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APPLICATION OF GEOSPATIAL INFORMATION SYSTEM FOR CRIME ANALYSIS: A CASE STUDY OF CRIMES IN DISTRICT BHAKKAR, PUNJAB, PAKISTAN FOR 2017

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ABSTRACT

Geospatial Technologies are applicable in Law enforcements agencies, especially new software developed by ESRI (ArcGIS). Geographic Information System (GIS) playing a vibrant role in current scenario. GIS contributed a lot in forecasting crime occurrence and designing blue prints to control crimes in an area. In developed countries crime mapping is now a tradition but in Pakistan GIS Technology applicability in crime analysis is on its early stages. Very little research done in the field of crime mapping in Pakistan and it is totally a new trend which needs more attention. In this current research an attempt has been made to investigate the role of Geospatial Technologies in crime mapping and analysis. The present study has been designed to explore the application of Geospatial Information Technology i.e. (GIS, GPS, RS) for crime analysis in district Bhakkar, Punjab-Pakistan. Study area for this research is Bhakkar District which lies in Sargodha division Punjab, Pakistan and it is one of the remote areas of Punjab, Pakistan. This research also explains that how GIS technology can help us to mapping crime in this remote area of Punjab. The purpose of this research is also exploring occurrence of crime in terms of its location for 2017 in Bhakkar. Data collection includes primary and secondary data of all crime incidents e.g. (Murder, Burglary, theft, Vehicle snatching, kidnapping) has been collected from 11 police station of District Bhakkar with the help of police officials. Total crime reported in the Bhakkar district 3908 for 2017.Collected data of crime analyzed geo-statistically in the form of hot and cold spot output. After creation of geo database spatial aspects analyzed through different kind of GIS analysis i.e. Buffering, Hotspot Crime Matrix, and Point Pattern Analysis, KDE(Interpolation). Methodology of this research paper done by using Arc GIS, Arc Map software under methods of Statistical based analysis of crime, hot spot analysis and interpolation of crime in district Bhakkar. Hotspot mapping shows a clear view that mostly crime is occurred in or nearest urban areas of Bhakkar. The weather and crime, population and crime relationship is also described in this current research. This research helps police officials to make new decision and better community policing by adopting GIS technology. Hot Spot analysis also help full to the police officer of patrolling in area. GIS based Crime mapping analysis can remove old traditional method of pin mapping with new computer-generated crime mapping technology.

KEYWORDS: Geography and Crime, GIS Role in Crime, Hotspot Analysis.

INTRODUCTION

In this era of Globalization, the world is facing different man made as well as natural challenges. Science is providing different tools like information

technology to overcome these issues. Geography with development of information technology has also developed Geospatial Information Tools which is mostly consist of different tools like Global Positioning System (GPS), Geographic Information System (GIS) and Remote Sensing (RS). These techniques are being used to collect quantitative as well as qualitative data, summarize, analyze, manipulate, and represent geographically referenced information. (Jahangir et al., 1991).

GIS and Police Department

In the Sixties and Seventies, the primary computer-generated maps of crime were created. Within the Nineties, geographic information systems (GIS) became extensively on the market and within the late Nineties the Criminologists and police departments begin GIS for crime analysis. Within the last decade, GIS has become a robust crime bar and investigation tool for mapping and analyzing crime patterns. Spatial analysis of crime, with the help of a geographic system (GIS) and spatial statistics, is currently wide used for analyzing mass behaviors of crime events to reveal uneven distributions of crime risks and spatial interaction between crime events. Various studies have highlighted the importance of temporal aspects in crime concentrations. It showed that separating stable and fluid hotspots is crucial for distinctive applicable crime reduction responses. Conceive to correlate the violent and nonviolent crime aggregates with the summer season for 2 cities of USA. Baron et al., 1978 found a big correlation between violent crimes and temperature. Though it's terribly tough to look at actual criminal behavior within the laboratory, it has many benefits over field analysis. One among the foremost ad-vantages is that the experimenter's ability to manage conditions and variable. A series of experiments has been conducted on the impacts of high close temperature on aggressive behavior. These researches suggest that there is a curving relationship between aggression and warmth i.e. aggression increase with heat. The use of modern techniques, uses of machines and computers has thrown new challenges before police force in any country, including Pakistan. There are no research works commanded in Pakistan to study the impact of information technology on crime analysis, mapping, forecasting and investigation for logical model and real-world illustration, police organizations are gradually betting a lot on the Geographical Information System (GIS). This trust involved law enforcement agencies to include completely different knowledge such as location, crime and social demographics to analyze crime. The GIS module can help police departments and investigator agencies to recognize the geographical location of crime events specifically and perfectly judge the crime scene. The GIS provides police officers with the information they need to estimate and decide where crime occurs and where the crime density is

higher. The ability to process the crime information and presenting it in a crime prediction model that can help police to distribute resources.

Crime Analysis

There are three fundamental which are used widely for crime analysis:

Crime data

Crime data is a central focus to do crime analysis which constitute type and sub type of crime, name of the person who commit crime, person involved in crime and victim of crime.

Location of crime

For crime analysis location is most important factor to look out where crime is happening, and we also needed the distribution of crime through space.

Socio demographic data and temporal element

Characteristics of individual like as sex, race, age, education is also important factor which is needed to do crime analysis. On the other side temporal element like as time and date is also necessary. (Kalaikumaran, T 2012).

Crime Analysis Model

5 varieties of crime analysis model used and utilized.

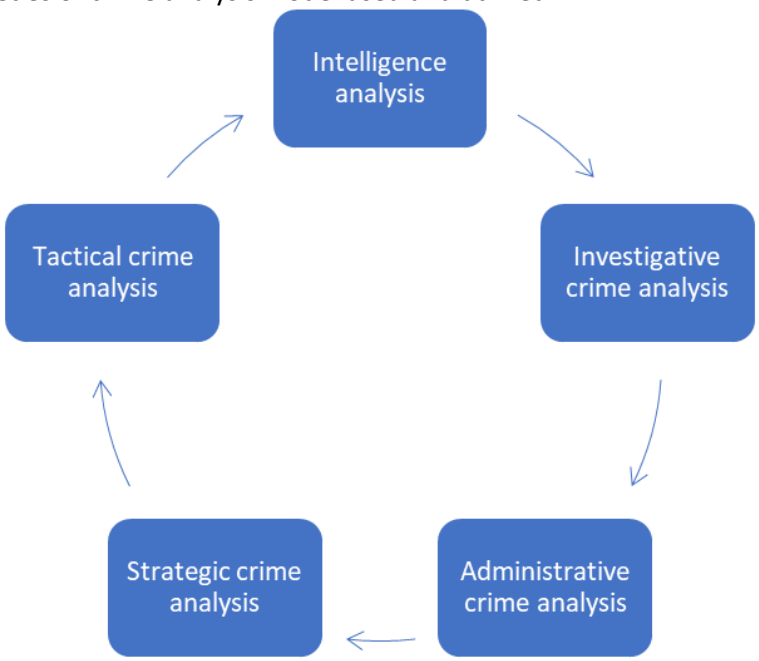

Figure 1: Varieties of crime analysis used

INTRODUCTION TO AREA OF STUDY

The area of study of the present thesis work is Bhakkar district, located in Punjab province of Pakistan. It shares its border with Mainwali in the North, Layyah in the South, Khushab in the North East, Jhang in the East and Dera Ismail khan in the West as shown in figure 1.1. It covers an area of 8,153 km^2 with the city of Bhakkar, Darya Khan being the principal town.

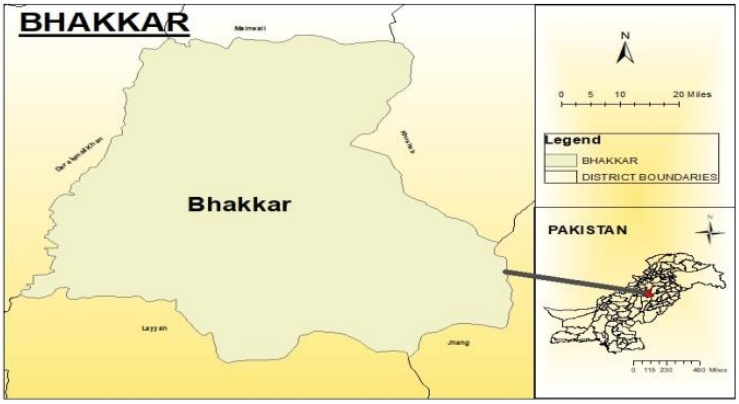

Figure 2: Study area map

It is sandy humid desert located in Southern Punjab. It lies in humid subtropical climatic category with mild and warm temperatures. According to census of 2017 the total population of the district Bhakkar was 1.651 million.

Detail of Police Station

Bhakkar district is covered by 11 police station and divided in 4 circles as follows:

Table 1: Name of police stations

Serial Number	Name of Police Station
1	City Bhakkar
2	Saddar Bhakkar
3	Sarai Muhajir
4	Behal
5	City Darya Khan
6	Saddar Darya Khan
7	Dullewala
8	Kalourkot
9	Jandanwala
10	Mankera
11	Hyderabad

OBJECTIVES OF RESEARCH

The basic objectives of my research are as follow.

- Current research explores occurrence of crime in terms of its location for 2017 in Bhakkar, and it also focuses on spatial and temporal distribution of crime.
- This research helps police officials to make new decision and better community policing by adopting GIS technology for better policing in remote area of Punjab
- Hot Spot analysis currently applied in this research support the police officer for better patrolling in area.
- Current research also identifies high-risk or potentially violent, and hazardous locations of crime in a police station area.

APPLICABILITY OF RESEARCH

The present research helps police officials to make new decision and better community policing by adopting GIS technology for better policing in remote area of Punjab. Hotspot analysis of crime identifies the highly dangerous places in the study area and it provides the base for creating plan URCE to the ground realities. Furthermore, GIS spatial technology

helps the departments to plan the night duties by using flow maps with advance location base services. Spatial technologies also play a vital role in controlling criminal activities and seeking new experiment.

LITERATURE REVIEW

GIS and Crime

Ahmadi et al., (2018) discussed that geospatial technologies are very useful for crime mapping at district level administrative division. They further explored that Global Positioning system (GPS), Geographic Information System (GIS) and remote sensing is the popular one that is practically applicable in Crime mapping. These technologies are not limited to mapping crimes, but they also play a vital role in Predicting, analyzing and forecasting future crime prone areas. They resulted that the rich database of crime occurring data are helpful for better decision making and for law enforcement agencies.

Sheikh et al., (2017) worked on how GIS is helpful in mapping and analyzing crimes. Crimes analysis are now a days is in fashion explained the role of GIS in Crime Mapping and Analysis and stated that crime analysis has become a broad-spectrum term in most recent years that needs a lot of research on crime analysis and crime mapping. Survey based analysis was conducted in which crime survey and victim survey was made in study area. These surveys help the criminologists and decision makers to find out the emergence of criminal's activities in an area and to develop solutions of the problems.

According to Canter (1997), spatial geo databases and analytical mapping are very important tools that are useful in analyzing, preventing, program evaluation of crime and being increasingly recognized by police departments. For analytic mapping by law enforcement agencies needs improved technological system, high graphic computerized GIS systems, and the availability of multiple sources of geographic data. GIS helps in identifying factors contributing to crime and it work as a tool, thus it allows law enforcement agencies are more smarty response to a situation before they become complex and problematic. GIS can be used in law enforcement agencies in multiple ways including crime analysis, strategy development, and decision making to applicability of strategies on real ground.

Block et al., (2006) worked on the relationship between space, place and crime. They used hotspot analysis for liquor-related crime. They explained how the linkage between place and specific situation affect crime ratio. They created a database (Geo Archive) for storing crime, geo code it and perform hotspot analysis. They resulted that the hotspot shown along the

insolated dance clubs and bars etc. They finalized that that there is direct relationship between space, place and crime occurrence and it is not rigid.

Formosa (2012) analyzed crime occurrence in Maltese islands using area designation analysis. He resulted that the study area facing high crime occurrence ratio like any urban area crime scenario. He highlighted the relationship between social and urban landscapes how they are related to crime occurrence. Land-use division are utilized to check which category is faxing more crime occurrence and resulted that Urban residential land use class is the one who is facing highest offence count. Reason behind high crime ratio is due to highest dynamic recreational activities and property related crimes are present in concentrated areas. His in-depth analysis resulted that crime in the recreational areas also linked with distance from retail entity. He more discussed that there is relationship between retail and crime after performing cluster analysis. Review of urban processes and their impact on crime was recommended since the phenomenon does not form part of the local planning process, with on-the-ground repercussions such as the post-decision diffusion of offences into surrounding areas, depopulation and its Broken Windows implications, hotspot concentrations into specific areas and the relative repercussions on the socio structural fabric. The CRISOLA constructs depend highly on changes within each, with physical landscapes providing a heavy push to the stability pendulum.

Srivastava (2016) worked on spatial distribution of crime for identifying geographic crime distribution pattern. Crime analyses are used to achieve required objectives. Multiple approaches are present for crime analysis, but GIS is the leading one. GIS software's can create mapping dashboards that combine multiple data layer into useful information which displayed in the form of maps and web maps. Several factor co-related with crime occurrence, the leading ones are demography, income, social conditions, education level and land-use type etc. These factors influence the offense rate and it's very important to include them analysis while performing crime analysis.

According to Ratcliffe (2010) research spatial crime mapping has great potential and it will become the fundamental tools in law enforcement agency. There are several approaches which are used for mapping crimes, the popular one is spatial temporal mapping and geographic profiling. These methodologies provide full platform to run analysis for crime mapping more easily without huge effort. Crime justice's system and intelligence agencies needs to adopt the technology for huge benefits from spatial technologies.

Olajuyigbe A. et al., (2016) experienced that the police force failed to pinpoint the occurrence of crime in the study area (Akure city). They shared the views after conducting the survey that the more criminal

activates seen in some core part of the city as compare to surrounding areas. They developed a geo database system for storing crime occurrence data of the study area. The aim of this database system is to perform hotspot analysis of crime, crime mapping, strategy planning and implementations and forecasting crimes.

Cohen (2000) suggested that such studies have not been undertaken frequently since 1900. One was indeed hard pressed to find any, although Huntington (1945-1962), Kaplan (1960) and Miller (1908) have all examined some aspects of the relationship between crime and climate. In the past two decades, more emphasis was given on the social problem in urban studies by 1989s it can be fairly claimed that the study of social problems constitutes a main concern of urban geography and the crime and delinquency were prominent examples of such problem, but the concern of was recent and the research was still in many ways in its formative stages.

Hotspot Analysis

Wanget al., (2012) has presented a tool for analyzing crime named as crime hotspot optimization tool. This method is pretty like existing hotspot mapping methods, but it has some advanced functions. It not only utilizes the density of targeted crimes but also take the useful information about the targeted crime and factors associated with it. The information extracted from these related factors using spatial data mining techniques. The major one is hot and cold spot, significance level and other related information. This method is used for crime visualization as well as crime related factors. They concluded that hotspot analysis is the best approach for crime mapping especially for a long duration of time.

Wu et al, (2013) divided the crimes into four major crime types which are robbery, burglary, aggravated assault and stolen-vehicles. All the crime types were analyzed trough hotspot analysis separately. The resulted were over layered in GIS software's to check the distribution of different types of crime. They also used cartogram technique to show data on the maps. Different variation of crime was seen in the study area. Finally, the compare the hotspot method with conventional methods such as density mapping and temporal analysis separately and predict hotspot analysis is the suitable one for crime mapping.

Adepejuet al., (2016) used hotspot analysis and discussed that hotspot analysis mapping is the favorite one for crime analysis. It is most widely used and efficient technique of mapping high and low intensity of crime in an area. GIS helps to predict and forecast crime hotspot analysis on time series data of crime. Hotspot also correlated the crime occurrence with density of the area. They concluded that hotspot analysis is the best

approach for crime mapping and law enforcement agencies needs to adopt it for public safety.

DATA COLLECTION AND METHODOLOGY

Police Station Wise Crime Occurrence of 2017 in Bhakkar.

Table 2: Registered Crime in 2017

Source: Data Collected by Author in 2018

Circle Name	Serial Number	P.S Name	Registered Crime in 2017
Saddar Bhakkar	1	Saddar Bhakkar Police Station	763
	2	City Bhakkar Police Station	481
	3	Behal Police Station	292
	4	Sarai Muhajir Police Station	314
Darya Khan	1	City Darya Khan Police Station	317
	2	Saddar Darya Khan Police Station	408
	3	Dullewala Police Station	210
Kalourkot	1	Kalourkot Police Station	430
	2	Jandanwala Police Station	378
Mankera	1	Mankera Police Station	276
	2	Haider Abad Police Station	139

Detail of registered crime in district Bhakkar showing the crime rate for 2017 police station wise .Sadder Bhakkar police station have high rate of crime as 763 and police station Haidera bad have lowest 139 crime registration as crime is a variable factor and change with season and urban to rural areas so Saddar Bhakkar is the main head quarter of the district and counted as urban area as Haiderbad police station have mostly the rural area so there is a lot of difference in crime rate between these two police station (Crime index Bhakkar, 2017).

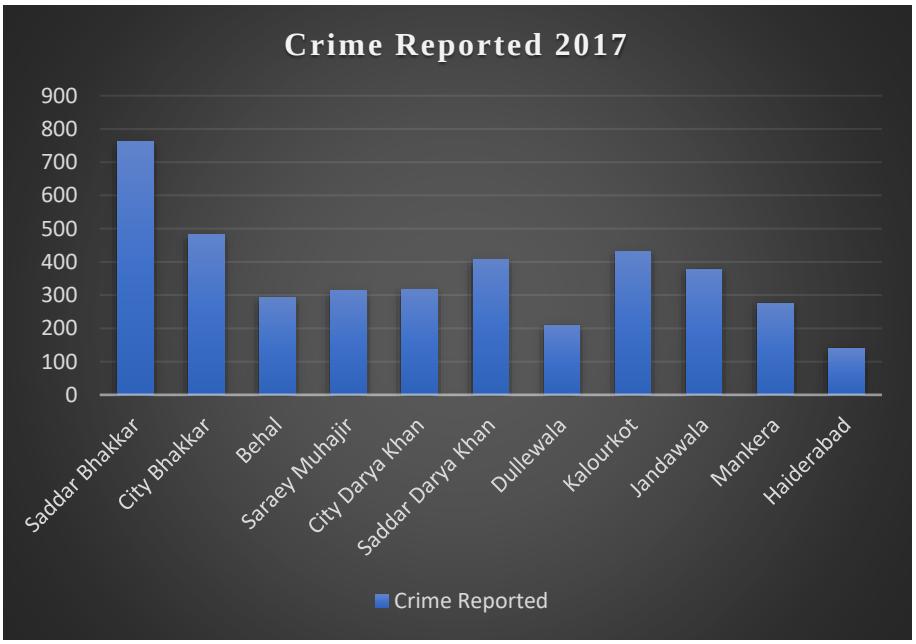

Figure 4: Crime reported in 2017

Conversion of Data into A GIS Developed Manipulated Map

Collect events convert crime incidents data in to weighted point data. In ArcMap collect event tool can be found under spatial statistics tool extension. After opening the collect event tool, a window had shown two fields for adding integrated data and specifying path of output file. The tool completes the operation and shown in following figures.

RESEARCH TOOLS AND METHODOLOGY

Second section explains the procedure adopted for performing the analysis. Based on needs of this project, software's used for performing hotspot analysis are as follows.

- ArcGIS 10.6
- MS Excel 2007
- MS Word 2007

- Google Earth Pro

FINAL PREPARATION OF DATA TO GET RESULT

The data acquired from police station has information about the estimated crime distance from the desire police station.MS Excel is used to prepare data in a meaningful spreadsheet after this a geo database file is created. It helps to generalize the crime in the study area. As the location of police stations wasn't available in proper GIS data format, the existing geo restriction maps of all the police station were acquired. Map to image geo-referencing method was adopted for geo-referencing maps and on-screen digitization method was adopted for digitizing geo restrictions and location of available police Stations. The outputs were store in shape file formats for further analysis.

As the location information, estimated distance and direction from the police stations was present in Spread sheet data. The police station shape file was used to create multiple buffers using multiple rings buffer tools in ArcMap. Furthermore, the unique codes were assigned to each crime location. Finally, both the shape file and crime data were joining by using Spatial Join tool in ArcMap. These steps were repeated with all the data of all police stations. The following model explains the final process of data to get the result of research work.

Final Hotspot Result of Saddar Bhakkar

763 registered crime of Sadder Bhakkar occurred in 2017 was finally analyzed to check out hotspot. There are 2 spots which show 90 to 99 % confidence The output shown hot to cold spots of crime in the study area.

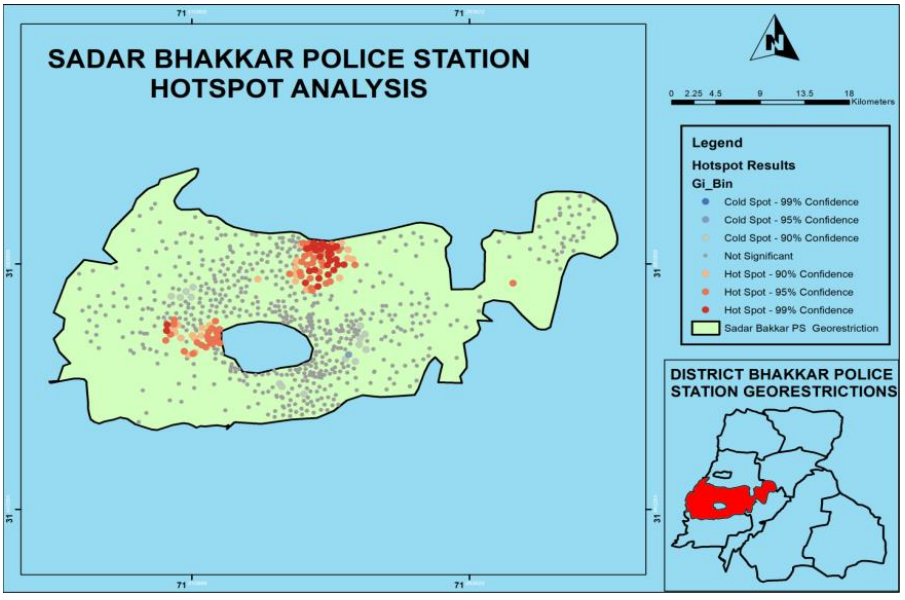

Figure 5: Sadar Bhakkar police station hotspot analysis results

Final Hotspot Result of City Bhakkar

481 registered crime of city Bhakkar occurred in 2017 was finally analyzed to check out hotspot. There are 2 highly spot which show 90 to 99 % confidence The output shown hot to cold spots of crime in the study area.

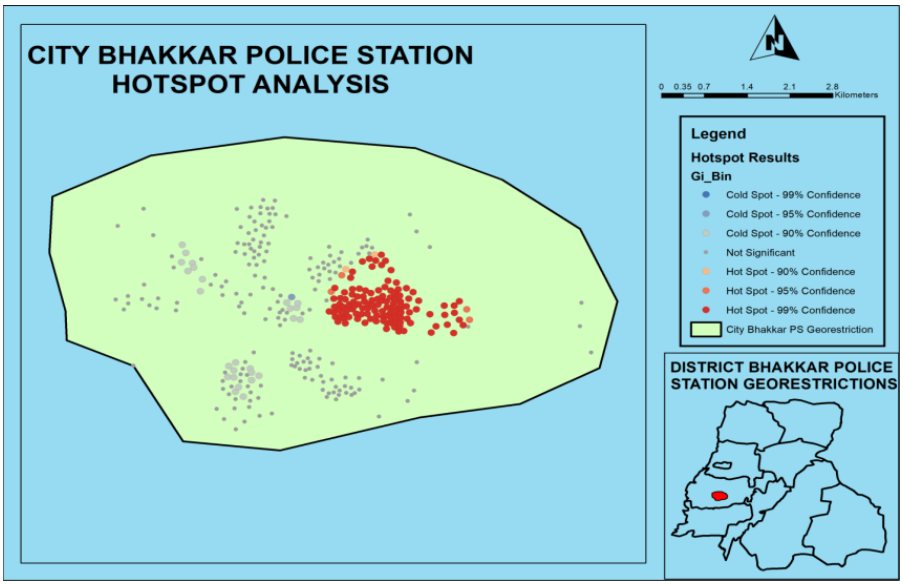

Figure 6: City Bhakkar police station hotspot analysis results

Final Hotspot Result of Saraey

Muhajir Police Station

314 registered crime of Saraey Muhajir occurred in 2017 was finally analyzed to check out hotspot. There is are 2 spot which show 90 to 99 % confidence The output shown hot to cold spots of crime in the study area.

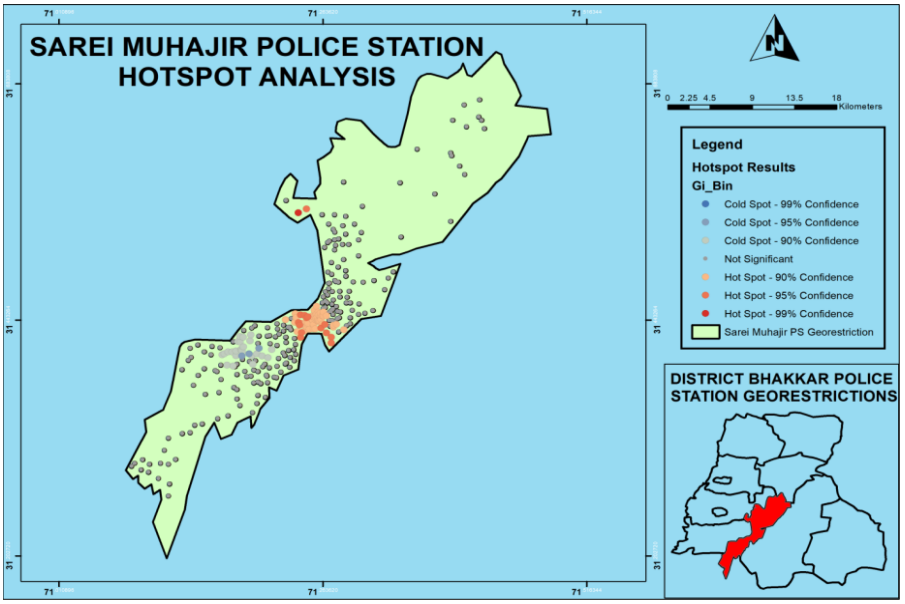

Figure 7: Sarei Muhajir police station hotspot analysis results

Final Hotspot Result of Behal Police Station

292 registered crime of P.S. Behal occurred in 2017 was finally analyzed to check out hotspot. There is one spot which show 90 to 99 % confidence The output shown hot to cold spots of crime in the study area.

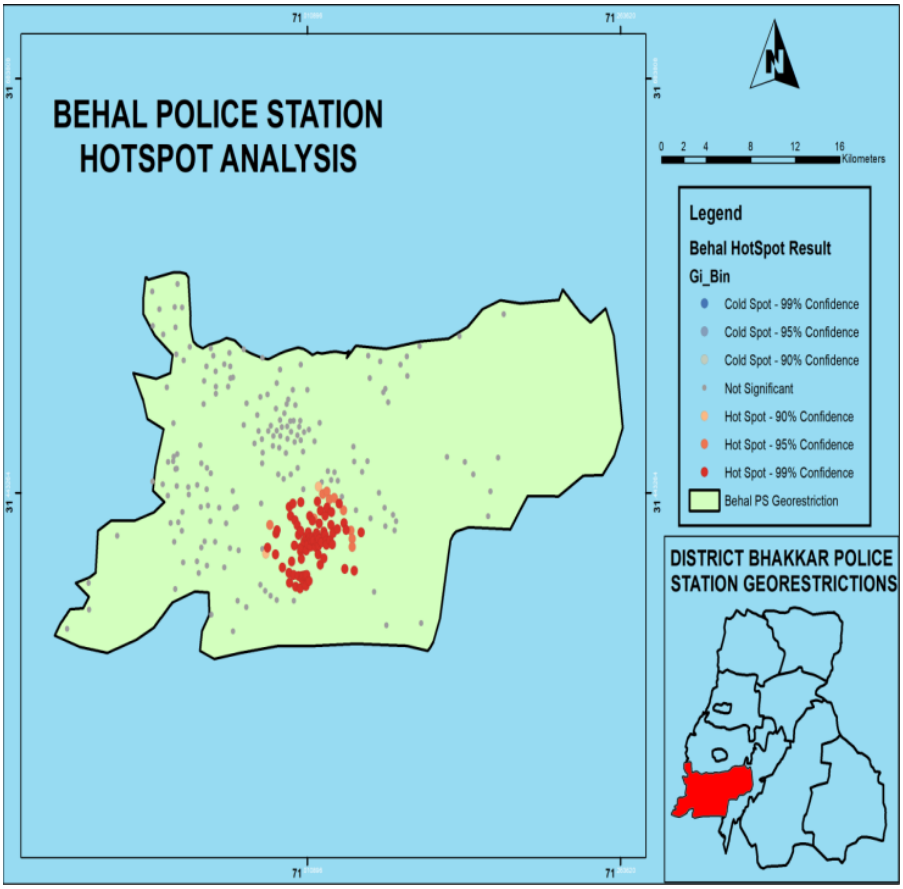

Figure 8: Behal police station hotspot analysis results

Final Hotspot Result of Mankera Police Station

276 registered crime of P.S Mankera occurred in 2017 was finally analyzed to check out hotspot. There is one spot which show 90 to 99 % confidence The output shown hot to cold spots of crime in the study area**.**

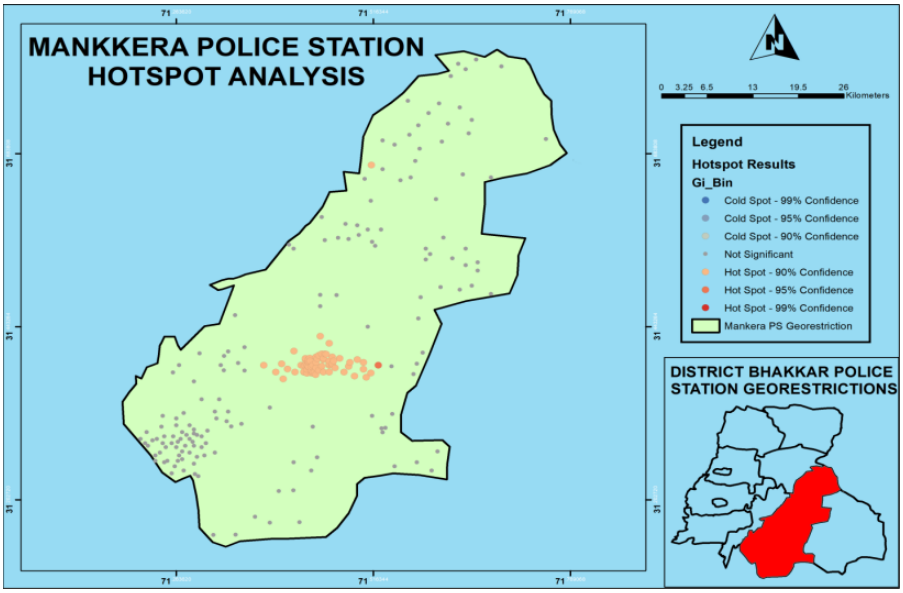

Figure 9: Mankkera police station hotspot analysis results

Final Hotspot Result of Haiderabad

Police Station

139 registered crime of P.S Haider Abad occurred in 2017 was finally analyzed to check out hotspot. There is dispersed spot which show 90 to 99 % confidence The output shown hot to cold spots of crime in the study area.

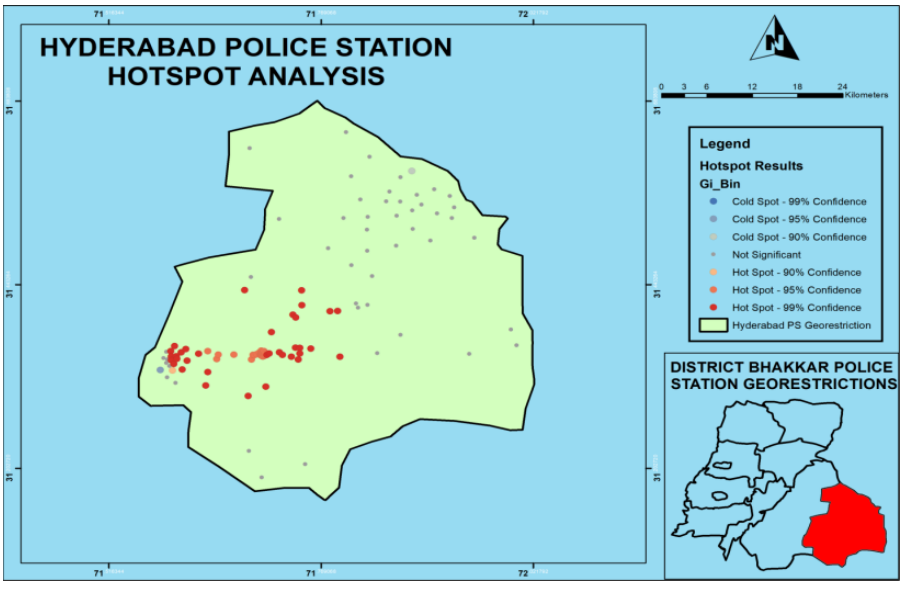

Figure 10: Hyderabad police station hotspot analysis results

Final Hotspot Result of Jandanwala

Police Station

378 registered crime of P.S Jandanwala occurred in 2017 was finally znalyzed to check out hotspot. There are 3 spot which show 90 to 99 % confidence The output shown hot to cold spots of crime in the study area.

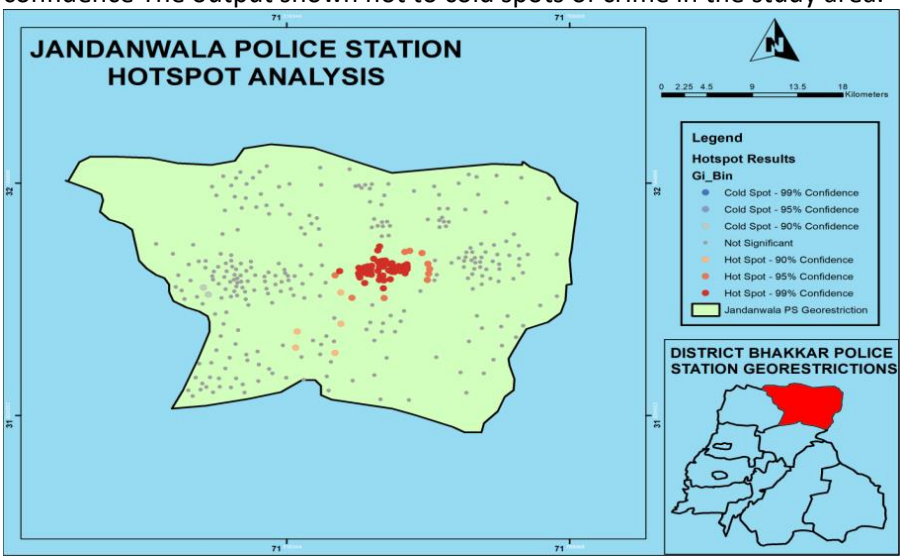

Figure 11: Jandanwala police station hotspot analysis results

Final Hotspot Result of Kalourkot

Police Station

430 registered crime of P.S Kalourkot occurred in 2017 was finally analyzed to check out hotspot. There is one spot which show 90 to 99 % confidence The output shown hot to cold spots of crime in the study area.

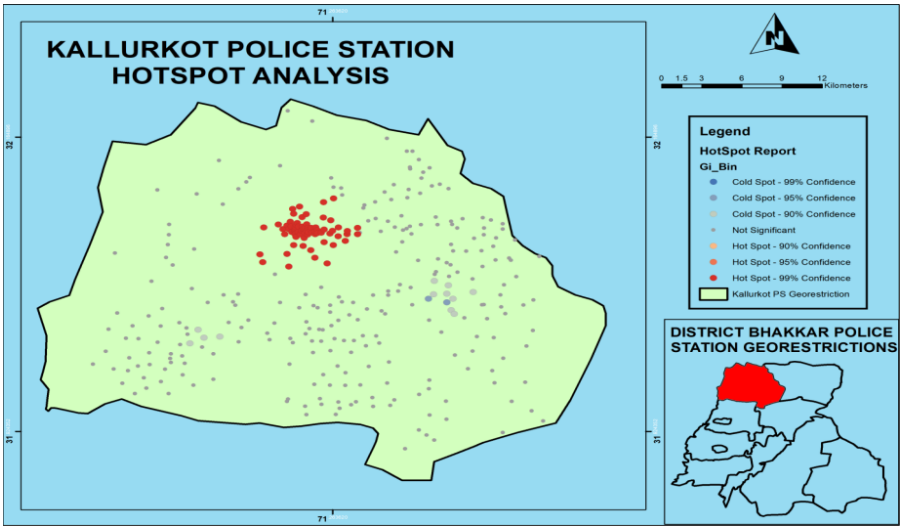

Figure 12: Kallurkot police station hotspot analysis results

Final Hotspot Result of City Darya Khan

Police Station

317 registered crime of City Darya Khan occurred in 2017 was finally analyzed to check out hotspot. There is one spot which show 90 to 99 % confidence The output shown hot to cold spots of crime in the study area.

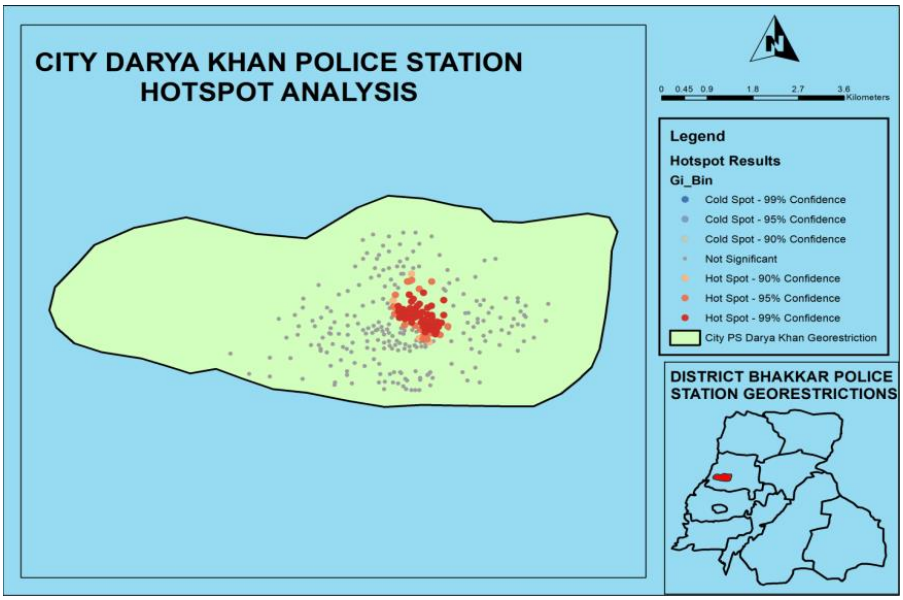

Figure 13: City Darya police station hotspot analysis results

Final Hotspot Result of Saddar Darya Khan Police Station

408 registered crime of Saddar Darya Khan occurred in 2017 was finally analyzed to check out hotspot. There is 3 spot which show 90 to 99 % confidence The output shown hot to cold spots of crime in the study area.

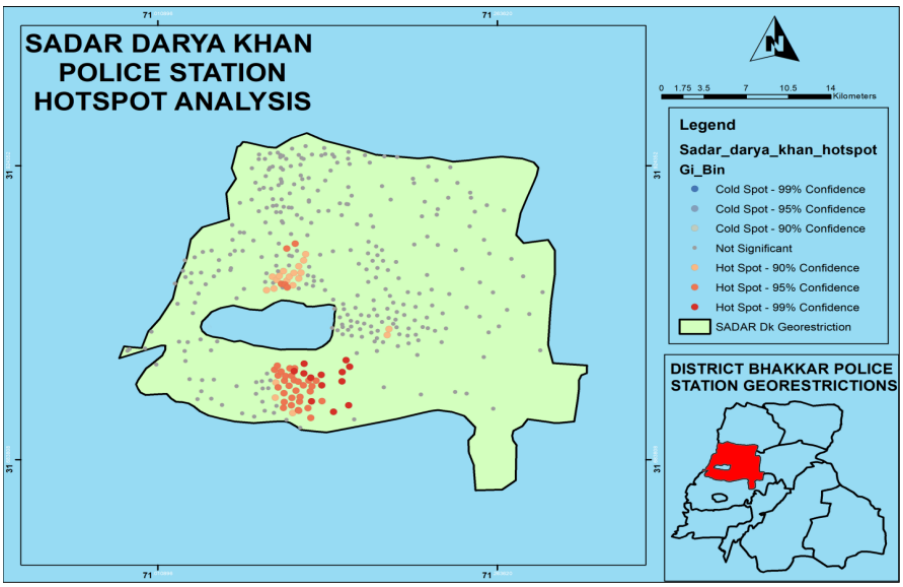

Figure 14: Sadar Darya Khan police station hotspot analysis results

Final Hotspot Result of Dullewala

Police Station

210 registered crime of P.S Dullewala occurred in 2017 was finally analyzed to check out hotspot. There is one spot which show 90 to 99 % confidence The output shown hot to cold spots of crime in the study area.

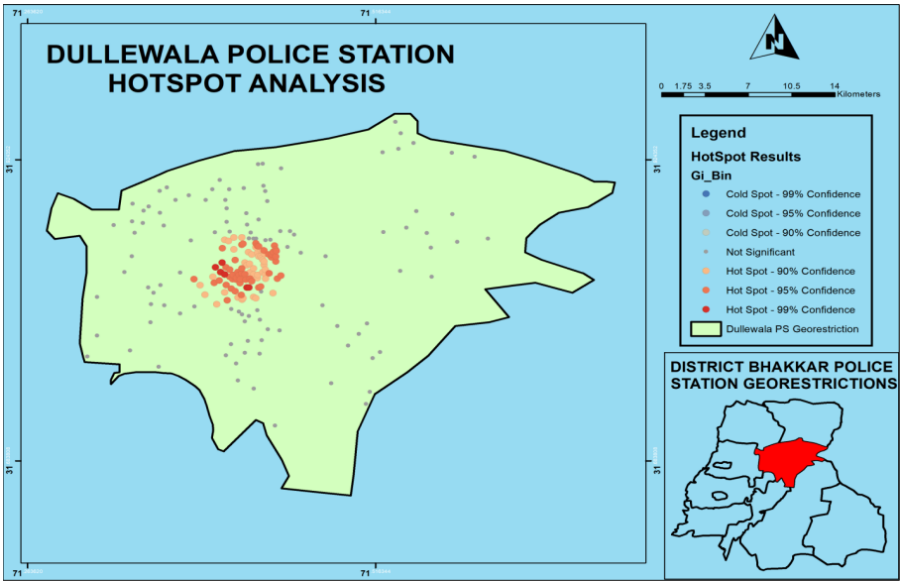

Figure 15: Bullewala police station hotspot analysis results

CONCLUSION

Geospatial technologies are very useful tools for effective crime mapping and management in remote areas including Bhakkar district. Spatial crime occurrence data is very important for analyzing the distribution of crime in an area. Hotspot used for analyzing crime distribution. It decreases the potential for internal violence by providing better grasp and control. It highlights the high risky areas as well as low risky areas. It provides the gateway to patrolling officers by highlighting the high-risk areas. GIS Technology helps to control crimes, find routes, and create flow maps to minimize the crime rate by investigative multipart discrete criteria and displaying them all in a graphical, layered, spatial interface or map. Urbanization is directly linked to the crime rate because most hotspots seen in urban areas. Climatic factors also effecting crime occurrence including temperature and precipitation. Geospatial technologies are very important for collecting, analyzing, and predicting and forecasting crime occurrence.

Crime mapping basically have three main functions

- Firstly, it offers cartographical map that helps to clear the analysis results.
- Secondly it simplifies the spatial pattern and its nature for visualization with statistical analysis based on crime and other types of incident.

- Thirdly it permits the analysts to linkage other data bases together based on its geographical such as census data, socioeconomic state and ancient crime data for a common area.

RECOMMENDATIONS

Arc GIS help you to improve public operations by pushing data and analysis out of officer in field enables shared situation awareness. Mobile app can support real time up date and data collection to enhance officer safety. Spatial tracking devices like as GPS, cell phone, and automated license plate reader playing a vital role and taking police into an intellectual era of modern policing.

The Government needs to implement spatial technologies in Law enforcement agencies to control crime. Law enforcement agencies needs to hire GIS panel and should set up GIS department in a circle of district, which controls the responsibility of handling crime data and performing analysis. It needs to developed database system crimes which records and share data with all law enforcement agencies. The patrol officer should be equipped with GPS so that their location could be known.

Hotspot analysis should perform automatically on that data and share the results in the form of web maps with all desire officials. Police routing and Monitoring should be according to analysis output. Crime forecasting will lead to a huge success if government facilitates the GIS users. It not just forecast the crime, but it reduces the crime rate too.

Future Crime Prevention by Modern Technologies

Promotion of live stream video by using CCTV cameras. Online reporting of crime at the spot by citizen without any delay or special access. Digital skills and use of spatial technology like as Remote Sensing, Global positioning system, software of geographic information system must be taught to patrolling and investigation officers.

Development of Web based GIS

As the advancement of global word order, there are a lot of Geospatial Resources accessible on the internet; it is required to be suitably systematized as per the training requirement. Open source software and web-based mapping and other resources for image processing, photo grammetry, mapping, GIS besides Microwave and Hyper spectral data analysis needs to be utilized for better community policing. (Christopher et al. 2004).

GIS in Pakistan

In Pakistan GIS technology is on its early stages. In Pakistan local and federal authorities are realizing the importance of GIS in Pakistan but lack of knowledge expertise resources and standard data base design are major

constraints in moving forward toward the implementation of GIS. Now a day's GIS is frequently used by researcher in different filed like as education, urban planning and forest mapping and meteorological application of GIS are commonly used by research scholar in universities. Whereas crime mapping is still barren of its utility to effectively apply in the field of crime. The crime mapping/analysis is widely used in developed country such as in Canada (Eikenboom et al 2017), in USA (Jefferson 2017; Bunting et al 2017) and in New Zealand (Curtis-Ham and Walton, 2017) but very few researches has been done in the field of crime mapping especially in developing country like as. Khalid et al 2017 estimated and produced hotspot mapping of crime in Faisalabad, Punjab, Pakistan.

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