



Harnessing Crime Mapping and GIS Technologies for Public Safety: Analyzing Crime Patterns and Optimizing CCTV Coverage in Apayao, Philippines

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Abstract

This study evaluated crime mapping for the strategic placement of Closed-Circuit Television (CCTV) and other targeted security interventions in the province of Apayao. Anchored on Routine Activity Theory, Situational Crime Prevention Theory, and Social Control Theory, the research examined index crimes from 2021 to 2023, categorized into crimes against persons and crimes against property. Utilizing spatial analysis tools, particularly Quantum Geographic Information System (QGIS), the study visualized crime distribution across seven municipal police stations in Apayao. Data were obtained from the Crime Information Reporting and Analysis System (CIRAS) through the Provincial Investigation and Detective Management Unit (PIDMU). Findings revealed that rape consistently ranked as the most prevalent crime against persons, while theft dominated crimes against property. Crime Clearance Efficiency (CCE) ranged from 91.6% to 100%, and Crime Solution Efficiency (CSE) from 75.76% to 92% over the three-year period. Thematic crime maps demonstrated patterns and hotspots, which informed recommendations for optimized CCTV deployment. Qualitative data further reinforced the quantitative insights, highlighting community perceptions and the need for enhanced surveillance. The study recommends a data-driven approach for CCTV allocation, integrated community involvement, and sustained police-community partnerships to strengthen crime prevention efforts in Apayao.

Keywords: Crime mapping, CCTV placement, Apayao, crime prevention, QGIS, index crimes, police efficiency, spatial analysis, public safety

Introduction

Technological advancements and evolving security threats demand innovative solutions. Harnessing new technologies improved the lives of individuals and communities, adapting these innovations for the common good and fostering safer, more comfortable lives. The internet's significant positive impact on lives is well-documented [1]. With the integration of these various technologies, innovations have become increasingly relevant in today's generation. One such innovation that has emerged prominently over the years, is the use of crime mapping, empowered by GIS and data analytics, offers a powerful lens through which to understand the spatial dynamics of crime.

Crime mapping is the process through which crime analysts and researchers use location information about crime events to detect spatial patterns in criminal activity. Early crime mapping efforts typically involved placing physical markers, such as pins, on maps to designate the locations where crimes occurred. Patterns



of criminal activity were determined primarily through visual inspection of these maps. With the advances in computing, geographic information system (GIS) software, such as MapInfo and ArcGIS, enables researchers to convert geographic information (addresses or global positioning system [GPS] coordinates) into coordinates used with virtual maps. Researchers and crime analysts can then use a number of analytic software packages to examine and detect patterns of criminal activity from these virtual maps [2].

The use of GIS programs for mapping has been the most important advance in the field of crime mapping. There are several important advantages in using virtual maps instead of physical maps. First, computers have dramatically reduced the time and effort required to produce crime maps. Given the relatively low cost and user-friendliness of many of these software programs, it no longer requires a substantial investment for agencies that wish to engage in crime mapping. Second, these GIS programs reduce the amount of error associated with assigning geographic coordinates to crime events. Third, virtual maps are much more flexible than physical maps, allowing researchers and crime analysts to compare the geographic distribution of crimes against other characteristics of the area under investigation (e.g., census bureau information, city planning and zoning maps, and maps produced by other agencies). Finally, GIS and other spatial analysis software provide powerful statistical tools for analyzing and detecting patterns of criminal activity that cannot be detected through simple visual inspection [2].

Crime mapping also play an important role in the policing and crime reduction process, from the first stage of data collection through to the monitoring and evaluation of any targeted response. It can also act as an important mechanism in a more pivotal preliminary stage, that of preventing crime by helping in the design of initiatives that are successful in tackling a crime problem [3].

Crime mapping is a critical analytical tool used by law enforcement agencies to visualize and analyze the spatial patterns of crime. By employing Geographic Information Systems (GIS), crime mapping allows analysts to identify crime hotspots, track trends over time, and allocate resources effectively [4].

With the help of those crime maps and using GIS, it's possible to cross the data from the crimes with locations and see what's located in that area – for example, schools, churches and, pawn shops – and overlay the maps with the census demographics. That's how law enforcement agencies create strategies to combat the crimes in each location, as they can understand the causes of the crimes happening in the area. Police also benefit from those online crime maps as they can have an accurate idea of how many officers they need to locate in each area in order to deal with emergencies [5].

Crime mapping also includes limitations and challenges and one of the main limitations of crime mapping is data quality. Crime data is often incomplete, in accurate, or biased, which can affect the validity and reliability of crime maps. Data quality issues can have a significant impact on the results of crime mapping while it often focuses on a single point in time, such as a year or a month. This can be useful for identifying long-term trends in crime and it may miss important short-term fluctuations in crime patterns. Second, the public concerns, the public



availability of crime data raises questions about privacy and the potential for stigmatization of neighborhoods as crime hotspots [6] and lastly, the Interpretation Variability, as different users, including police officers and community members, may interpret crime maps differently. This can lead to inconsistent responses to the data [7].

In March 2019, the brutal murder of 16-year-old Marjorie (not her real name) shocked the Philippines. Her body was found with multiple stab wounds and her face skinned to the bone. The local police utilized CCTV footage from various cameras around the area where she was last seen, showing a man following her, which led to the identification and arrest of the suspect. The footage was instrumental in piecing together the events leading up to the crime and solving the case. Similarly, in 2016 in Luna, Apayao, the shooting incident involving the Sanggunian Bayan Secretary, Ms. Epifania Cayetano, and in 2023, Hon. Rodrigo Parinas, Punong Barangay of San Gregorio, were solved through CCTV camera footage. These cases highlight the critical role of CCTV systems in solving crimes and their strategic placement in high-crime areas, commercial establishments, public transport systems, and residential neighborhoods as a deterrent to criminal activities.

To determine the number of operational CCTV cameras in Apayao, the researcher through the various municipal intelligence units conducted an informal survey in May 2023, the survey collected a total data of 286 operational CCTV cameras across the province. A breakdown by municipality showed: Calanasan had 2 operational government-owned and 1 operational privately-owned camera; Conner reported 10 operational and 2 non-operational government-owned cameras, along with 11 operational and 3 non-operational privately-owned cameras; Flora had 2 operational government-owned and 10 operational privately-owned cameras; Kabugao had 9 operational government-owned and 5 operational privately-owned cameras; Luna had a significantly higher number with 311 operational and 75 non-operational government-owned cameras, and 220 operational and 9 non-operational privately-owned cameras; Pudtol reported 10 operational government-owned and 13 operational privately-owned cameras; and finally, Sta. Marcela had 2 operational government-owned and 13 operational privately-owned cameras. This data highlights significant variations in CCTV camera deployment across Apayao's municipalities.

As the crime mapping technology's proven efficacy in reducing crime and enhancing public safety, the technology's capacity to quickly and precisely identify the geographic locations where crime (and other events) take place and to link those events to a host of other data sources raise concerns that it might be misused to infringe on or violate civil liberties and/or undermine civil rights. [8]. Crime Mapping technology potentially provides law enforcement and other government entities with a robust capacity to surveil the public and, by collecting and correlating various data sources with geographic information, to infringe on the privacy interest of individuals and groups. [9&10].

Despite from the widespread adoption of crime mapping, there are gaps for strategic CCTV placement and other targeted security interaction in the crime-prone areas. It is easy to see how mapping and use of data is useful for police, but



what is less clear is the value of opening the data for public websites to help reducing crime or catching those responsible for the incidents reported on websites. [11]. Due to critical implications of mapping, the analysis requires a systematic and analytical evaluation of the information available. For this reason, different mapping techniques have been developed for identifying crime hotspot and the most common are the Spatial and Temporal Analysis of Crime, Thematic mapping of geographic boundary areas and Quadrant thematic mapping [12]. Thus, the unique characteristics of barangays, such as population density, socioeconomic factors, and specific community dynamics, pose distinct challenges in crime prevention and maintaining public safety are very important.

The focused of this study assessing the specific needs on crime mapping strategic for CCTV camera placement and other targeted security interaction is essential. By bridging the global perspective on CCTV technology with the local realities of Apayao, it enhanced CCTV placement in Apayao, providing valuable insights into effective strategies for improving safety and security. Recognizing the importance of incorporating crime mapping for strategic CCTV placement in communities allows residents to enhance safety, deter criminal activities, and contribute to a more secure and comfortable way of life, ultimately serving the common good.

Statement of the Problem

This research sought to map various evaluated the crime mapping for strategic CCTV placement and other targeted security interaction in Apayao. Specifically, it seeks answers to the following problems:

1. What are the Index crimes committed for the last 3 years in the province of Apayao when categorized into:
 - a. Crimes against property
 - b. Crimes against persons
2. What are the most prevalent crimes against property and crimes against person in the province of Apayao for the last three years (2021-2023)
3. What recommendation can be forwarded to local government units and line agencies to optimize the use of CCTV in crime prevention in Apayao?

Theoretical Framework

The study on crime mapping for strategic placement and other targeted security interaction were supported by the following theories:

Routine Activity Theory: This theory posits that crime occurs when three elements converge - a motivated offender, a suitable target, and the absence of a capable guardian. CCTV systems can act as capable guardians by increasing the perceived risk for offenders and deterring criminal activities [13].

Situational Crime Prevention Theory: This theory emphasizes the manipulation of immediate opportunities for crime through environmental design and management. CCTV systems can be seen as a form of situational crime prevention



by increasing the perceived risk of detection and apprehension for potential offenders [14].

Social Control Theory: This theory suggests that individuals are less likely to engage in criminal behavior when they feel connected to their community and have strong social bonds. CCTV systems, by promoting a sense of surveillance and accountability, can contribute to social control mechanisms within a community [15].

By grounding the study in these theoretical frameworks, researchers can better understand the role of CCTV systems in shaping crime prevention strategies and enhancing public safety.

CCTV Camera in Crime Prevention, camera surveillance using CCTV units can be considered as a technique of Situational Crime Prevention (SCP) which aims to strengthen formal surveillance on a specific location, thus increasing the criminal's perceived hazards of instigating crime and minimizing opportunities for crime to occur [16]. CCTV cameras enable users to watch over an area in real time and record happenings in the vicinity which can then be reviewed later whenever the need to do so arises.

RESEARCH METHODOLOGY

This chapter outlines the research design and methodology employed in the study. It describes the methods used for data collection and analysis, the locale and respondents involved, as well as the research instruments, procedures, ethical considerations, and statistical treatments applied. The study utilized spatial analysis techniques, specifically through the Quantum Geographic Information System (QGIS), to examine crime mapping for strategic CCTV placement and other targeted security interventions in the province of Apayao. This approach allowed for the visualization and analysis of geospatial data, enabling predictive insights and actionable recommendations. The research was conducted in the Apayao Police Provincial Office, located at Camp Gov. Elias K. Bulut Sr. & Training Center, Brgy. Sta. Lina, Luna, Apayao, encompassing the seven municipal police stations of Calanasan, Conner, Flora, Kabugao, Luna, Pudtol, and Sta. Marcela.

The primary respondents of the study included personnel from the Provincial Investigation and Detective Management Unit (PIDMU), with whom the researcher coordinated to obtain secondary data on crime incidence from the Crime Information Reporting and Analysis System (CIRAS). Upon receiving formal approval from the Provincial Director, the researcher collaborated with the E-Project Police Non-Commissioned Officer (PNCO) of PIDMU to plot the crime data from CY 2023 using QGIS. This enabled the creation, editing, visualization, and analysis of crime-related geospatial data. The research instruments involved QGIS-generated thematic maps and statistical summaries of crime data, particularly focusing on crimes against persons and property. These maps helped identify hotspots and assess the potential for CCTV deployment.

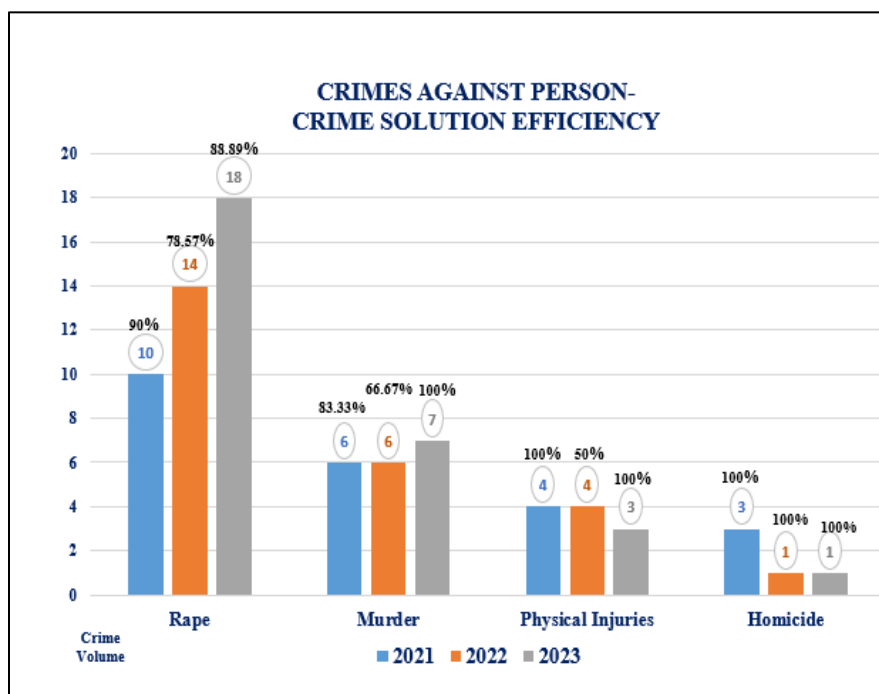
In addition to analyzing secondary crime data, a comparative analysis was conducted to evaluate CCTV system placement by comparing crime rates, clearance rates, and public perception before and after CCTV installations in Apayao. Qualitative data analysis, including thematic and content analysis, was also integrated to understand the motivations, experiences, and perspectives of stakeholders such as local authorities, community leaders, and residents. These insights enriched the quantitative data and informed more grounded recommendations.

Thematic crime maps were presented to local government units for their review, allowing for stakeholder input and validation. Ethical considerations were strictly upheld throughout the study, including informed consent, confidentiality, and data protection, ensuring the integrity and trustworthiness of the research process. For the statistical treatment of crime data from CY 2021 to 2023, ranking and percentage techniques were used to categorize and analyze the most prevalent crimes. The final recommendations were addressed to local government units and relevant agencies to enhance the strategic placement of CCTV systems and improve targeted security interventions in the province of Apayao.

RESULTS AND DISCUSSIONS

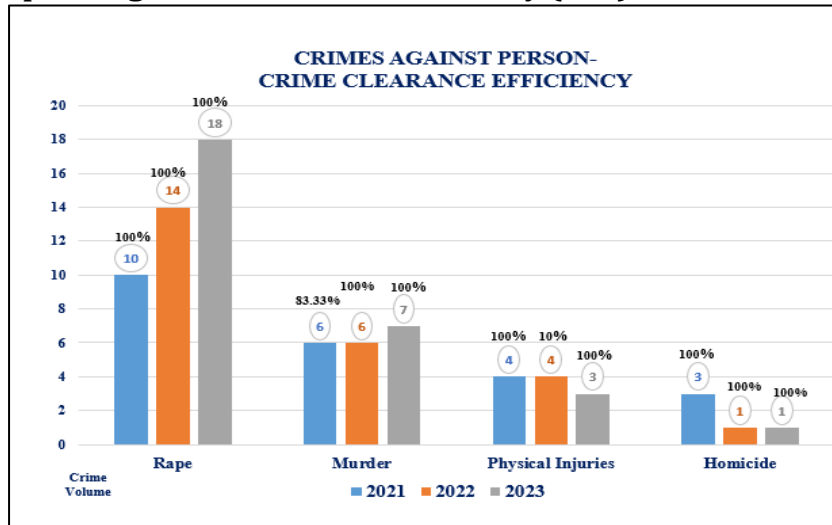
This chapter presented the analysis and interpretation of the data gathered that provided answers to the problem of the study.

Graph 1 showed the Index Crime for CY 2021-2023 when grouped according to Crime against person with the corresponding Crime Solution Efficiency (CSE).

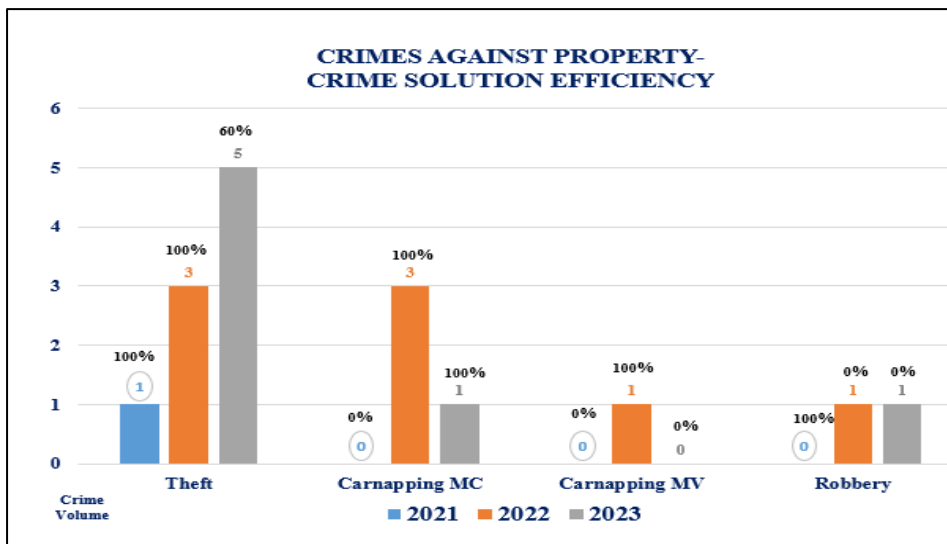


Graph 2 showed the Index Crime for CY 2021-2023 when grouped according to Crime against person with

the corresponding Crime Clearance Efficiency (CCE).



Graph 3 showed the Index Crime for CY 2021-2023 when grouped according to Crime against Property with the corresponding Crime Solution Efficiency (CSE).



Graph 4 showed the Index Crime for CY 2021-2023 when grouped according to Crime against Property with the corresponding Crime Clearance Efficiency (CCE).

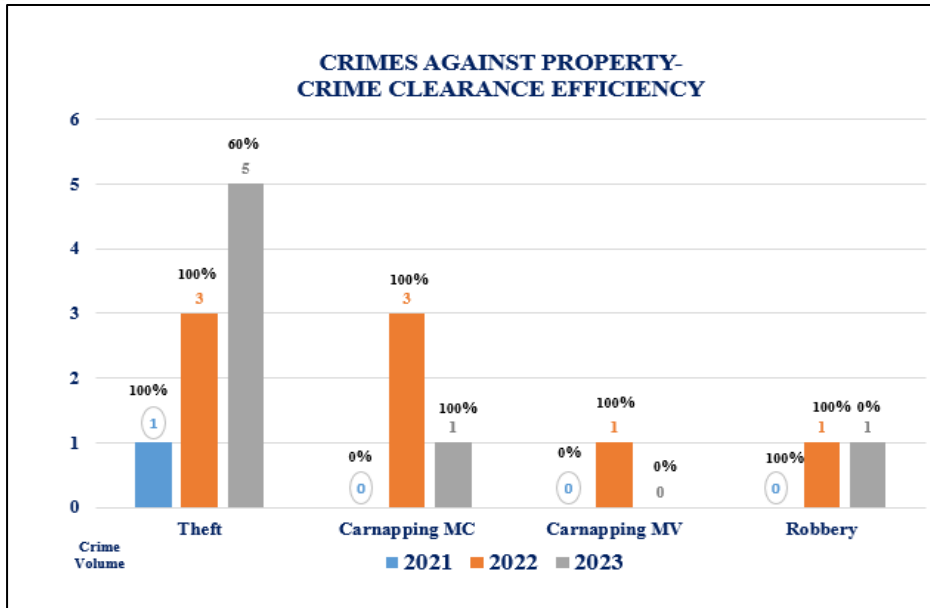


Table 1 showed the Index Crime for CY 2021-2023 when grouped according to Crime against person and Crime against property with CSE and CCE.

2021				2022			2023		
Crime Category	Crime Volume	CCE	CSE	Crime Volume	CCE	CSE	Crime Volume	CCE	CSE
CRIMES AGAINST PERSON									
Homicide	3	100%	100%	1	100%	100%	3	100%	100%
Murder	6	83.3%	83.3%	6	100%	66.7%	7	100%	100%



P h y s i c a l I n j u r i e s	4	1 0 0 %	1 0 0 %	4	1 0 0 %	5 0 %	1	1 0 0 %	1 0 0 %
R a p e	1 0	1 0 0 %	9 0 %	1 4	1 0 0 %	7 8 . 5 7 %	1 8	1 0 0 %	8 8 . 8 9
CRIMES AGAINST PROPERTY									
C a r n a p p i n g M C	0	0 %	0 %	3	1 0 0 %	1 0 0 %	1	1 0 0 %	1 0 0 %
C a r n a p p i n g M V	0	0 %	0 %	1	1 0 0 %	1 0 0 %	0		
R o b b e r y	1	1 0 0 %	1 0 0 %	1	1 0 0 %	0 %	1	0 %	0 %
T h e f t	1	1 0 0 %	1 0 0 %	3	1 0 0 %	1 0 0 %	5	6 0 %	6 0 %
T O T A L	2 5	9 6 %	9 2 . 0	3 3	1 0 0 %	7 5 . 7	3 6	9 1 .	8 6 . 1



			0 %			6 %		6 %	1 %
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To understand Crime Clearance Efficiency (CCE), refers to a crime that is considered cleared when it is amicably settled, for record purposes and filed without arrest which shall include only cases handled by the police station, while on the Crime Solution Efficiency (CSE), a crime shall be considered solved when the following elements concur: a) the offender has been identified; b) there is sufficient to charge the offender; c) the offender has been taken into custody; and d) the offender has been charged before the prosecutor's office or court of appropriate jurisdiction. Moreover, a case shall also be considered solved when some elements beyond police control prevent the arrest of the offender, such as when the victim refuses to prosecute after the offender is identified or the offender dies or absconds. The CSE is the efficiency of the police expressed in the percentage of the number of cases solved by the police out of the total number of crime incidents that are recorded into the police blotter for a given period.

To compute for the Crime Clearance Efficiency is equal to $\text{Cleared/Crime Volume} \times 100\%$ ($\text{CCE} = \text{Cleared/Crime Volume} \times 100\%$) and for Crime Solution Efficiency is equal to $\text{Solved/Crime Volume} \times 100\%$ ($\text{CSE} = \text{Solved/Crime Volume} \times 100\%$).

Based on Table 1, the Total crime volume for CY 2021 is 25. Under the crime category on crimes against person, the most crime volume is Rape with 10 crime committed, followed by Murder with 6 crime volume, then Physical Injuries with 4 crime volume and Homicide with 3 crime volume and on crimes against property are Carnapping Motorcycle and Motor Vehicle, Theft and Robbery with total crime volume of 2. As to the overall result, the Crime Clearance Efficiency is 96% while the CSE is 92%. The results implied that out of the 25 crimes committed in the province some cases are still under investigation since the suspect/s was/were unidentified or while some suspects are still at large. Thus, the PNP needs to improve their performance to investigate all cases and solve it to attain a 100% performance for a better safety of the people.

For CY 2022, the crime volume is 33, under the crime category of crimes against person the most crime committed is Rape with 14 crime volume, followed by Murder with 6 crime volume, then Physical Injuries with 4 crime volume and Homicide with 1 crime volume and on crimes against property, the most crime committed is Carnapping Motorcycle and Theft with 3 crime volume followed by Carnapping Motor Vehicle and Robbery with 1 crime volume each with a 8 total crime volume. As to the overall result, all crimes were cleared with a 100% CCE while the CSE is 75.76%. The results implied that all crimes were properly addressed, and all suspects were identified which led to the attainment of 100% Crime Clearance Efficiency.

For CY 2023, the crime volume is 36, with the same crime category of crimes against person, the most common crime committed is Rape with 18 crime volume, followed by Murder with 7 crime volume Homicide, the Physical Injuries with 3 crime volume and Homicide with 1 crime volume with a total of 29 under this crime category and on the crimes against property category, the most common crime committed is Theft with 5 crime volume, followed by 1 crime volume for carnapping Motorcycle and 1 crime volume for Robbery with a total crime volume of 7, and not all crimes were cleared with a 91.6% CCE while the CSE is 86.11% The results implied that all crimes were not

properly addressed, and all suspects were not identified which led for not attaining the 100% Crime Clearance Efficiency and Crime Solution Efficiency. Nevertheless, the crime clearance efficiency of crime increased from 2021 of 96%, 2022 was 100% and 2023 was 91.6% while for the Crime Solution Efficiency from 2021 of 92%, 2022 was 75.76% and 2023 was 86.11%. The implications of the results mean that the PNP needs to gain more support and trust from the community to attain 100% crime solution efficiency.

Table 2. Distribution and Ranking of the most prevalent Index Crime committed as to the Crimes Against Person CY 2021-2023 of the 7 MPS.

CY 2021 Crime Volume									
	CRIMES AGAINST PERSON								
C r i m e C a t e g o r y	C a l a s a n M P S	C o n n e r M P S	F l o r a M P S	K a b u g a o M P S	L u n a M P S	P u d t o l M P S	S t a M a r c e l a M P S	G r a n d T o t a l	R a n k i n g
H o m i c i d e				2		1		3	4
M u r d e r		2	2	2				6	2
P h y s i c a l I n j u r i e s					2	2		4	3
R a p e	2	2	2	1	1	1	1	10	1
T o t	2	4	4	5	3	4	1	23	



a									
l									
CY 2022 Crime Volume									
CRIMES AGAINST PERSON									
C r i m e C a t e g o r y	C a l a n s a n M P S	C o n n e r M P S	F l o r a M P S	K a b u g a o M P S	L u n a M P S	P u d t o l M P S	S t a M a r c e l a M P S	G r a n d T o t a l	R a n k i n g
H o m i c i d e		1						1	4
M u r d e r		3		2			1	6	2
P h y s i c a l I n j u r i e s		1		1	1		1	4	3
R a p e	2	5	2	1	2	1	1	14	1
T o t a l	2	10	2	4	3	1	3	25	
CY 2023 Crime Volume									
CRIMES AGAINST PERSON									
C r i m e	C a l a n s	C o n n e r	F l o r a	K a b u g	L u n a M	P u d t o	S t a M a	G r a n d	R a n k i



C a t e g o r y	a s a n M P S	r M P S	M P S	a o M P S	P S	I M P S	r c e l a M P S	T o t a l	n g
H o m i c i d e			1	1			1	3	3
M u r d e r			1	2	1	2	1	7	2
P h y s i c a l I n j u r i e s					1			1	4
R a p e	4	3	4	1	1	2	3	18	1
G r a n d T o t a l	4	3	6	4	3	4	5	29	

Based on the table 2, the distribution and ranking of the most prevalent index crime committed as to crimes against person for CY 2021, the Rape case incident have the largest crime volume with a total of 10 counted offenses that made it to be the rank number 1, all the seven municipal police station have a counted offenses, the Calanasan, Conner and Flora MPS with 2 counted offenses each and the rest with one counted offense for Kabugao, Luna, Pudtol and Sta.Marcela MPS. Next in the ranking for the most prevalent crime committed on crimes against person is the Murder incident with 6 total crime volume wherein Conner, Flora and Kabugao MPS have 2 counted offenses.

Third in rank is the Physical Injuries incident with a 4 total crime volume both 2 counted offenses for Luna and Pudtol MPS.

Lastly, is the homicide incident with a total crime volume of 3, 2 for Kabuao and 1 for Pudtol MPS.

For the distribution and ranking of the most prevalent index crime committed as to crimes against person for CY 2022, the Rape case incident again have the largest crime volume with a total of 14 counted offenses that made it to be the rank number 1, all the seven municipal police station have a counted offenses which include the Conner MPS with 5 crime volume followed by Calanasan, Flora and Pudtol with 2counted offenses, and rest with one counted offense for Kabugao, Pudtol & Sta.Marcela MPS.

Next in rank is the murder incident which it has a 6 total crime volume, 3 for Conner, 2 for kabugao & 1 for Sta.Marcela while Physical Injuries got ranked number 3 in the most prevalent crime committed, 1 Conner, Kabugao, Luna and Sta.Marcela. Lastly, is the Homicide incident wherein only Conner has 1 counted offense.

For the distribution and ranking of the most prevalent index crime committed as to crimes against person for CY 2023, the Rape case incident have the largest crime volume that made it to be rank number 1, that all the seven municipal police stations have a counted offense which includes the Calanasan and Flora, both with 4 crime volume followed by Conner and Sta.Marcela with 3 counted offenses, 2 for Pudtol and both 1 for Kabugao and Luna MPS.

Next in the ranking, is the Murder with a 7 total crime volume, Kabugao and Pudtol both have 2 counted offenses and the rest which include Flora, Luna and Sta. Marcela has 1 counted offense. Third in the ranking of most prevalent crime committed is the Homicide incident with a total of 3 crime volumes which includes 1 counted offense for Flora, Kabugao and Sta. Marcela. Lastly, is the Physical Injuries with a total of 1 crime volume and only Luna MPS has a counted offense.

Table 3. Distribution and Ranking of the most prevalent Index Crime committed as to the Crimes against Property for CY 2021- 2023 of the 7 MPS.

CY 2021 Crime Volume									
	CRIMES AGAINST PROPERTY								
C r i m e C a t e g o r y	C a l a n a s a n M P S	C o n n e r M P S	F l o r a M P S	Ka b u g a o M P S	L u n a M P S	P u d t o l M P S	S t a M a r c e l a M P S	G r a n d T o t a l	R a n k i n g
C a	0	0	0	0	0	0	0	0	



r n a p p i n g M C									
C a r n a p p i n g M V	0	0	0	0	0	0	0	0	
R o b b e r y	0	0	0	0	1	0	0	1	1
T h e f t	0	0	1	0	0	0	0	0	1
T o t a l			1		1			2	
CY 2022 Crime Volume									
CRIMES AGAINST PROPERTY									
C r i m e C a t e g o r y	C a l a n a s a n M P S	C o n n e r M P S	F l o r a M P S	K a b u g a o M P S	L u n a M P S	P u d t o l M P S	S t a M a r c e l a M P S	G r a n d T o t a l	R a n k i n g
C a r n a p p i n g	1		1		1			3	1



M C									
C a r n a p p i n g M V			1					1	2
R o b b e r y			1					1	2
T h e f t		1				2		3	1
T o t a l	0	1	3	0	1	2	0	8	
CY 2023 Crime Volume									
C o u n t o f O F F E N S E	CRIMES AGAINST PROPERTY								
R o w L a b e l s	C a l a n a s a n M P S	C o n n e r M P S	F l o r a M P S	K a b u g a o M P S	L u n a M P S	P u d t o l M P S	S t a M a r c e l a M P S	G r a n d T o t a l	R a n k i n g
C A R N A		1						1	2



P P I N G M C									
C A R N A P P I N G M V								0	
R O B B E R Y				1				1	2
T H E F T				4	1			5	1
G r a n d T o t a l		1	0	5	1	0	0	7	

Based on the table 3, the distribution and ranking of the most prevalent index crime committed as to crimes against property for CY 2021, only robbery and theft have a counted offense wherein 1 to Flora MPS for theft incident and 1 for Luna MPS for robbery incident.

For the distribution and ranking of the most prevalent index crime committed as to crimes against person for CY 2022, the Robbery and Carnapping MC case incident with the largest crime volume of 6 counted offenses that made it to be the rank number 1 followed by Carnapping MV and theft with two (2) counted offenses.

For the distribution and ranking of the most prevalent index crime committed as to crimes against property for CY 2023, Theft incidents have a total crime volume of 5 wherein Luna MPS have 4 counted offenses and 1 for Pudtol MPS followed by robbery with 1 crime volume of Kabugao MPS and 1 Carnapping Motorcycle of Conner MPS.

Thus, crime mapping plays a crucial role in preventing crimes in Apayao through several mechanisms and strategies. Firstly, the mere presence of CCTV cameras acts as a

significant deterrent to potential thieves. Criminals are less likely to attempt to commit crimes if they know that their actions are being recorded and that there is a higher risk of being identified and caught. This preventive effect is particularly strong in areas where CCTV cameras are prominently visible and well-maintained, creating an environment where the risk of apprehension outweighs the potential rewards of the crime. [36]

Moreover, CCTV footage provides valuable evidence that can be instrumental in investigating committed crimes in areas captured by CCTV through a high-resolution video recording, it can capture critical details such as the appearance of the suspects, the license plate numbers of vehicles involved, and the precise time and method of the theft. This information is invaluable to law enforcement agencies, enabling them to identify and track down suspects more efficiently. In many cases, the availability of clear CCTV footage has led to swift arrests and successful prosecutions, thereby removing car thieves from the streets and preventing further crimes. [37]

CCTV systems also contribute to the quick recovery of stolen vehicles. By monitoring key locations such as parking lots, streets, and highways, CCTV cameras can track the movement of stolen cars. Real-time monitoring allows law enforcement to quickly respond to thefts, increasing the chances of recovering the vehicle before it is damaged or dismantled. In some cases, integrated systems that combine CCTV with automated license plate recognition (ALPR) technology can alert authorities immediately when a stolen vehicle is detected, facilitating rapid intervention and recovery. [38]

Additionally, the presence of CCTV cameras in high-risk areas can influence public behavior and enhance community vigilance. When people are aware that their surroundings are being monitored, they are more likely to report suspicious activities and cooperate with law enforcement efforts. This heightened sense of vigilance and community engagement can further deter criminal activities, including car theft, and foster a safer environment for everyone. [37]

Analyzing the impact of CCTV system in crime prevention and investigation in Apayao contributed to community policing initiatives on police effectiveness and performance metrics such as crime reduction, crime solution and public satisfaction.

For the trend analysis on the status of crimes within the province of Apayao, the researcher made use of the QGIS (Quantum Geographic Information System) of the PNP for the detailed map depicting the crime location for strategic CCTV placement and other targeted security interaction for crime prevention.

Below is the crime category with crime map legend of the seven municipalities in Apayao and the table of crime volume which is the researcher's basis in depicting the crime mapping for CY 2023 as a thematic map that helped locate the Index Crimes in the province of Apayao.



LEGEND

For Crime Map2

- ADULTERY
- COMPREHENSIVE DANGEROUS DRUGS ACT OF 2002
- COMPREHENSIVE LAW ON FIREARMS AND AMMUNITION
- DIRECT ASSAULTS
- DISCHARGE OF FIREARMS
- HOMICIDE
- LIBEL
- MALICIOUS MISCHIEF
- MURDER
- NEW ANTI-CARNAPPING ACT OF 2016 - MC
- OMNIBUS ELECTION CODE OF THE PHILIPPINES
- PD. NO. 1602
- QUALIFIED THEFT
- ROBBERY
- THE FORESTRY REFORM CODE OF THE PHILIPPINES (ILLEGAL LOGGING)
- THEFT
- Vehicular Traffic Accident

Apayao Municipalities

- Calanasan
- Conner
- Flora
- Kabugao
- Luna
- Pudtol
- Santa Marcela

Table 4. Crime category legend of the Seven Municipalities in Apayao for CY 2023.

CY 2023 Crime Volume								
CRIME CATEGORY	Calanasan MP S	Conner MP S	Flora MP S	Kabugao MP S	Luna MP S	Pudtol MP S	Santa Marcela MP S	Grand Total
1. Adultery		1						1
2. Comprehensive Dangerous Drug Act of 2002		2		2	1	1		6
3. Comprehensive Law on Firearms and Ammunition			1					1
4. Direct Assaults						1		1
5. Discharge of Firearms			1					1
6. Homicide			3	2	1		1	7
7. Libel								0
8. Malicious Mischief						1		1
9. Murder	1		1	4	2	3	2	13
10. New Anti-Car napping Act of 2016-MC		1						1
11. Omnibus Election Code of the Philippines					1			1
12. PD.No.1602		1			1			2
13. Qualified Theft		1						1



14.Robbery				1				1
15.The Forestry Reform Code of the Philippines (Illegal-Logging)		1	1		1			3
16.Theft		0			2	1		3
17.Vehicular Traffic Accident	3	6	4	4	1 6	7	3	4 3
Grand Total	4	1 3	1 1	1 3	2 6	1 4	6	8 5

The researcher did not included the rape incident cases on the crime mapping and listings for this crime maps often used anonymized data to protect the privacy of victims. Rape cases due to their sensitive nature, may be excluded from public maps to safeguard the identities of the survivors. Thus, it is important that the reasons for excluding the rape incidents from crime maps can vary depending on the specific map's purpose, data sources, and the policies of the organization creating it.

It is inappropriate and unethical to recommend venues for rape. Rape is a serious crime and should never be discussed in a way that suggests it is acceptable or commonplace.

Although many crime mapping systems are used initially for a single purpose, the best systems are designed to serve many functions. The three most common uses of computerized Crime mapping are to measure police performance, solve specific crime problems, and inform the public. [35].

Based on the thematic map of the Apayao, the most prevalent crime committed by the seven municipal police stations is the Vehicular Traffic Accident with a total crime volume of 43, 3 counted offenses in Calanasan, 6 in Conner, 4 in Flora, 7 in Pudtol, 3 in Sta. Marcela and the municipality of Luna committed the greatest number of crimes that happened along the streets and barangays in Turod, San Isidro Sur, Capagaypayan, Sta. Lina and Quirino with a time of commission from 8:00 -9:30 A.M, and 4:20 P.M- 11: 40 P.M. Thus, with the use of crime mapping of the Luna MPS could measure their performance and hold themselves accountable typically trying to monitor changes in crime over time or to compare crime levels in different barangays and how they could optimize CCTV surveillance placement through crime mapping for a strategic positioning for enhanced crime prevention within the area of responsibility.

Second, is the Rape incident with a total crime volume of 18 wherein 4 counted offenses in Calanasan, 3 in Conner, 4 in Flora, 1 in Kabugao, 1 in Luna, 2 in Pudtol and 3 in Sta. Marcela. The researcher did not include the placement of crime mapping for this rape case for confidentiality purposes although all the seven municipalities have recorded crimes within their Area of Responsibility.



Third is the Murder incident with a total crime volume of 13. 1 counted offense in Calanasan, 1 in Flora, 2 in Luna, 3 in Pudtol, 2 in Sta. Marcela and the municipality of Kabugao committed the greatest number of crimes with a total of 4 that happened in Brgy. Cabeyatan, Madatag, Madduang and Lucab, Kabugao, Apayao.

The fourth most prevalent crime committed within the Apayao province is the Homicide incident with a 7 total crime volume. 2 counted offenses in Kabugao, 1 in Luna and the municipality of Flora committed the greatest number of crimes with a total of 3 happened in Brgy. Balasi, Balluyan and Poblacion and all cases were solved.

Fifth is the Comprehensive Dangerous Drugs Act of 2002 with a total crime volume of 5. The municipality of Kabugao, Luna and Pudtol have 1 counted offense while the municipality of Conner has 2 counted offenses that happened Brgy. Caglayan and Paddoang wherein suspect/s were arrested and detained which resulted in the case to solved.

Sixth are the Forestry Reform Code of the Philippines (Illegal Logging) and Theft with a total crime volume of 6 wherein there were 3 counted offenses for Illegal Logging, 1 in Brgy. Guinamgaman, municipality of Conner, 1 in Brgy. Tamalunog, Flora and 1 in Brgy. Turod, Luna while 3 counted offenses on Theft, 1 in Cabatacan, Pudtol and 2 in Brgy. San Isidro Sur, Luna.

Seven prevalent crimes committed in Apayao is PD No.1602 (Illegal Gambling) with a total crime volume of 2 that happened in Brgy. Guinamgaman, municipality of Conner and Brgy. San Sebastian, Luna.

For the remaining crime categories with 1 counted offense which includes the Adultery in Brgy. Ripang, Conner, Apayao, Comprehensive Law on Firearms and Ammunition in Brgy. Allig, Flora, Apayao, Direct Assaults in Brgy. Cappanikian, Pudtol, Apayao, Malicious Mischief in Brgy. Aga, Pudtol, Apayao, New Anti-Carnapping Act of 2016-MC in Brgy. Malama, Conner, Apayao, Omnibus Election Code of the Philippines in Brgy. San Isidro Sur, Luna, Apayao and Robbery in Brgy. Poblacion, Kabugao, Apayao.

Conclusion

The study concludes that strategic crime mapping using geospatial tools like QGIS is a valuable approach for enhancing public safety in Apayao through the optimized placement of CCTV systems. Over the three-year period (2021–2023), the analysis of index crimes revealed that crimes against persons—particularly rape, murder, and physical injuries—were consistently more prevalent than crimes against property. The highest incidence across all years was rape, making it the most pressing crime concern for the province. Meanwhile, theft was the most common property crime. These findings underscore the urgent need to prioritize preventive measures in both private and public spaces where such crimes are most likely to occur.

Furthermore, the calculated Crime Clearance Efficiency (CCE) and Crime Solution Efficiency (CSE) showed fluctuations across the three years, with a notable decline in CSE in 2022 and a partial rebound in 2023. These variations suggest the importance of not only improving surveillance infrastructure but also strengthening investigative capacities and community cooperation in crime-solving efforts.



By integrating Routine Activity Theory, Situational Crime Prevention Theory, and Social Control Theory, the study highlights that CCTV systems can deter criminal behavior, reinforce the visibility of law enforcement, and enhance the sense of safety within communities. Theories show that effective crime prevention relies on reducing opportunities, increasing risks for offenders, and fostering community engagement—all of which CCTV can support when strategically implemented.

The study's use of crime heat maps and municipal-level data revealed specific hotspots that should be prioritized for CCTV installation. These include areas with repeated offenses, particularly those identified as vulnerable zones by local police units. Moreover, the results of qualitative interviews with stakeholders emphasized the public's demand for greater security presence and confidence in crime deterrence through visible surveillance measures.

In light of these insights, the study recommends that local government units (LGUs) and line agencies adopt a data-driven, evidence-based approach to CCTV deployment. This includes continuous monitoring, public consultations, policy integration, and inter-agency coordination. Future efforts should also consider expanding CCTV coverage in underserved areas, integrating AI-driven surveillance technologies, and conducting regular assessments of system effectiveness.

Conclusively, crime mapping in Apayao is not just a technological or operational endeavor—it is a strategic and community-based initiative. By combining geospatial analysis with theoretical insights and local engagement, the province can build a more responsive, efficient, and preventive crime control system that ensures the safety and well-being of its residents.

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