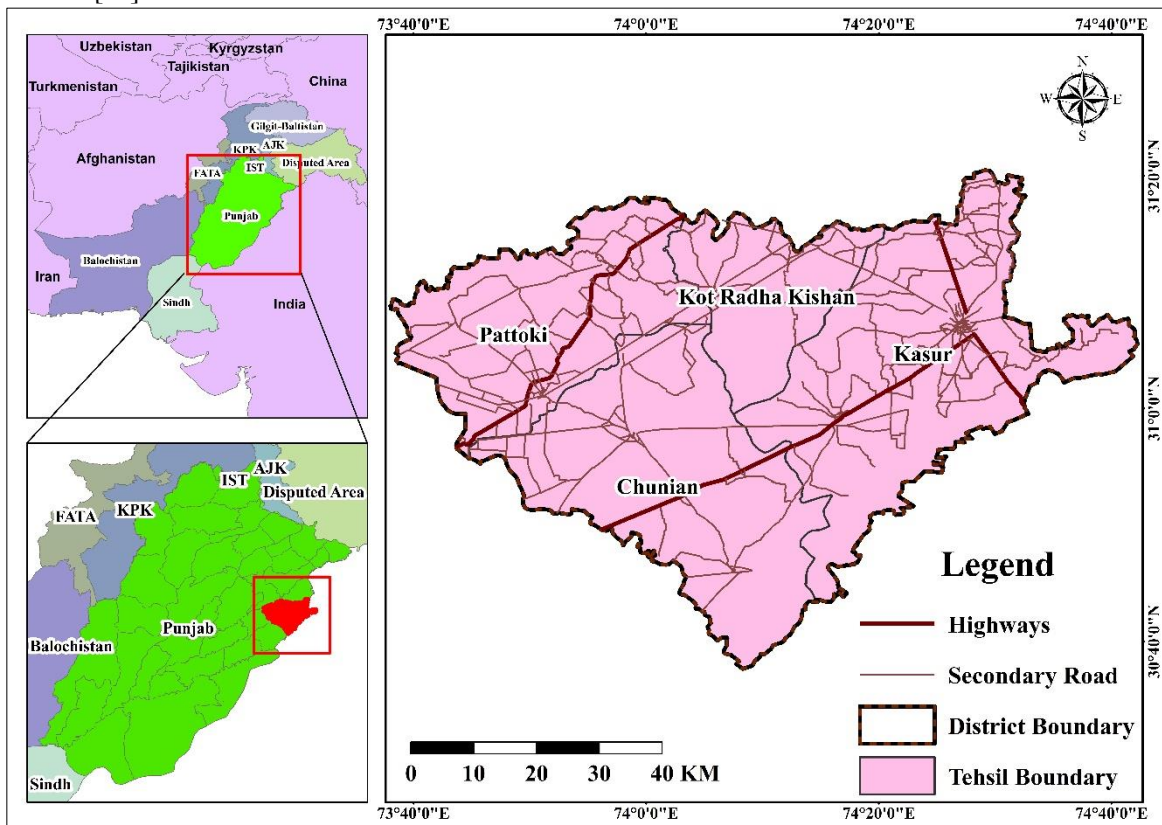

Figure 1. Map of District Kasur

Material and Methods

The present study is mainly based on secondary data sources. The administrative information regarding the details of the district and tehsil, along with the road network of district Kasur, was obtained from The Urban Sector Planning & Management Service Unit. GPS was used to collect the coordinate of each of the (20) police stations in the study area. (figure 3) depicts the names of each police station. Geo-referencing the scanned image using Arc GIS 10.8 and creating the police station boundary for plotting the crime incidents. The number of crimes and the population of each police station was entered into each column. The obtained crime data was initially arranged in columns, and several polygon vector layers were created according to selected crime types in ArcGIS 10.8 software.

Crime Density = Total number of crimes/ police station jurisdiction area per km^2

Crime rate = Total number of reported crimes /per 1000 of the total population.

Furthermore, the frequency of crime types reported from different police stations in the study area during the reference year was depicted using radar charts and other means.

Police Stations Location & their Boundary

In this section, We conducted a field survey to collect the coordinate of each police station in the study area. The police stations were plotted on the map as a point feature. The police station's boundaries were generated from scaned images that were collected from the DPO office in Kasur. Figure 2 describe the methodology adopted in this study.
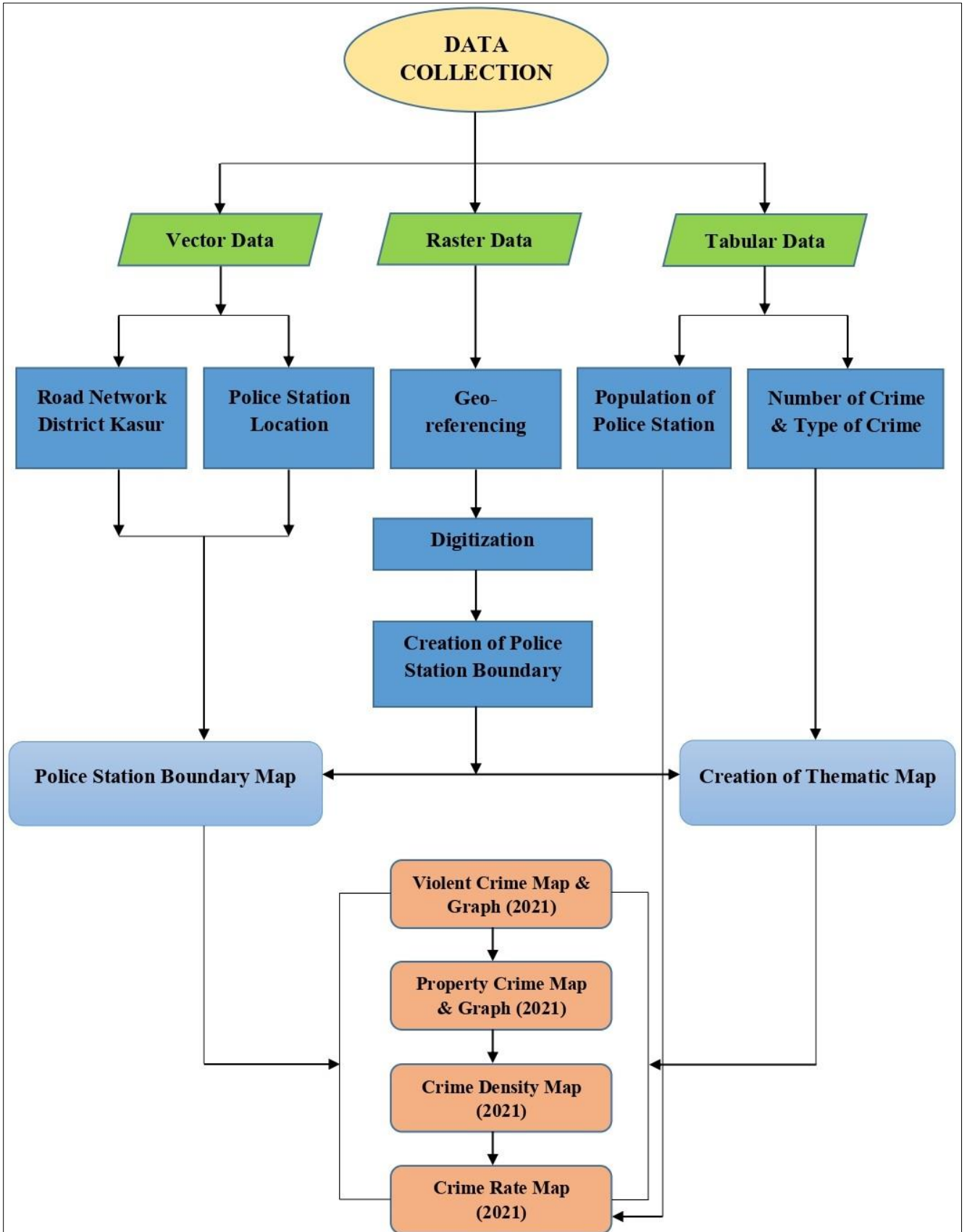
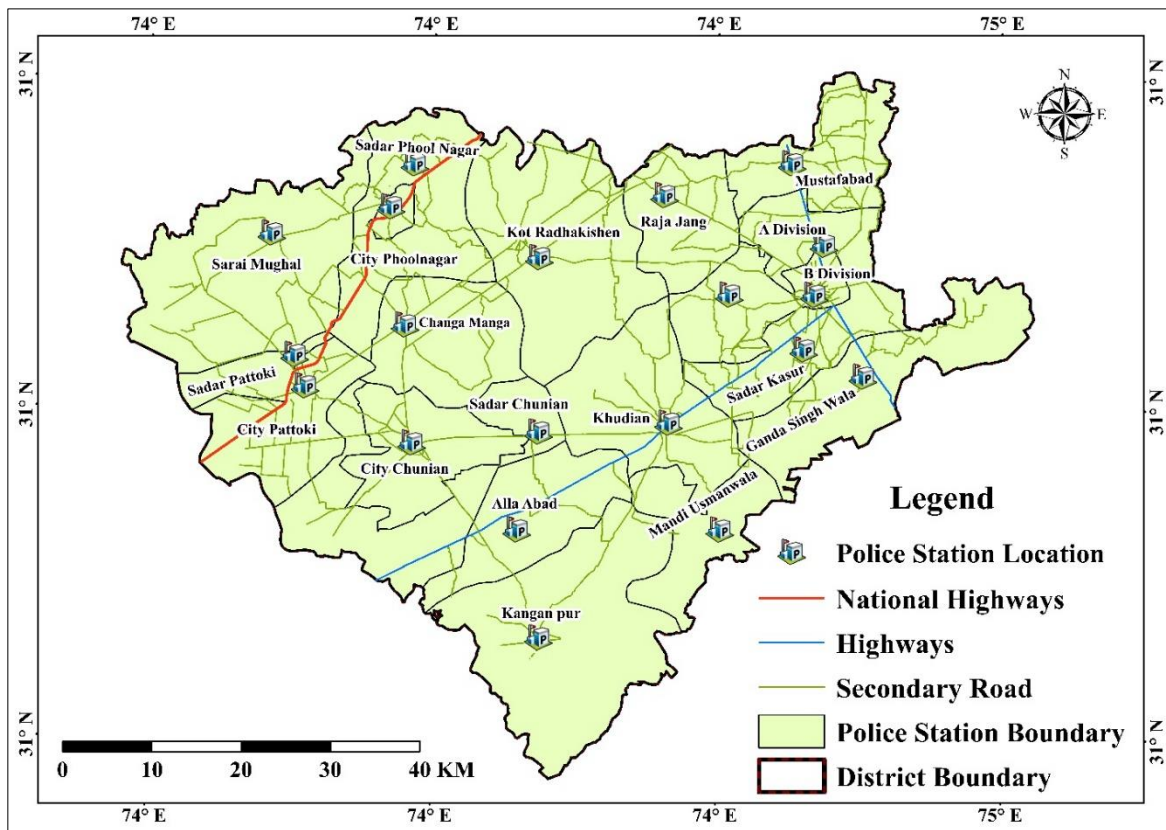**Figure 2.** Methodological framework of the study

Figure 3. Police station boundary map of the study area

Results and Discussion

Distribution of Crimes in District Kasur by Violent Crimes

According to the data obtained from the DPO office, a total number of 12,517 crimes were reported in Kasur District during the year 2021. The total number of crimes were 607, which included murder, rape, ,kidnapping, and baby kidnapping (figure 4) [18]. Figure 4 shows an overall synoptic view of violent crimes at a glance. The highest number of murder cases were reported from Sadar Kasur and Kot Radhakishen police stations, whereas the Kidnapping and rape was the most reported crime in the study area. The highest incidence of rape was reported in Alla Abad and Sadar Kasur police stations. Moreover, kidnapping rape was the most reported crime in the study area.

On the other hand, the cases of baby kidnapping were found very few, and the highest was reported from Sadar Phool Nagar and City Chunian police stations, respectively.

In recent days, geospatial mapping has become a assential for the common citizens and administrative agencies due to its potential to pool several data set which is generally presented to them. [16]. Cartography work was done, and a crime map of each police station in the study area was created.

Similarly, a dasymetric map was prepared using Arc GIS 10.8 software to show the spatial distribution of violent crimes (figure 5), which gave a clear idea of the whole situation of crime incidence in the study area.
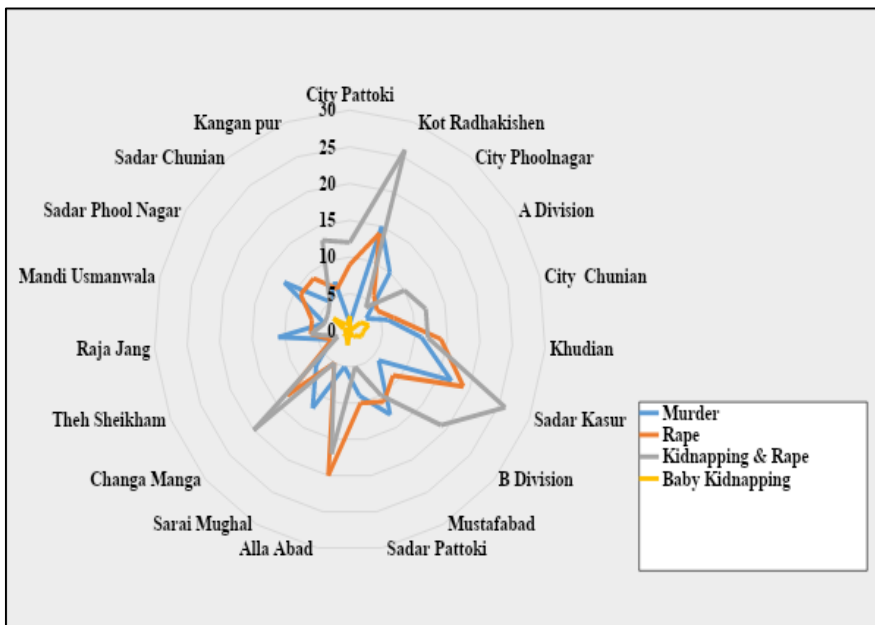
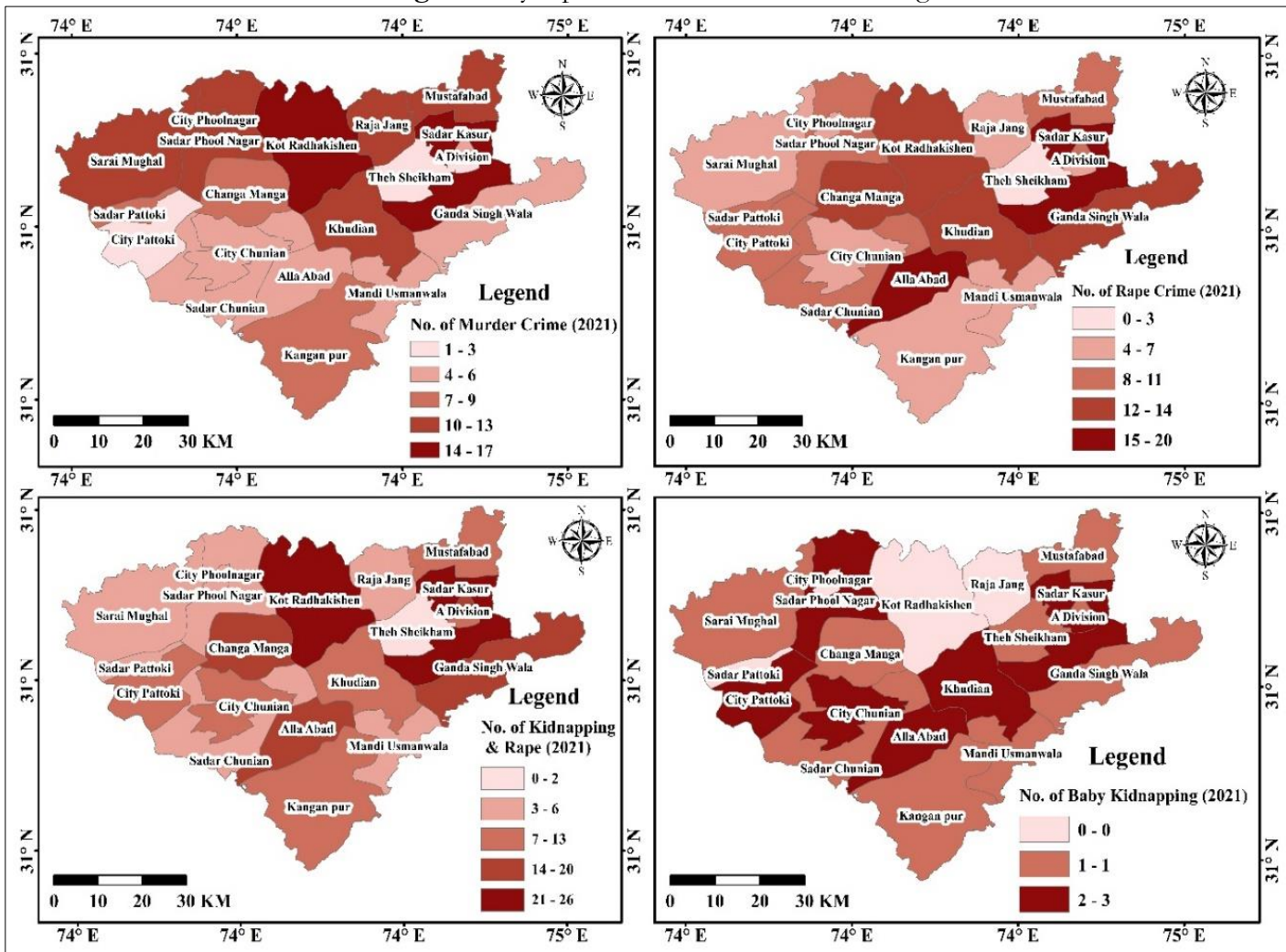**Figure 4.** Synoptic view of violent crimes at a glance

Figure 5. Spatial distribution of violence crimes in the study area during the year 2021

4.2   **Distribution of Crimes in District Kasur by Property Crimes**

Besides, the property crimes were 855 in number, which included vehicle theft, theft, and dacoity (figure 6). It can be seen from figure 6 that theft was found to be the most reported crime within   the highest number was reported from Sadar Kasur and city Pattoki police stations. Additionally, the maximum number of vehicle theft cases were reported from A Division and Kot Radhakishen police stations. The highest number of dacoity cases were reported from City Pattoki, Sadar Kasur, and Sadar Pattoki police stations. The distribution of property crimes in the study area can be further seen in figure 7 as well. Additionally, figure 8 represents an overall situation of violence and property crimes reported from district Kasur during the year 2021.
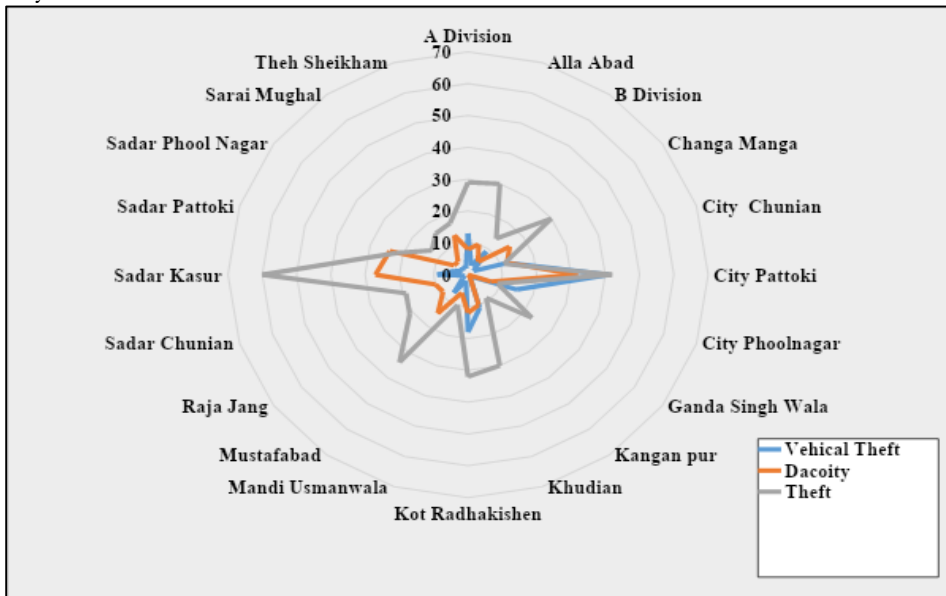

Figure 6. Frequency of property crimes in the study area for the year 2021

Distribution of Crimes in District Kasur by Crime Rate

A "crime rate" is defined as adding the total number of crimes reported in an area and then dividing it by the collective population of the area [19]. It is an important method through which a better understanding of crime incidence and crime prevalence in any region can be made. If the general opinion of the relationship between crime rate and density is precise, it is expected to have a positive relationship between these two variables. In other words, the higher the population, the higher the crime rate. We also assume that the higher the unemployment and poverty rates, the higher the crime rate. On the other hand, the lower the education level, the higher the crime rate. Same results were computed int the research as in [17].

As Table 1 shows, the highest crime rates were found at Khudian and City Chunian police stations, with 7.03 and 6.9 crimes per thousand people, respectively. The lowest crime rates were observed at Sadar Chunian, Theh Sheikhum, and Ganda Singh Wala police stations, with 2.35, 2.53, and 2.6 crimes per thousand people, respectively. The distribution of crimes by crime rate within the study area during the year 2021 can be further analyzed in figure 9.
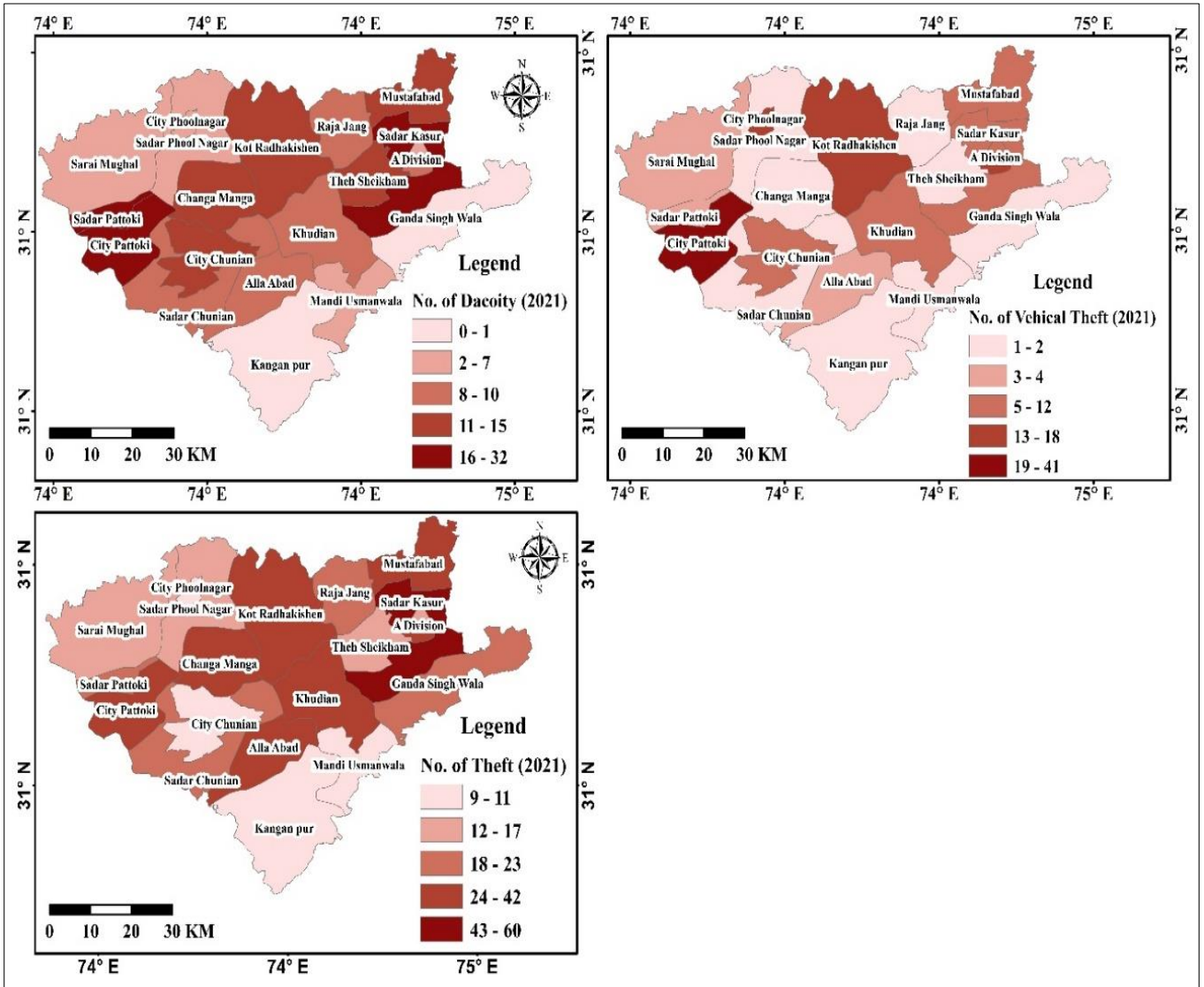
Figure 7. Spatial distribution of property crimes in the study area during the year 2021
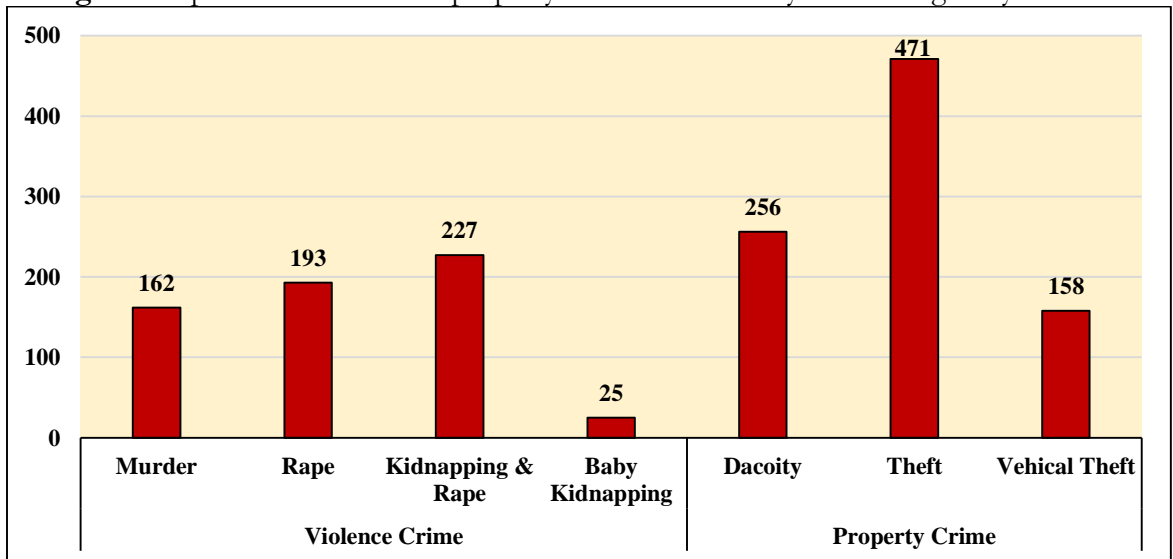

Figure 8. Number of violence and property crime in the study area for the year 2021
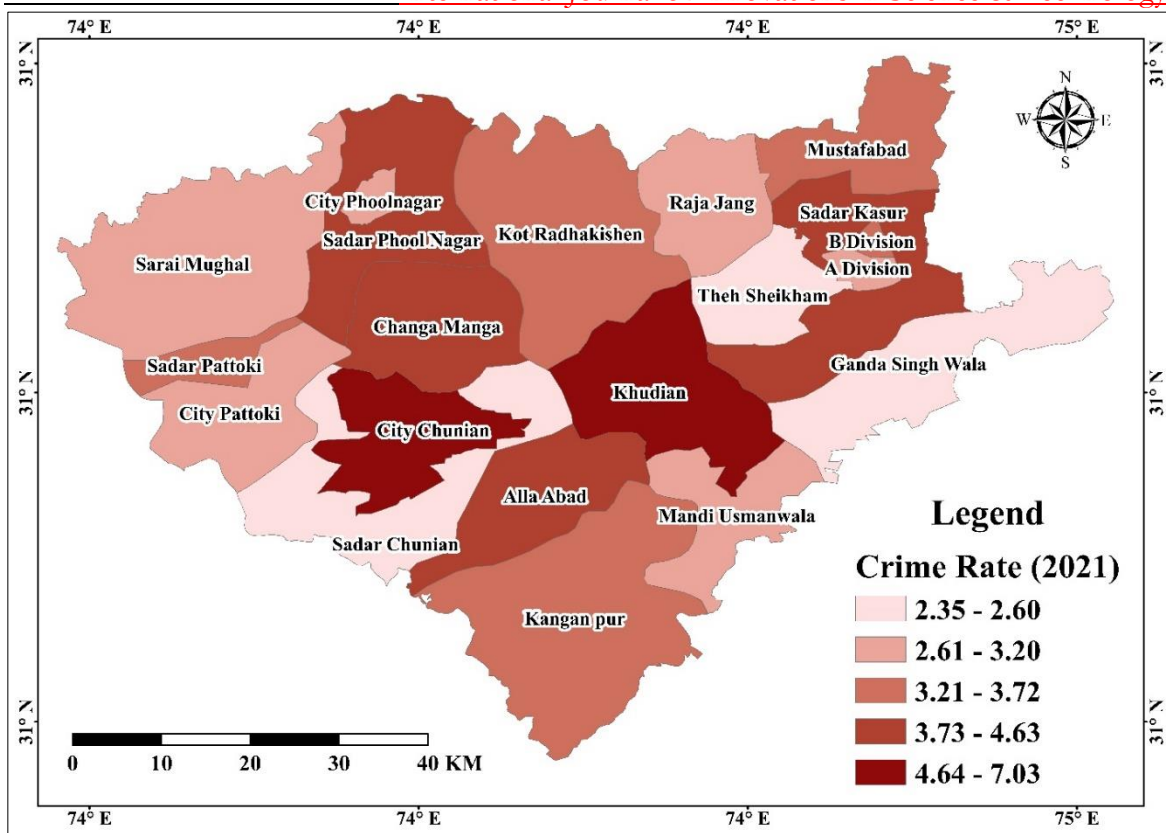
Figure 9. Distribution of crime rate in the study area

Distribution of Crimes in District Kasur by Crime Density

Crime density is measured by the number of crimes that happen per km2 in each police station [19]. It is an important way to measure the density of street crimes that occurred for each police station as it further explains the intensity of crime within a region on a smaller scale. In the present study, a police station-wise crime density was also calculated for district Kasur and is mentioned in table 1. It is obvious from Table 1 that the highest density of crime was seen at B-Division and A-Division police stations, with 75.98 and 32.53 crimes per km2, respectively. It is noticeable that both police stations, though they cover a small zone in terms of area but are identified as the densest crime locations in the study area. On the other hand, the lowest crime density was seen at Sarai Mughal, Kangan pur, and Sadar Chunian police stations, with 1.1 1.11, and 1.32 crimes per km2, respectively.

Table 1. Police station-wise crime database

Police Station	Area (Km²)	Population (2021)	No. of Crimes (2021)	Crime Density (Crime/Km²)	Crime Rate (Crime/1000 Pop.)
A- Division	23.58	265140	767	32.53	2.89
Alla Abad	191.9	210565	891	4.64	4.23
B-Division	10.53	240142	800	75.98	3.33
Changa Manga	204.49	145123	672	3.29	4.63
City Chunian	177.49	102180	705	3.97	6.9
City Pattoki	179.14	259198	829	4.63	3.2
City Phoolnagar	21.16	148985	477	22.55	3.2
Ganda Singh Wala	259.17	178982	452	1.74	2.53
Kanganpur	441.13	134256	489	1.11	3.64

Khudian	263.08	111875	787	2.99	7.03
Kot Radhakishan	378.13	249840	883	2.34	3.53
Mandi Usman Wala	146.32	82546	253	1.73	3.06
Mustafabad	169.09	201561	749	4.43	3.72
Raja Jang	155.29	157122	486	3.13	3.09
Sadar Chunian	266.69	149640	351	1.32	2.35
Sadar Kasur	258.41	258642	1052	4.07	4.07
Sadar Pattoki	58.81	161932	550	9.35	3.4
Sadar Phoolnagar	253.34	121553	548	2.16	4.51
Sarai Mughal	410.25	150471	450	1.1	2.99
Theh Sheikhum	121.86	125243	326	2.68	2.6

Source: DPO Office Kasur, 2021

The whole situation is fully revealed in figure 10 that when the area of the police station is increased, then the density of crime also decreases. Some medium-dense crime areas were found close to the high dense crime areas like Raja Jhang, City Chunian, Alla Abad, Khudian, and Sadar Kasur police stations. It was also perceived that the low-dense crime was situated near the outskirts of medium-dense crime areas. The low, dense crime-prone area was found as a nearly pure domestic area with low business activity. Therefore, it was noticed that crime density is closely associated with the land use characteristics of a city and is higher in density where commercial land uses are present along with the core urban activity.
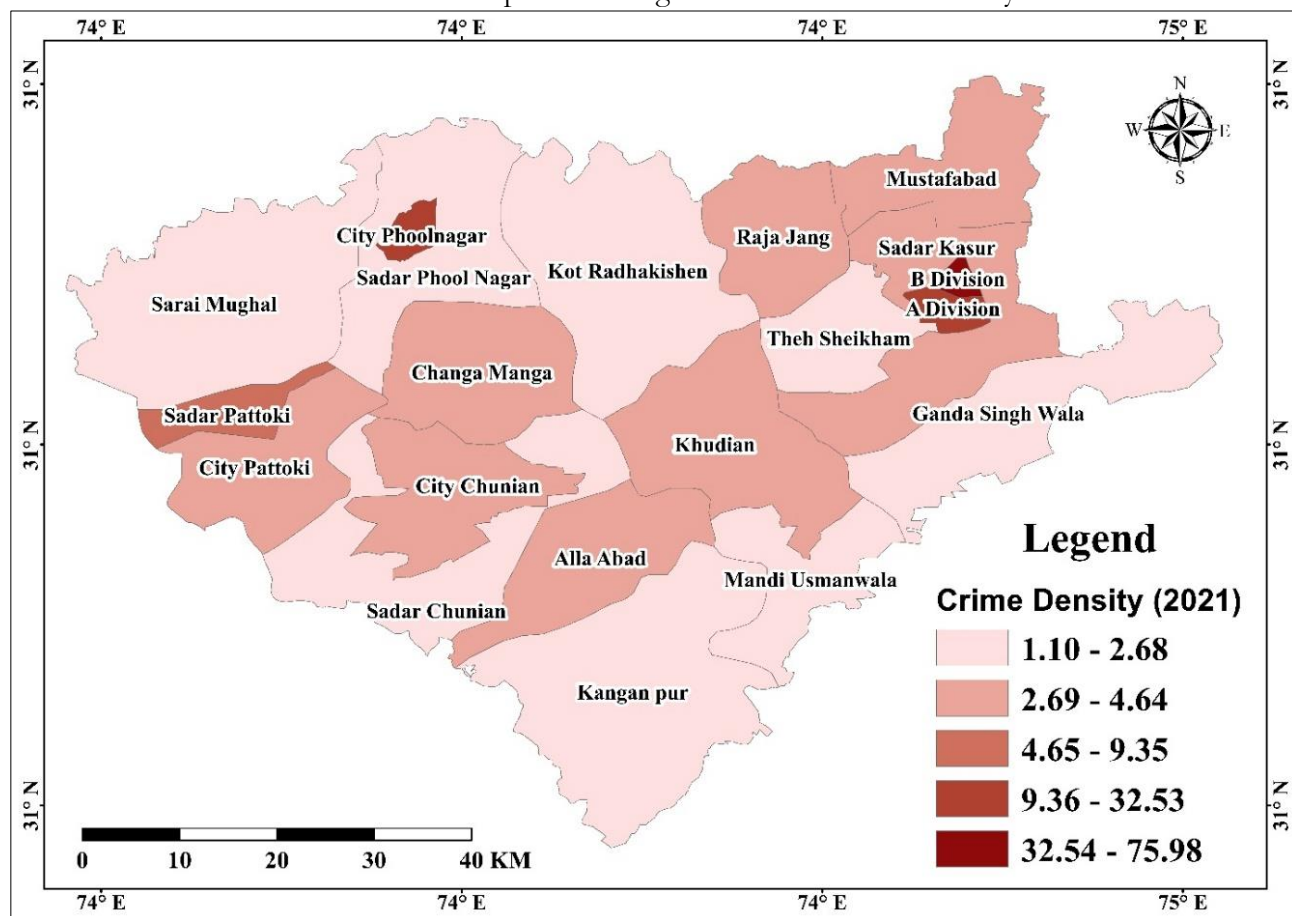

Figure 10. Distribution of crime density in the study area

Conclusion

GIS, remote sensing and GPS are very useful in adding technology to crime analysis and crime identification. Historical crime information and its position when analyzed with other thematic information such as an area of a police station, road network, recreational Centre with urban sprawl, building, school, college, mobile police van location and installed camera location, etc. so forth several clues which can be very useful for crime identification & prevention. Furthermore, data on several crimes can be utilized to install a CCTV camera and establish the new police station area, organizing police patrolling. District Kasur is affected by the influence of poverty, economic inequality, and unemployment. Poverty is the main clause and the significance of exclusion & discrimination. Unless a political and social order is created in which everyone gets a respectable life which implies proper incomes, proper employment, education, healthcare, and food for kids, one cannot eliminate crime. This is the responsibility of every resident of the nation to know about their job in ensuring the security and safety of society at large. By and large poverty, unemployment, illiteracy, poor socioeconomic situations, and slow removal of the legal dispute are the purpose behind crime in society.

Future Scope

To improve the value of the outcome and its accuracy, real-time information on the crime rate can be used. Using temporal data on crime rate can help to expect future crimes to happen and decrease crime incidence. Real-time GPS data can help the police to reach the crime scene from the shortest route, which can diminish the effect of crime.

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