# CRIME MAPPING AND ANALYSIS USING GEOSPATIAL TECHNIQUES IN BAHAWALPUR CITY, PUNJAB-PAKISTAN

#### HAFIZA AYESHA AMN\* AND ZOBIA BAQIR

Department of Geography, The Islamia University of Bahawalpur, Pakistan

\*Corresponding author's e-mail: ayeshaamn18@gmail.com

#### ABSTRACT

Global urban crime is rising. Many modern nations use geospatial technology to monitor, avoid, prevent, and regulate crime to avoid this problem. Developing nations are only starting this practice. Thus, Bahawalpur crimes were analyzed and mapped.2016–2020 data is used. The analysis uses two methods. Geospatial and statistical methods. Statistical methods analyze crime rates, cross-tabulations, and linear regression. Geocoding address data creates hotspot maps using geospatial methods. Statistical, geographical, crime-weather, and crime dynamics were the main goals. Crime rates rose from 450 to 780 per lac. Drug and theft cases outnumber all others. Baghdadul-Jadeed police reported most offences. July and January had the most crimes. Winter crimes like vagrancy and temporary residency were greater than summer crimes like murder and sound system prohibition. Drug-related offences were constant throughout the year. Thus, whether supports crime. The hotspot maps showed that most crimes occurred in highly populated regions including the old city, Circle Road, model towns B, C, and Shahdra. In this study, the author explained the dynamics of crime, citing low literacy, lack of law awareness, increasing population growth, low-income classes, and of industries, unemployment, agricultural landlessness, lack and homelessness as major socio-economic factors. This study indicated that the use of geospatial approaches and perspective and mapping of crime data helps citizens and police departments to plan and monitor municipal crimes and May even prevent them from occurring. Since police and security organizations have unnoticed crime-prone areas, this research is the first to use this crime data for the safety of society and citizens.

**KEYWORDS:** Geospatial techniques, crime mapping, Bahawalpur City, urban areas, Crime trend

#### **1. INTRODUCTION**

In all emerging countries, the rate of crime is going up. This is because of changes in people's abilities and lifestyles and bad social, political, and environmental situations. Since people cause events, they don't happen by chance in different parts of the landscape. People choose where they'll violate the law based on several things, like how many possible victims are and how easy it is for them to get there (Gupta et al., 2012). The rate at which crimes are committed in Pakistan has been steadily increasing for quite some time, and minimizing these crimes has become challenging for law enforcement, particularly given the rapid rate at which the country's

population is expanding. The agencies of law enforcement, security, and police in Pakistan are armed with cutting-edge contemporary technology and equipment to combat this issue. The ratio of the number of security guards and police officers to the total population of various places makes it difficult for these authorities to deal effectively with issues relating to criminal activity. Crime trends need to be analyzed to find a solution to this issue (Eman et al., 2023).

The efforts put into crime analysis, and mapping are valuable; nevertheless, the actual potential of crime mapping resides in its capacity to discover early warning indicators across time and geography and guide a proactive approach to police problem resolution and crime prevention. Today, due to the fast development of technology, the use of computerbased methods for investigating, visualizing, and explaining the occurrences of criminal behaviours has become vital (Alan Murray & Grubesic, 2001). The geographic information system (GIS) has been one of the most prominent technologies in aiding research of the geographical distribution of crime (Ratcliffe & McCullagh, 1999). The capacity to mix geographical information with other types of data makes geographic information systems (GIS) so important, as (Murray et al., 2001) points out. The Geographic Information System (GIS) and the Remote Sensing technique use geography and digital maps as an interface to integrate and retrieve large volumes of location-based information. The term "geographic information system" refers to a kind of information system that represents things in terms of location (Spencer Chainey, & Jerry Ratcliffe, 2010). Ferreria & Joao (2012), In the process of mapping and analyzing crime, GIS plays a vital role. Geographic Information Systems (GIS) is one of the current technological developments that may function as a decision support system to help identify better ways to decrease crime (A L & Rose, 2016). This is one of the recent technological advancements that have been made. This research aims to conduct a spatial and temporal analysis of crimes in Bahawalpur City. This research aims to examine the statistical analysis, spatial analysis, and weather relationship with the occurrences and dynamics of crimes in the study area for the last five years. The related studies of the crime types, their occurrences, and the other factors are discussed below:

In their study from 1991, Brantingham and Brantingham say that position is one of the most important things to help stop crimes in the future, especially in places where they happen a lot. They talked about how putting crimes on a map with the support of GIS can give a much better view of how to stop crimes (Brantingham & Brantingham, 1991). Block (1995), saw in a police officer that the pins on the map show the worst-hit places. He noticed that these maps make it easy to see where there are

many crimes in the city. With the help of the GIS start, law enforcement organizations were able to respond to these trends in the right way. So that these steps can be taken with the help of crime maps to stop crimes from happening in those places (Block, 1995). Kocsis and Irwin mapped the locations of three types of repeat criminals in Australia in 1997: serial rapists, serial arsonists, and serial thieves. They used Canter and Larkin's method, described in the Circle Theory of Environmental Range. They looked at where the crimes of repeat offenders happened and decided that the Circle Theory of Environmental Range was a good fit for this kind of research in Australia. Portnov did a study in 2003 on how crimes are spread in Israel. The study was done on poor towns with high crime rates, which the author says shows that crime rates vary by town. There was a multivariate study. The results were given to regional planning and development to help stop crime and keep these poor neighbourhoods safe (Kocsis & Irwin, 1997).

Ackerman and Murray (2004) did a study on the review of GIS mapping of crimes to determine if these maps can help the cops and the city. They got information about Lima, which is a place in Ohio State. Property crimes and dangerous crimes were looked at to get the information. They looked at small and big crime data pieces in the same city (Ackerman & Murray, 2004). From 1988 to 2001, kernel density maps and graded maps were made. According to this study, the GIS could be a useful tool for improving crime prevention plans. Beauregard, Proulx, and Rossmo did a study about the spatial analysis and regional profiling of sex offenders in 2005. This study looks at the idea of "geographic profiling" of criminals from an academic point of view. The crime pattern theory, the logical decision theory, and the regular activity theory are all parts of their study. The paper discusses how people act in space and the different crimes. Chainey, Tompson, and Ulig (2008), did a study to identify where crimes are likely to happen. They do a lot of analysis, like spatial ellipses, grid theme mapping, kernel density estimates, and point mapping. They took notes on burglaries, street crimes, thefts of cars, and thefts from vehicles (Chainey et al., 2008). The results showed that kernel density maps are best for predicting crimes in a large area, while hotspot maps are best for predicting crimes on the street. The GIS mapping could be used to predict crimes in cities. Ceccato and Oberwittler (2008), studied how European towns change over time and space. The study includes both comparison and cross-sectional studies, which compare criminal crimes in eastern and western European towns to see how they affect society and daily life. For example, they chose the towns of Tallin and Cologne and compared the results. They found that the results overlapped, but the theft rate was

higher in Tallinn than in Cologne. GIS was used to do geographic and statistical research (Ceccato & Oberwittler, 2008).

Andresen (2009), looked at how crimes happen in different places to measure how similar the two towns are. Many studies have used this method and found it useful for tracking and analyzing crime in different places (Andresen & LaRue 2015). Harper, Khey, and Nolan (2013), studied where robberies happen most often in New Orleans tourist spots. According to the study, most of the crime in towns happens near tourist spots, while the second-most dangerous places were private areas where there were no cops at all. The hotspot maps and the regular activity theory were used in the study (Harper et al., 2013). Asl, Moghadam, and Pariz did a study on crime analysis and maps in the area of Islamabad in the city of Zanjan, Iran, in 2014. They used graphs, statistics, and maps to look at places with many people. The study uses the mean centre test, the standard deviation ellipse, the nearest neighbour index, and the quartic kernel density maps. They found that most crime trends were centred and close to each other. Most of the crimes in this area were violent or involved drugs. In places with many people, the crime rate was six times higher (Asl et al., 2014). Khalid, Wang, Shakeel, and Xia (2015), studied in the city of Faisalabad, Punjab, to look at urban street crime's spatial and temporal trends and how they changed between 2012 and 2013. They also used the CompStat model to look at how well the cops in the study area did their jobs. They also found that crime had decreased significantly since they started using the GIS tool (Khalid et al., 2015). Malleson and Andresen (2015) studied the relationship between social media and crime in crowded places. For the geographic data and maps, they used the Getis-Ord G and GAM methods. They found that crime prevention can be made more effective by using the location of crimes, which is a key part of spatial analysis and application.

Linning (2015) studied how property crimes change depending on the time of year in the Canadian towns of Vancouver and Ottawa. Both towns have different kinds of weather. Vancouver is in a climate zone called "temperate," while the city of Ottawa is in a "humid continental." This study aimed to determine if there are more crimes in the summer because it is hot or if other micro-spatial factors cause more crimes (Linning, 2015). The author used Andresen's (2009) spatial point pattern method by looking at crime records from both towns' police stations. The data showed that property crimes didn't change much over the year. At the same time, the author says that the link between crime and surroundings can be different in different places. Andresen and LaRue did a study in 2015 on the regional trends of crime in the Canadian city of Ottawa in 2006. The writers' ideas are supported by the theory of social

disorganization and the theory of everyday activities. They also found a strong link between the socioeconomic and demographic makeup of the area. It is said that crime is not an independent variable but relies on social, economic, demographic, and physical factors. Yar and Nasir did a study in 2016 about where and when crimes happened in Mardan, Khyber Pakhtun Khawa. The study examined how heat affects violence and where hotspots are. They mostly used acts that killed people and those that hurt people. In 2009, they found that 50% of crimes happened in the summer months (May to September), and 32% happened in the winter months (October to February). They found that there was a strong link between the weather and crime (Andresen & LaRue, 2015)

Weinborn et al., (2017) used the Crime Harm Index (Sherman, 2013) to examine hotspots and harmful places in fifteen United Kingdom districts. They found that the worst acts are linked to things on the street (Weinborn et al., 2017). Hussain, Azhar, and Farooq (2018), wrote a historical account of the relationship between crime and social and economic factors. They found that crime was common in the area and district of Bahawalpur. This history study gives a short account of this area's environment, the laws and rules put in place by the State, the criminal groups and tribes that were named, and the major crimes committed in the old State, along with comparisons to how things are now. This study helps us understand how society and the economy are changing and the issues that come with crime (Hussain et al., 2018). Quick, Li, and Brunton-Smith (2018) studied how four types of crimes are spread out in Greater London, UK. There were break-ins, robberies, crimes against vehicles, and dangerous crimes. These events were put on a map, and a Bayesian multivariate method was used to determine how they were spread across the city (Quick et al., 2018). It was found that there was a strong link between stealing and breaking in. Hussain (2019), studied crime analysis in the Bhakkar District of Punjab using maps in GIS. For 2017, information was gathered on murder, burglary, car theft, and kidnapping.

Different kinds of mapping were done, such as hotspot maps, kernel density maps, and gaps. The study found that GIS mapping can help a lot with crimes if used, which it is just starting to do in poor countries. Boivin and Melo (2019) studied the S-Index, which shows how similar or different shapes are in space. In the city of San Francisco, the study was done. They found that the S-Index needs to be changed, especially for the cases that aren't zero in the study area (Boivin & Melo, 2019). Mansoor M., Siddiqui, Tariq, and Sanaullah (2020) did a study on mapping crime hotspots in Lahore. The goal of this drawing and study was to look at how heat and aggression are related. They got information about Saddar Lahore for the years 2018 and 2019. They made maps with GIS software. The study found

that 47% of all crimes happened in summer, 40% in winter, and 14% in spring. From May to September, when half of all crimes happened, there were more crimes than any other time of the year. So, there is a strong link between temperature and behaviour, and heat angers people (Mansoor et al., 2020). In 2020, Azhar and Siddique wrote a history of the area and district of Bahawalpur (Azhar & Siddique, 2020). The study examined how the weather affects crime and found that most crimes happen in the summer. The paper also talks about the district's people and how they live. The history of the castes and tribes is given since some of them were made illegal by the Act of Criminal Caste and Tribe in 1911. This paper also talks about how crimes change over time. Crime is not static; it is affected by social and economic forces. This paper talks quickly about each cause. It can help you understand how crimes happen in Bahawalpur and the places around it.

# 2. MATERIAL AND METHODS

# 2.1. Study Area

The city of Bahawalpur is selected for this study. Bahawalpur city is located in the south of Punjab on the left bank of the Sutlej River, its area is 120 km2, and its population is nearly 0.8 million. It was the capital of the former State of Bahawalpur which was supervised by the British Indian Govt. under the Punjab States. It is now the divisional headquarters of Bahawalpur Division. The Municipal cooperation is situated around three circles; City Circle, Saddar, and Cantonment Board. The tehsil of Bahawalpur is divided into 21 Union Councils; therefore, all the union councils are considered for spatial and temporal analysis and mapping of crimes that occurred in Bahawalpur City. There are 5 police stations located in the city. In the south of Bahawalpur, the Great Indian Desert is located, locally the part of this desert is called 'Cholistan or Rohi'. The climate of Bahawalpur is very hot in summer, the temperature reaches 45°C, and in winter the climate is cool reaching 7°C. The day-night fluctuations are high. Late Monsoon prevails in this area, winds reach late in the summer months, and most of the rainfall occurs in August. The annual rainfall is not more than 250mm.

# 2.2. Data and Sources

Most of the information for this study comes from the survey. The Urban Sector Planning & Management Service Unit gave us official information about the district and tehsil, as well as the road network in Bahawalpur. GPS was used to figure out where each of the five (5) police posts in the study area were. (Figure 2) shows what each police station is called. Data required for this research was based on the crimes reported in all the police stations located within the premises of the city, types of crimes, and

time (year, month, day). Primary data for this study includes interviews with the different personnel from DPO, and reported cases of crimes from all the police stations, while secondary data was collected from various reports/ documents/ surveys of the Bureau of Statists Punjab, DPO, and Population Census



Figure1. Map of Bahawalpur

Crime density is the number of crimes per square kilometre in an area covered by a police station. The crime rate is the number of crimes that have been reported divided by 1,000 people. Also, graphs charts, and other tools were used to show how often different types of crimes were reported to different police posts in the study area during the reference year. Where police stations are and their boundaries are in this part, we did a field survey to get the coordinates of each police station in the study area. The unprocessed data on crimes that were used for this investigation were kept in an Excel file that was straightforward to examine. The information included in the file was organized into columns and rows. We made the information more comparable by subdividing the whole region into five distinct zones following how the police station distributes its investigations.

## 2.3. DATA COLLECTION

Data required for this research was based on the crimes reported in all the police stations located within the premises of the city, types of crimes, and

time (year, month, day). Traditionally, data collection methods can be divided into two categories depending on the nature of the data, i.e., primary data and secondary data. Primary data for this study includes interviews with the different personnel from DPO and reported cases of crimes from all the police stations, while secondary data was collected from various reports/ documents/ surveys of the Bureau of Statists Punjab, DPO, and Population Census. Furthermore, based on the nature of data for this research thesis can be divided into categories of crimes.



Figure 2. Methodology Framework

# 2.4. DATA ANALYSIS

The term "data analysis" refers to the processes and techniques used to obtain findings, such as patterns of crime distribution and temporal trend changes of crime types committed in the city as extracted from raw data acquired for research. The results of any study are heavily influenced by the data analysis conducted; hence, the data analysis for this study may be broken down into statistical analysis and analysis based on GIS.

## 2.5. Statistical Analysis

To get legitimate, objective, and useful findings from research, it is vital to use the most applicable statistical analysis. For this research thesis, the

level of sophistication of the statistical analysis ranges from very basic to sophisticated; nevertheless, the primary statistical analysis is carried out by calculating the crime rate and percentages, the crime index, and the crime frequency and using time series analysis (TSA), etc.

# 2.6. Spatial Analysis

The GIS platform can do the mapping. GIS is known relative to spatial events research because it provides an important geographic background to exploring spatial patterns in crime distribution and police station networks. GIS, as a tool in Criminology, offers a combined set of techniques that permits both the analytical operation and the graphic representation of spatial and temporal data. In the context of criminological studies, this provides an influential aid to the analysis and understanding of relationships between geography, and the physical and human environment. Hotspot maps and Kernel density are the main GIS techniques applied for spatial analysis of crimes in the study area.

## 2.7. Data Processing

The basic soul of data presentation is to make the relationship between facts and data analysis. Results of the current study are presented in various ways depending upon the nature of the analysis executed on data. Among spatial analysis results in presentation, hotspot maps kernel density and are specifically applied to crime data. At the same time, graphs are used for presenting environmental data. In comparison, statistical data presentation used for temporal analysis of crime data is usually in charts and graphs.



Figure 3. Data Presentation Methods

# 3. RESULTS AND DISCUSSION

## 3.1. Statistical Analysis

Police station websites provided the data. Each station's total offences are shown below. From 2016 to 2020, total offences rose to 22567. Only Bahawalpur's police stations' recorded cases are shown here.

City Ci	rcle	Saddar				
Year	Kotwali	Cantt.	Civil Lines	Baghdad	Saddar	Total
2016	390	503	740	1181	546	3360
2017	517	637	889	1216	553	3812
2018	438	686	777	1020	488	3409
2019	678	809	1124	1647	1128	5386
2020	743	1107	1340	1732	1678	6600
Total	2766	3742	4870	6796	4393	22567

Table 1: Total number of crimes by year and station

Source: District Police Office

## 3.2. Descriptive Statistics

Descriptive statistics is the use and analysis of summary statistics that quantify aspects from a dataset. Table 1 descriptive statistics. Table 2 contains station descriptive statistics.

Station	Kotwali	Cantt.	Civil Lines	Baghdad	Saddar	City
Average	553	748	974	1359	879	903
Max	743	1107	1340	1732	1678	1732
Min	390	503	740	1020	488	390

Table 2: Descriptive Statistics by Station (2016-20)

The table above displays station averages, maximums, and minimums and study area information. 903 offences per station are averaged. Thana Kotwali in Old City had 390 crimes in 2016. Baghdad station had 1732 offences in 2020. Average yearly instances are 4513, the lowest are 3360, and the highest are 6600.

## 3.3. Crime Rate

Crime rates are represented as crimes per population or another basis. Crime rates are more similar than totals. Crime rates are more similar than totals. Crime rates are affected by several indirect causes. Because more objects are insured and insurance companies demand police records before paying out, burglary rates may rise. Politicians, journalists, and the public all care about crime data.

Crime rates per 100,000 persons are computed by dividing the number of recorded crimes by the country's population. 100,000 crimes Population Countries, states, and cities should be compared by crime rates, not numbers. Criminologists frequently study crime rates rather than individual crimes. They investigate crime rates and social group differences. Crime rate = prevalence x incidence.

Total	Crimes	Population*	Crime Rate pe	erCrime Rate per
			1000population	100000 population
2016	3360	744,000	4.52	451.61
2017	3812	762,111**	5.00	500.19
2018	3409	796,000	4.28	428.27
2019	5386	820,000	6.57	656.83
2020	6600	845,000	7.81	781.07
*Source: N	<b>Nacrotrends</b>		**Sourc	ce: Census 2017

 Table 3: Crime Rate in the Study Area (2016-20)

Source: Macrotrends

The research area's per-thousand-and-one-lac crime rate is computed. 1000 is used since just one city is selected. Crime rates are presented for each year and are rising significantly. Rates have almost doubled.

#### 3.4. **Cross Tabulation**

Stations and crimes are cross-tabulated. These two factors are connected to determine which crimes are associated with a station. Interesting findings. These variables are cross-tabulated in the following table. This analysis uses SPSS.

	Drugs		Gambl Murde	ling er	Sound Stolen	Systen	nIncome Vagrano	Tax cy Total	Temporary	Residence
	Count	159	34	9	86	96	60	72	12	528
	% within	Statio	n6.40%	1.70%	16.30%	18.20%	11.40%	13.60%	2.30%	100.00%
Baghda	<b>d</b> % within 45.20%	Felon	y25.60%	629.00%	36.00%	22.60%	51.30%	38.70%	18.80%	34.10%
	% of Total	10.30%	2.20%	0.60%	5.60%	6.20%	3.90%	4.70%	0.80%	34.10%
	Count	42	24	9	50	125	21	17	20	308
	% within 13.60%	Statio	<sup>n</sup> 7.80%	2.90%	16.20%	40.60%	6.80%	5.50%	6.50%	100.00%
Cantt.	% within	Felon	y18.00%	629.00%	20.90%	29.40%	17.90%	9.10%	31.30%	19.90%
	% of Total	2.70%	1.60%	0.60%	3.20%	8.10%	1.40%	1.10%	1.30%	19.90%
	Count	91	35	11	71	123	19	62	14	426
	% withi	n Statio	n8.20%	2.60%	16.70%	28.90%	4.50%	14.60%	3.30%	100.00%
21.40% <b>Civil Lin</b> 25.90%	nes % with	in Felon	y26.30%	%35.50%	29.70%	28.90%	16.20%	33.30%	21.90%	27.50%

Table 4: Cross-tabulation of Crimes and Stations

	% of Total	5.90%	2.30%	0.70%	4.60%	8.00%	1.20%	4.00%	0.90%	27.50%
	Count	60	40	2	32	81	17	35	18	285
	% within 21.10%	Station	n14.00%	60.70%	11.20%	28.40%	6.00%	12.30%	6.30%	100.00%
K QM&	% within 17.00%	Felon	y30.10%	6.50%	13.40%	19.10%	14.50%	18.80%	28.10%	18.40%
	% of Total	3.90%	2.60%	0.10%	2.10%	5.20%	1.10%	2.30%	1.20%	18.40%
	Count	352	133	31	239	425	117	186	64	1547
	% within	Station	n8.60%	2.00%	15.40%	27.50%	7.60%	12.00%	4.10%	100.00%
Total	within F 100.00%	elony :	100.00%	6100.00%	6100.00%	6100.00%	6100.00%	6100.00%	100.00%	100.00%
	% of Total	22.80%	8.60%	2.00%	15.40%	27.50%	7.60%	12.00%	4.10%	100.00%

Table 4 compares the Felony offence category and station. The findings are intriguing since most stations had higher values. The good relationship is shown at drugs at Baghdad station, gambling with Kotwali station, murder cases with Civil Lines, sound system felonies with Baghdad, and theft at Cantt. and Civil Lines, Income Tax crimes with Baghdad are quite higher, felonies of temporary residence at Baghdad and Civil Lines, and vagrancy crimes with Cantt and Kotwali.

## 3.5. Questionnaire-based Survey

The use of most statistical analyses is necessary for the preparation of the results of legitimate and meaningful studies. A questionnaire survey is a technique of gathering statistical information about the characteristics, attitudes or actions of a population through a compiled set of questions. In this research, I have conducted three surveys which are as follows: -

- Public Perception of Crime in City Bahawalpur (using Google Forum)
- A Study of Criminal Behaviours (visited and collected data from criminals at Central Jail Bahawalpur)
- Victim Questionnaire (visited different places in Bahawalpur City spoke with victims and collected data)

Three types of questionnaires were used to collect data. Data collected from public perception, criminals and victims.

## 3.6. Crime Mapping (Spatial Analysis)

Mapping is done by QGIS software which is an open source. The importance of location is evident in the relativeness of events and patterns because it provides an understanding of the geographic background to explore spatial patterns in the distribution of crime. GIS as a tool in crime mapping offers a combined set of techniques that allow both analytical operations and graphical representation of spatial and temporal data. In this context, GIS provides effective support for the analysis and

understanding of the relationship between the physical and human environment. Hotspot maps are the primary GIS technique used for spatial analysis of crime in a study area:

Each type of crime is mapped individually to visualize the distribution of that particular type of crime in the study area.



Figure 1. Localities of Crimes Reported at City Circle Stations

The above figure only shows the crimes which are reported at the police stations of City Circle, these crimes were not reported at Saddar police station. The crimes occurrence at Saddar were quite large data and due to time limitation and labour, these crimes were excluded in mapping for the feasibility of the Author. The Fig above shows that most of the crimes have occurred all over the main city. But many other places have also reported crimes in these police stations. The location of police stations is also shown on the map. Crime mapping is a useful tool to have a quick look at and is helpful for the management of crime prevention and policies at local, regional and global levels. Many maps were prepared to see the distribution and spatial pattern, but few maps were selected by the Author to describe the distribution.



Figure 2. Hot Spot Map of Total Crimes Reported at City Circle Stations (2016-20)

The total number of crimes reported at the City Circle stations was drawn with the help of hotspot maps tools, which have been presented in the above figure. The map shows that most of the crime occurrence areas are located in the main city areas; which include the Old City, Circular Road and its neighbourhoods, General Bus Standard and Model Towns. Whereas, other hot spot areas are Satellite Town, Tibba Badr Sher, and Dera Izzat.



Figure 3. Hotspot Map of Crimes Related to Drugs & Narcotics

The above hotspot map shows that most of the crimes are related to drugs & narcotics. These are reported from the General Bus Stand, Model Town C located north side of the city and shown in clusters. The other areas include Tibba Badr Sher, Satellite Town, and Muhajir Colony, which are located on the eastern side of the city.



Figure 4. Hotspot Map of Crimes Related to Stolen Property

The above map shows the hotspot map of crimes related to stolen property. This indicates that most of these crimes are reported from the General Bus Stand, Model Town C. These areas are located on the northern side of the city and show clusters. The other areas include Tibba Badr Sher, Satellite Town, and Muhajir Colony, which are located on the eastern side of the city.



Figure 5. Crimes related to Gambling

The above map shows the hotspot map of crimes related to gambling and most of these crimes are reported from the old city, General Bus Stand, Model Town C, Hamaitian, and Deralzzat. The pattern is scattered and distributed all over the city which shows that the crimes are higher in the centre of the City.



Figure 6. Crimes Related to Sound System Prohibition Laws

The above map shows the hotspot map of crimes related to the prohibition of the sound system which shows that most of these crimes are reported from the General Bus Stand, Old City, Model Town C, Model Town A, Deralzzat, Shadab Colony, Chak 9 BC. Such crimes are reported at the city circle police stations from various places, which are spread all over the city showing that such crimes are higher in the centre of the city.



Figure 7. Murder Crimes

The above map shows the hotspot map of crimes related to murder which

shows that most of these crimes are reported from various places at the City Circle police stations. It is noted once again that Saddar police station crimes were not included in this study for the spatial analysis due to limitations. Whereas, the spatial pattern shows that even being at the minimum level the murders are reported from every corner of the city. The spatial distribution covers the entire city, and the pattern is scattered.



Figure 8. Income Tax Crimes

The above map shows the hotspot map of crimes related to Income Tax law. The map shows that most of these crimes are reported from different parts of the city, the major areas are the old city, the general bus stand, and the neighbouring areas of Hasilpur Road specifically included in this type of crime.



#### Figure 9. Murder Crimes

The above map shows the hotspot map of crimes related to murder

crimes. The map shows that most of these crimes are reported from various places at the city circle police stations. It is noted once again that Saddar police station crimes were not included in this study for the spatial analysis due to limitations. Whereas, the spatial pattern shows that even being at the minimum level the murders are reported from every corner of the city. The spatial distribution covers all of the city, and the pattern is scattered.



Figure 10. Vagrancy-related Crimes

The above map shows the hotspot map of crimes related to vagrancy act crimes which shows that most of these crimes are reported from the major roads of the city, the circular road, the railway station, the general bus stand, Model town C, B and A.

## 3.7. Crimes' Relationship with Heat

Numerous studies have examined the relationship between crime and climate. Crime data was collected along with its occurrence dates and statistically analyzed. Figure 6 shows that most crimes occur in July, being the month with the highest temperature. Drug-related crime is shown in Figure 27 which shows a linear relationship between crime and average temperature in the study area. The trend line shows a neutral relationship and the line is stable, indicating that the drug is heat-neutral or has no affinity. The R2 between drug crime and temperature is 0.001. Gambling-related crime is shown in graph (b) which shows the relationship between average monthly temperature and several committed in the study area. The R2 of the study area is 0.0001 which shows a neutral relationship. Murder crimes are aggressive crimes and they have been correlated in the literature in different study areas around the world. None of the studies were conducted before, therefore, it was assumed that aggression has a strong relationship with heat. The monthly number of murder crimes of



the last five years (2016-2020) was correlated with the average monthly temperature.

Figure 11. Linear Relationship of Temperature and Crime

The trend line shows a positive relationship with such crimes, the  $R^2$  is 0.1135. Sound System Prohibition violations were found strongly in relationship with heat, the  $R^2$  is 0.1152 and the trend line shows a positive relationship. Crimes related to stolen property show a negative trend line, which means that most of the crimes are committed in the months of winter, and fewer crimes are committed in the months of summer. The  $R^2$  is0.1423. Income-related crimes are found mostly in the month of summer and show a positive relationship with temperature. The  $R^2$  is0.0059. Most of the Crimes related to temporary residents are found in the months of winter. Therefore, the relationship is found weak with temperature. The  $R^2$  is found 0.0999. Vagrancy crimes are mostly found in the months of

moderate temperature, e.g. spring and winter. Therefore, the relationship is shown as weak relationship, the  $R^2$  is 0.0184.

## 3.8. Crime Dynamics

Criminal activities are dependent on other activities and conditions, e.g., socioeconomic conditions which own a large regime of factors including age, sex, gender, social status, occupation, education, income, and technology, etc. This section discusses the dynamics of crimes and crime is not an independent variable, it depends on many other demographic, social, economic, environmental, and technological factors. This section is an effort to discuss these dynamics to provide insights about the problems which might be helpful for the readers for their understanding of the study area.

# 3.9. High Population Growth Rate

The high population growth rate is a major problem in the world. The study area is also facing an increasing number of populations, there is a lot of burden on natural resources and industrial sectors to fulfil the demand of people. The higher number of populations the higher number of crimes.

# 3.10. Unemployment

Unemployment is sometimes known as the evil of all the crimes. There is a large number of people who are unemployed and there are not many opportunities in the study area. The increasing population is one of the major problems.

# 3.11. Industrial Development

In the modern world, industrialization is very necessary for the development of the economy and higher life standards. Industrial development provides job opportunities and increases GDP and GNP. In the study area, there is a lack of industries, therefore, there is an urgent need for different types of industries in the study area.

# 3.12. Unawareness of Laws

A large portion of the population is unaware of laws and regulations. Also, there have been new laws which are not practised in many countries in the world, and such laws have several violations. There is an urgent need to not only educate the people about the laws but also the governments and democratic system needs to review many laws.

# 3.13. Low Literacy Rate

Educated societies develop more rapidly than traditional or un-educated

societies. The societies living in Bahawalpur are not encouraged to educate their kids, and also there is a tradition of not getting an education at a higher level. Most of the people have lower levels of education, therefore, there is a low literacy rate among the population. The education system of the country is also not very efficient, there is a lot of need for improvements and science education and thoughts should be encouraged to study.

## 3.14. Landlessness

Many people in the study area are related to the occupation of agriculture. The percentage of such people is 67%, whereas few people own their land and work on other people's lands. Such type of feudalism prevails in the study area, which revokes the development of laymen, and poor people become poorer.

## 4. CONCLUSION

The geographical mapping and statistical analysis of crimes that have been committed in the city of Bahawalpur between the years 2016 and 2020 are being drawn. Because it has been so long since it was last monitored, it has come to light that the rate of criminal activity has practically doubled in the years that have gone by. The annual rate of crime varied very near to exactly between 428 and 500 from 2016 to 2018, however, it is estimated that it will rise to 656 in 2019 and 781 in 2020. This is even though it is expected to expand to higher numbers in each of those years. According to the findings of the study that was carried out each month, the months of January and July are the ones in which the rate of occurrence of criminal behaviour is at its greatest point during the whole year. The month of January has the coldest on average, and the month of July has the temperature that is the hottest on average in the region that is the subject of this study, despite predicted growth each year. Criminal acts recorded by police have skyrocketed in the last two years. In this study, Dynamics explained by the author cites low literacy, lack of law awareness, growing population, low-income class, lack of industries, unemployment, agricultural landlessness, and homelessness as major socio-economic factors of crime. This study indicated that the use of Arc Map geospatial approaches and perspective and mapping of crime data can help citizens and police departments plan and monitor municipal crimes and may even prevent them from occurring. Since police and security agencies have crime-prone areas, this research is the first to use this crime data to protect society and citizens.

## RECOMMENDATIONS

Using real-time crime data may boost the study's usefulness and precision. Time series analysis of crime data helps reduce crime rates by predicting when crimes would occur. Using real-time GPS data, law enforcement may take the fastest possible path to the site of a crime, mitigating the perpetrator's potential impact. 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 reach the crime scene from the shortest route, which can diminish the effect of crime.

## REFERENCES

Ackerman, W. V., & Murray, A. T. (2004). Assessing spatial patterns of crime in Lima, *Ohio. Cities, 423-437.* 

Andresen, M. A, & LaRue, E. (2015). Spatial Patterns of Crime in Ottawa: The Role of Universities. *Canadian Journal of Criminology and Criminal Justice*, *57*(*2*), *189-214*.

Asl, H. B, Moghadam, H. Z., & Parhiz, F. (2014). Analysis of Spatial Patterns for Urban Crimes in the Informal Settlement Area of Islamabad in Zanjan. *International Journal of Academic Research in Business and Social Sciences*, *4*, 1-9.

Azhar, M., & Siddique, K. (2020). *Crime Dynamics in District Bahawalpur: A Case Study in Socio-Economic Paradigms. Uliim-e-Islamia, 27(1), 63-78.* 

Block, C. R. (1995). STAC Hot-Spot Areas: A Statistical Tool for Law Enforcement Decisions. (R. B. C, M. Dabdoub, & S. Fregly, Eds.) Crime Analysis through Computer Mapping, *Police Executive Research Forum Washington DC*, 15-32.

Boivin, R, & Melo, S. N. (2019). Comparing global spatial patterns of crime. Policing: *An International Journal*, *42(6)*, *1097-1106*. *101*.

Brantingham, P. J., & Brantingham, P. L. (1991). Environmental Criminology. Prospect Heights.

Ceccato, V, & Oberwittler, D. (2008). Comparing spatial patterns of robbery: Evidence from a Western and an Eastern European city. 25(4), 185-196.

Chainey, S, Tompson, L, & Ulig, S. (2008). The utility of hotspot mapping for predicting spatial patterns of crime. *Security Journal*, 1-25.

Ferreria, & Joao. (2012). "GIS For Crime Analysis: Geography for Predictive Models". *Electronic Journal Information Systems Evolution. Vol.1, No.*15.

Harper, D. W., Khey, D. N, & Nolan, G. M. (2013). Spatial Patterns of Robbery at Tourism Sites: A Case Study of the Vieux Cane in New Orleans. Am J Crim Just, 589-601.

Hussain, M., Azhar, M., & Farooq, M. A. (2018). Crime Dynamics in District Bahawalpur: A Case Study in Socio-economic Paradigms. *International Journal of Social Sciences, Humanities and Education, II(4), 1-8.* 

K. Eman, J. Gyorkos, K. Lukman, & G. Meško. (2023). "Crime mapping for the purpose of policing in Slovenia -. *Recent Developments," Rev. Za Kriminalistiko Kriminologijo,64, no. 3, pp. 287–308.* 

Khalid, S, Wang, J., Shakeel, M, & Xia, N. (2015). Analysis of Spatial Patterns of Urban Street Crimes by using GIS: A Case Study of Faisalabad City. 2015.23rd International Conference on Geoinformatics, 1-7.

Kocsis, R. N, & Irwin, H. J. (1997). An analysis of spatial patterns in serial rape, arson, and burglary: The utility of the circle theory of environmental range for psychological profiling. *Psychiatry, Psychology and Law, 4(2), 195-206.* 

Linning, S. J. (2015). Crime seasonality and the micro-spatial patterns of property crime in Vancouver, BC and Ottawa, ON. *Journal of Criminal Justice*, 43(6), 544-555.

Mansoor, M, Siddiqui, S., Tariq, A., & Sanaullah, M. (2020). Hotspot Analysis and Relationship of Crime to Heat and Aggression in Saddar area, Lahore, Pakistan. 2020. *International Graduate Workshop on Geo-Informatics, 8.* 

Murray, A.T, McGuffog, J.S, & P. Mullins. (2001). "Exploratory spatial data analysis techniques for examining urban crime." *British Journal of Criminology. 41: 309-329*.

Quick, M, Li, G., & Brunton-Smith, (2018). Crime-general and crime-specific spatial patterns: A multivariate spatial analysis of four crime types at the small-area scale. *Journal of Criminal Justice*, *58*, *22-32*.

R. Gupta, K. Rajitha, S. Basu, &S.Mittal. (2012). "Application of GIS in Crime Analysis: A Gateway to Safe City,".14th Annu. Int. Conf. Exhib. Geospatial Inf. Technol. Appl. India Geospatial Forum.

R. Gupta, K. Rajitha, S. Basu, and S. Mittal, "Application of GIS in Crime Analysis: A Gateway to Safe City," 14th Annu. Int. Conf. Exhib. Geospatial Inf. Technol. Appl. India Geospatial Forum, pp. 1–6, 2012,

Ratcliffe, J.H., & M.J. McCullagh. (1999). "Hotbeds of crime and the search for spatial accuracy. *Journal of Geographical Systems.1: 385-398.* 

Weinborn, C., Ariel, B, Sherman. L. W, & Dwyer, E. (2017). Hotspots vs. harmspots: Shifting the focus from counts to harm in the criminology of place. *Applied Geography, 86, 226-244.*