BIBLIOGRAPHY

ALMERA L. CARIAS, JINKY ROSE J. JUSTO and LIZEL A. MAXIMINO, April 2009. Principal Component Analysis of Crime Occurrences at La Trinidad, Benguet. Benguet State University, La Trinidad, Benguet.

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ABSTRACT

Specifically the study aimed to: 1) identify the different types of crimes committed at the different barangays of La Trinidad, Benguet; 2) identify the barangay that has the most number of crimes; 3) the month and year that has the most number of crimes; and 4) the pattern of crime occurrences in La Trinidad, Benguet.

Across year, the most prevalent crimes that were committed are theft, robbery and physical injuries. Of the 7 crimes committed at La Trinidad Police District Station, 5 crimes namely: murder, homicide, acts of lasciviousness, robbery, and theft occurred with similar pattern from 2004 to 2008 and accounted 54% of the variation in the percent occurrences. The second group of crimes which accounted 29% variability are rape and physical injury.

Looking across month, three crime clusters was noted. The first group consisting of acts of lasciviousness and murder were prevalent from February to November. Rape and robbery, the second group of crimes were prevalent in the

month of May. The third group comprising theft, physical injury and homicide were prevalent from January to December.

Barangay-wise, homicide, physical injuries, robbery, illegal possession of fire arms, carnapping, women abuse and child abuse showed similar pattern of occurrences in Balili and Pico. Murder, rape, theft, illegal drugs, adultery and malicious mischief were also found to have similar pattern of occurrences in Pico and Betag.

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INTRODUCTION

<u>Background of the Study</u>

Crimes are divided into felonies and misdemeanors which vary in seriousness. A felony is a serious crime such as rape, homicide, or aggravated assault for which punishment typically ranges for more than a year's imprisonment to death. A misdemeanor is a minor crime that is typically punished by less than a year in jail. In either event, a fine maybe part of the sanction as well (Kendall, 2004).

Crimes are usually prevalent in areas inhabited by people with mixed culture and with different values orientation as in the Philippines. Generally speaking, crime occurrences are fewer in countries where there is a settled way of life and a traditional respect for law.

Crime occurrences due to some factors such as economic, peer influence, personality, culture and other factors are prevalent in urban and suburban areas where business establishments are located.

Rampant robbery, stealing, rape and other unlawful actions are usually prevalent in such areas where business and school transactions, and other social activities are performed.

Because of the harm it may inflict on the innocent people victimized by these criminal elements in the society, it is necessary that police authorities should

come up with a study to establish crime spots in all areas where business transactions and other social activities are being performed.

With this establishment of crime patterns in La Trinidad areas, it can be used by the government to come up with strategies that will prevent the occurrences of such crimes.

Hence, the authors of this study are willing to help the police authorities in establishing crime spots in La Trinidad area by Principal Component Analysis.

Statement of the Problem

The study sought to determine the most prevalent crimes committed by people, crime hot spots, and the period when a particular crime is being committed. Specifically, the study intended to answer the following questions:

1. What are the different types of crimes committed at the different barangays of La Trinidad, Benguet?
2. What barangay has the most number of crimes committed?
3. What month and year has the most number of crimes committed?
4. Where and when the crime hot spots occurred?

Objectives of the Study

With the application of the Principal Component Analysis (PCA), the study aimed to determine the areas and period of crime hot spots in La Trinidad, Benguet. Specifically, the study aimed to identify the following:

1. the different types of crimes committed at the different barangays of La Trinidad, Benguet;

2. the barangay that has the most number of crimes;

3. the month and year that has the most number of crimes; and

4. the pattern of crime occurrences in La Trinidad, Benguet.

Significance of the Study

Results of this study may give information to the society, local government and law enforcers about the crimes being committed in a particular place. It could also provide crime patterns so that the law enforcers and policy makers could have an idea on what actions to take to prevent and/or lessen the incidence of different crimes.

Scope and Delimitations

The data collection was from December 2008-February 2009. The data were gathered from the La Trinidad Police District Office. The data collected were crime statistics by year (2004-2008), by month (2004-2007) and by place or barangay (2005-2008).

REVIEW OF RELATED LITERATURE

Crime Occurrences

Seasonality of crime occurrences is valuable information to law enforcers for crime prevention. It is important to police officers in their decision-making not only for long reallocation of uniformed officers across precincts but also for short-term targeting of patrols for hotspots and serial criminals (Cohen, J. et al., 2003). As reported by Block (1984) and Wright (1996), property crimes peaked in the months of June to December while violent crimes peaked on summer months.

Crime occurrences is a known fact that they may occur everywhere in urban areas such as vandalism and destruction of public properties, robbery, stealing and many others because of varied cultures and races of people in the area. Hence, these are some issues that people should know for them to take precautions for their personal safety such as staying away from high crime areas, transferring to other neighborhood or avoiding walking alone at night if there is a perceived danger on their lives. (Hoel, L. A., 1999).

Because of the seriousness and frequency of crime occurrences, the US Federal Bureau of Investigation chose seven offenses to compromise a "Crime Index" and serve as indicators of the nation's crime experience. Crime Index includes homicide, rape, robbery aggravated assault, burglary, theft/larceny, grand theft auto and arson.

Crime statistics showed that in 2007, a small increase in in violent crime incidents from the previous year was noted although violent crimes were still down by 27% from 2005. In 2007, incidents of larceny/theft increased by 25%, while burglary dropped 9% and auto theft by 17%. In virtually every community nationwide, larceny/theft represents the highest percentage.

In the Philippines, crime occurrences had gone up significantly. Crime statistics reveal that the following crimes: theft, robbery and physical injuries were prevalent in urban places like Metro Manila, Baguio City and other cities in the country.

Is sub-urban areas like La Trinidad, Benguet, several crimes such as theft, robbery and physical injuries were likewise committed in different degrees.

Thus, the researchers of this study were challenged to propose a study that will determine the patterns of crime occurrences by year, season, and places in La Trinidad, Benguet.

In finding the patterns of the occurrences of the different crimes, a multivariate statistical technique known as Principal Component Analysis was proposed to be used.

Application of Principal Component Analysis

Principal Component Analysis (PCA) was employed in ecologic studies conducted by Horel,S.et.al., (2006) to determine a relationship between alcohol

outlet densities, illicit drug use and violence. The study examined this relationship using a sample of 439 census tracts. Neighborhood socio-cultural covariates, alcohol outlet density, drug crime density and violent crime data were collected for the year 2000. Four neighborhood explanatory variables were identified using PCA. The best fitted model was selected as one considering both unstructured and spatial dependence random effects. The results showed that drug law violation explained a greater amount of variance in violent crime rates than alcohol outlet densities. The analysis suggests that activity around illicit drug markets is more strongly associated with violent crime than is alcohol density.

Cohen, J. et.al, (2003) used Principal Component Analysis in their study of estimation of crime seasonality. It is a method of data reduction closely related to factor analysis, to characterize the ecological structure of each spatial unit or place. The dependent variables in their models of seasonality for each crime type are the monthly crime counts recognizing that the spatial units in their analysis vary not only in their seasonality but also in their relative overall levels of crimes, adding a dummy variable for each spatial unit. Furthermore, the spatial unit dummies are interacted with the time trend variables to allow each spatial unit to have a unique time trend.

The concept of crime place is essential to crime pattern theory because the characteristics of place influence the likelihood of a crime. According to Coomb et. al., (1994), some areas are more prone to criminal activity than others. Motivation

to perpetrate a crime tends to be person-specific, whereas opportunity tends to relate more specifically to the characteristics of place (Eck & Weisburd, 1995). The recognition of the concept of place in crime theory allows a new dimension to implementing crime prevention.

Chen, D. (2000) identified aspects of the natural and built environment that may be conducive to crime, and thereby will provide an independent determinant of the local crime rate. The data set used includes large number of independent variables listed under these headings of propensity and opportunity. And since each variables listed under the headings has a high likelihood of being correlated, the number of variables was reduced by means of Principal Component Analysis. Using a varimax rotation with 25 iterations, the number of variables under "propensity" was reduced to three components. The result revealed that crime locations are not spatially random and that place characteristics influence the decision to commit a crime. The study also showed that certain land use activities are prone to criminal activity, including commercial and residential areas.

THEORETICAL FRAMEWORK

Principal Component Analysis (PCA) is one of the simplest of the multivariate methods. The object of the analysis is to take p variables $X_1, X_2, \ldots, X_p$ and find the combinations of these to produce indices $Z_1, Z_2, \ldots, Z_p$ that are uncorrelated.

The principal component analysis was first described by Karl Pearson (1902). He apparently believed that this was the correct solution to some of the problems that were of interest to biometricians at that time, although he did not propose a practical method of calculation for more than two or three variables. He introduced the principal component approach to parsimony and studied the problem for the case of non-stochastic variables in a different context. The technique was generalized by Hotelling (1933) to the case of stochastic variables. Hotelling considered weighted sums of all the distinct random variable and attempted to find a set of weights that would maximize the variance of the sum. The new variable (weighted sum) is called the first principal component and oftentimes, its variance is such a further analysis which hinge on total variance. In the other problems, other weighted sums that are orthogonal to the first sum are also considered.

The object of the analysis is to take p variables $X_1, X_2, \ldots, X_p$ and find the combinations of these to produce indices $Z_1, Z_2, \ldots, Z_p$ that are uncorrelated. The

lack of correlation is a useful property because it means that the indices are measuring different 'dimensions' in the data.

There is always a hope that the variances of most of the indices will be as low as to be negligible. In that case, the variation in the data set can be adequately described by the Z variables with variances that are not negligible. Some degree of economy is then achieved and the variation in the p original x variables is accounted for by a smaller number of Z variables.

In general, the objectives of principal component analysis are (1) data reduction and (2) interpretation.

A PCA starts with data on p variables observed from n individuals, as shown in Table 1.

Table 1.   Data format for principal component analysis.

Individuals	X_1	X_2	.	.	.	X_p
1	X_{11}	X_{12}	.	.	.	.	X_{1p}
2	X_{12}	X_{22}	.	.	.	.	X_{2p}
.	.	.				.
.	.	.				.
.	.	.				.
n	X_{n1}	X_{n2}	.	.	.	.	X_{np}

The first principal component which is the linear combination of the variables $X_1, X_2, \ldots, X_p$, expressed as,

$$Z_1 = a_{11}X_1 + a_{12}X_2 + \ldots + a_{1p}X_p$$

usually accounts for the largest eigenvalue or maximum amount of variance of the sample covariance matrix on the condition that the sum of squares of the coefficient is equal to 1, that is

$$a^2_{11} + a^2_{12} + \ldots + a^2_{1p} = 1.$$

Thus the variance of Z_1, var (Z_1), is as large as possible given this constraint on the constants a_{1j}. The constraint is possible given this is not done then the var (Z_1) can be increased by simply increasing any one of the a_{1j} values. The second principal component,

$$Z_2 = a_{21}X_1 + a_{22}X_2 + \ldots + a_{2p}X_p,$$

is such that var(Z_2) is as large as possible subject to the constraint that

$$a^2_{21} + a^2_{22} + \ldots + a^2_{2p} = 1,$$

and also to the condition that Z_1 and Z_2 are uncorrelated. The third principal component,

$$Z_3 = a_{31}X_1 + a_{32}X_2 + \ldots + a_{3p}X_p,$$

is such that var(Z_3) is as large as possible subject to the constraint that

$$a^2_{31} + a^2_{32} + \ldots + a^2_{3p} = 1,$$

and also to the condition that Z_3 is uncorrelated with Z_2 and Z_1. Further principal components are defined by repeating the same process. If there are p variables then there can be up to p principal components.

Principal component analysis just involves finding the eigenvalues of the sample covariance matrix. The matrix is symmetric and has the form

$$C = \begin{bmatrix} c_{11} & c_{12} & \ldots & c_{1p} \\ c_{21} & c_{22} & \ldots & c_{2p} \\ . & . & & . \\ . & . & & . \\ . & . & & . \\ c_{p1} & c_{p2} & \ldots & c_{pp} \end{bmatrix}$$

Where the diagonal element c_{ii} is the variance of X_i and c_{ij} is the covariance of variables X_i and X_j.

The variances of the principal components are the eigenvalues of the matrix C. There are p of these, some of which may be zero. Negative eigenvalues are not possible for a covariance matrix. Assuming that the eigenvalues are ordered as

$$\lambda_1 \geq \lambda_2 \geq \ldots \geq \lambda_p \geq 0,$$

then λ_1 corresponds to the ith principal component.

$$Z_i = a_{i1}X_1 + a_{i2}X_2 + \ldots + a_{ip}X_p$$

In particular, var $(Z_i) = \lambda i$ and the constants a_{i1}, a_{i2}, ..., a_{ip} are the elements of the corresponding eigenvector, scaled so that $a^2_{i1} + a^2_{i2} + ... + a^2_{ip} = 1$.

An important property of the eigenvalues is that they add up to the sum of the diagonal elements (the trace) of C. That is

$$\lambda_1 + \lambda_2 + ... + \lambda_p = c_{11} + c_{22} + ... + c_{pp}.$$

If c_{ii} is the variance of X_i and λ_i is the variance of Z_i, this means that the sum of the variances of the principal components is equal to the sum of the variances of the original variables. Therefore, the principal components account for all of the variation in the original data.

The matrix C then takes the form

$$C = \begin{bmatrix} 1 & c_{12} & ... & c_{1p} \\ c_{21} & 1 & ... & c_{2p} \\ . & . & & . \\ . & . & & . \\ . & . & & . \\ c_{p1} & c_{p2} & ... & 1 \end{bmatrix}$$

where $c_{ij} = c_{ji}$ is the correlation between X_i and X_j. In other words, the principal component analysis is carried out on the correlation matrix. In that case,

the sum of the diagonal terms, which is the sum of the eigenvalues, is equal to p, the number of variables.

The steps in Principal Component Analysis

1) Start by coding the variables $X_1, X_2, \ldots, X_p$ to have zero means and unit variances. This is usual, but is omitted in some cases.

2) Calculate the covariance matrix C. this is a correlation matrix if step 1 has been done.

3) Find the eigenvalues $\lambda_1, \lambda_2, \ldots, \lambda_p$ and the corresponding eigenvectors $\partial_1, \partial_2, \ldots, \partial_p$. The coefficients of the ith principal component are then given by ∂_i while λ_i is its variance.

4) Discard any components that only accounts for a small proportion of the variation in the data.

Hence, we shall also consider some patterned matrices and their principal components. The component structure of a covariance or correlation matrix can sometimes be approximated rather well by inspection of the elements and knowledge of the characteristics roots and vectors of certain patterned matrices. We shall now give the components of two such special matrices and a general upper bound on the greatest characteristic root of any square matrix.

Definition of Terms

Crime**.** An act that are legally forbidden by a society.

Correlation**.** The extent to which two or more things are related ("correlated") to one another.

Covariance**.** A measure of joint or (co-) variance of two or more variables.

Eigenvalues**.** A statistic used if factor analysis, canonical correlation analysis and principal components analysis to indicate how much of the variation in the original group of variables is accounted for by a particular factor.

Homicide. A person was killed and the accused had the intention to kill, which is presumed.

Index Crimes/Felony. A serious crime for which punishment typically ranges for more than a year's imprisonment to death.

Murder. A person was killed and the killing was attended with treachery, taking advantage of superior strength, with the aid of armed men, or employing means to weaken the defense or of means or persons to ensure or afford impunity.

Non-Index Crimes/Misdemeanor. A minor crime that is typically punished by less than a year in jail.

Orthogonal**.** Intersecting or lying at right angles. Uncorrelated variables are said to be orthogonal because, when plotted on a graph, they form right angles to one of the axes (if there is no variance in one of the variables).

Principal Component Analysis**.** Methods for undertaking a linear transformation of a large set correlated variables into a smaller group of uncorrelated variables. This makes analysis easier by grouping data into more manageable units and eliminating problems of multicollinearity.

Robbery. Unlawful taking of personal property with intent to gain by means of violence against or intimidation of any person or force upon things.

Theft**.** Unlawful taking of personal property with intent to gain without the consent of the owner without the use of violence against or intimidation of person or force upon things.

Variance**.** A measure of the spread of scores in a distribution of scores, that is, a measure of dispersion. The larger the variance, the further the individual scores from the mean. The smaller the variance, the closer the individual scores to the mean.

METHODOLOGY

Data Source

Available data on crime occurrences by year, month and places were obtained from the police records of La Trinidad Police District Office. Different crimes committed by people and reported at the police station were included in this study.

Data Analysis

The raw data gathered were utilized and was reduced to three tables, crime occurrences by year, by month and by barangay. The data were transformed into percentage to obtain uniformity. To determine the pattern of crimes, Principal Component Analysis (PCA) was applied using the SPSS program.

Scatter plots of the different derived principal components by year, by month and areas were produced to show the trend of the occurrences of the different crimes.

RESULTS AND DISCUSSION

Mean Number of Crime Occurrences
from 2004-2008

      Table 2 shows the mean number of occurrences of the different crimes from 2004 to 2008 which ranged from about 2% to 33%. Theft was observed to have the most number of occurrences (33%) followed by physical injuries and robbery which have the same mean number of occurrences (28%). The least committed crime from 2004 to 2008 is acts of lasciviousness having 2% mean number of occurrence.

Table 2.   Prevalence of Crimes committed by individuals from 2004 to 2008 in La Trinidad, Benguet

	Mean	Standard Error	95% Confidence Interval	
Murder	2.80	0.66	0.96	4.64
Homicide	10.60	1.21	7.25	13.95
Rape	8.00	2.07	2.24	13.76
L.A.	2.20	1.02	-0.63	5.03
Physical Injuries	27.80	4.13	16.34	39.26
Robbery	27.80	3.02	19.41	36.19
Theft	33.40	5.71	17.53	49.27

An examination of the pattern of occurrences of the different crimes from 2004 to 2008 reveals that the occurrences of murder and homicide and the occurrences of robbery and theft were found significantly correlated. These results suggest that murder and homicide had occurred in similar frequencies. Likewise robbery and theft occurrences are in the same percentage. Since the occurrences of the different crimes by year showed such pattern, then the application of principal component to combine the crimes with similar occurrences is justified.

Table 3.   Correlations among the different crime occurrences in La Trinidad, Benguet from 2004 to 2008

Crimes	Homicide	Rape	Lascivious Acts	Physical injuries	Robbery	Theft
Murder	0.973**	-0.109 [ns]	-0.503 [ns]	-0.223 [ns]	-0.628 [ns]	-0.629 [ns]
Homicide		-0.080 [ns]	-0.390 [ns]	-0.215 [ns]	-0.457 [ns]	-0.458 [ns]
Rape			-0.497 [ns]	0.826 [ns]	0.375 [ns]	0.375 [ns]
Lascivious Acts				-0.117 [ns]	0.603 [ns]	0.603 [ns]
Physical Injuries					0.512 [ns]	0.512 [ns]
Robbery						1.000**

ns- not significant, $p > .05$
**- highly significant, $p < .01$

<u>Component loadings for the PCA Performed</u>
<u>on the Occurrences of Crimes in La Trinidad,</u>
<u>Benguet from 2004-2008</u>

The Principal Component Analysis Performed on the data on the different crimes committed in La Trinidad, Benguet from 2004 to 2008 yielded two principal component models. The first principal component (PC1) accounted for about 54% of the variations in the percent occurrences of the different crimes. The addition of the second principal component yielded a model that covers about 83% of the variations in the percent occurrences of the different crimes. The derived principal component models are given as follows:

$$PC1 = \mathbf{-0.89(X_1)} - \mathbf{0.78(X_2)} - 0.02(X_3) + \mathbf{0.80(X_4)} + 0.23(X_5) + \mathbf{0.84(X_6)} + \mathbf{0.84(X_7)}$$

$$PC2 = -0.07(X_1) - 0.05(X_2) + \mathbf{0.98(X_3)} - 0.428(X_4) + \mathbf{0.89(X_5)} + 0.40(X_6) + 0.40(X_7)$$

where:
X_1- Murder; X_2- Homicide; X_3- Rape; X_4- Lascivious Acts;

X_5- Physical Injuries; X_6- Robbery; X_7- Theft

As shown in Table 4, the crimes that load heavily on the first principal component are murder, homicide, acts of lasciviousness, robbery and theft. It is further observed that the crimes that load highly on the first principal component had a bipolar direction. Murder and homicide percent occurrences behave in a negative direction while the occurrences of the acts of lasciviousness, robbery and theft are in positive direction. This means that as murder and homicide occurrences

increase, there are corresponding decrease in the occurrences of acts of lasciviousness, robbery and theft.

The crimes that load in the second principal component are rape and physical injuries with similar direction.

Table 4. Principal Component Loadings (unrotated, rotated) of the different crimes committed by individuals from 2004-2008

| CRIMES | UNROTATED | | ROTATED | |
| | COMPONENT | | | |
	PC1	PC2	PC1	PC2
Murder (X1)	-0.847	0.276	**-0.888**	-0.072
Homicide (X2)	-0.741	0.261	**-0.784**	-0.045
Rape (X3)	0.365	0.912	-0.015	**0.982**
L.A. (X4)	0.576	-0.705	**0.803**	-0.428
Physical Injuries (X5)	0.552	0.737	0.226	**0.893**
Robbery (X6)	0.929	0.05	**0.838**	0.404
Theft (X7)	0.929	0.05	**0.838**	0.404

L.A.- Acts of Lasciviousness

Graphically, Figure 1 shows the resulting two-dimensional map of similarity measures. As shown in the figure, three clusters were formed which fall in the 2nd, 3rd and 4th quadrant of the two-dimensional map. In year 2004-2005, robbery and theft are prevalent. In year 2006 and 2008, murder and homicide are prevalent. Rape and physical injuries were prevalent in year 2007.
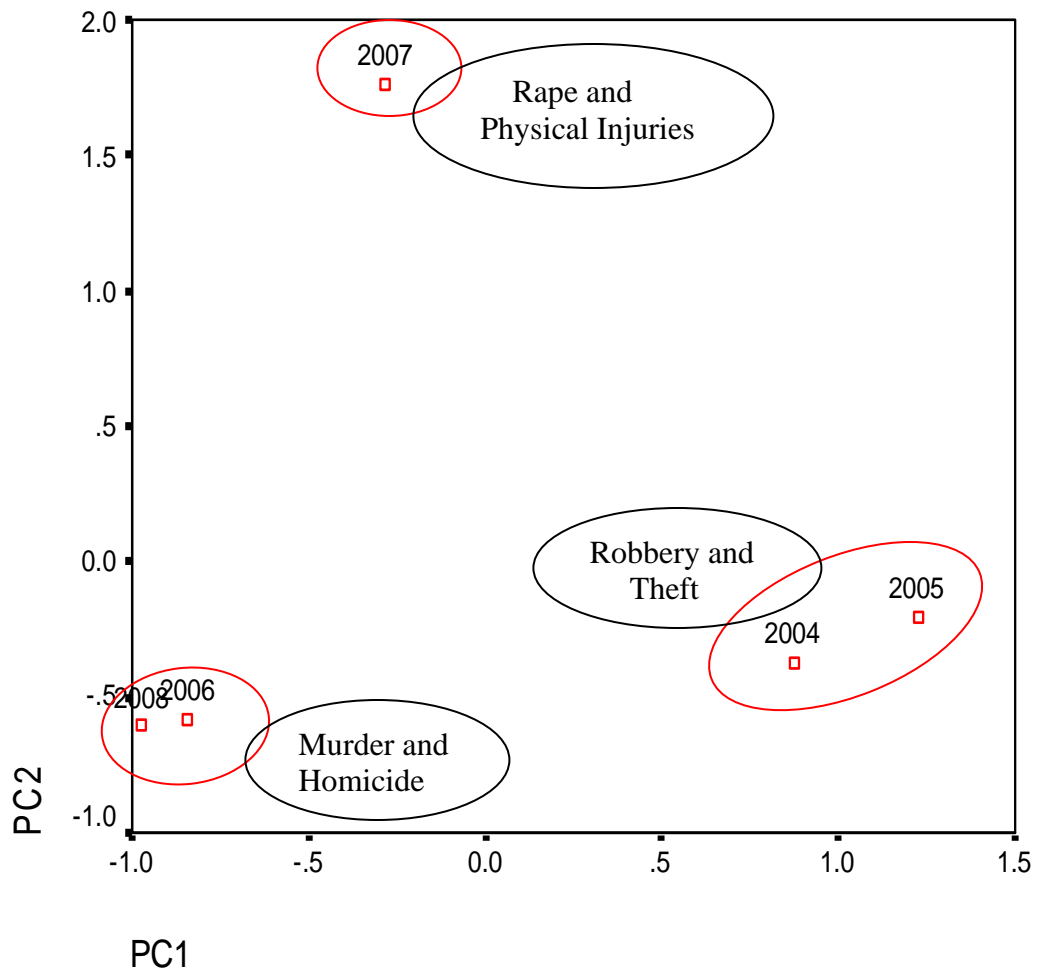
Figure 1. A scatter plot of the new PC2 versus PC1

<u>Mean Number of Crime Occurrences from</u>
<u>January to December (2004-2007)</u>

Table 5 shows that the mean number of occurrences of the different crimes

from January to December ranged from 0.75% to 11%. Theft was observed to have

the most number of occurrences (11%) followed by physical injuries and robbery.

The least committed crimes were murder and acts of lasciviousness.

Table 5. Prevalence of crimes committed by individual from January to
December (2004-2007)

Crimes	Mean	Standard Error	95% Confidence interval	
Murder	0.75	0.25	0.20	1.30
Homicide	3.17	0.53	1.99	4.34
Rape	2.92	0.43	1.96	3.87
L.A.	0.75	0.28	0.14	1.36
Physical Injuries	9.97	1.23	7.21	12.62
Robbery	9.58	0.99	7.41	11.76
Theft	11.00	1.39	7.95	14.05

*L.A. – Acts of Lasciviousness

Component Loadings for the PCA Performed
on the Occurrences of Crimes in La Trinidad,
Benguet, Monthly from 2004-2007

Performing Principal Component Analysis performed on the monthly data of the different crimes committed in La Trinidad Benguet, accumulated from 2004-2007, the analysis yielded three principal component models as shown in Table 6. The first principal component (PC1) accounted for about 29% of the variations in the percent occurrences of the different crimes. The addition of the second principal component (PC2) yielded a model that covers about 54% of the variations in the percent occurrences of the different crimes. And the addition of the third principal component (PC3) produced a model that covers about 70% of the variations in the occurrences of the different crimes.

The models are given as follows:

$$PC_1 = -\textbf{0.68(X_1)} + 0.58(X_2) - 0.001(X_3) + \textbf{0.93(X_4)} + 0.42(X_5) + 0.25(X_6) + 0.05(X_7)$$

$$PC2 = -0.12(X_1) - 0.26(X_2) + \textbf{0.87(X_3)} + 0.10(X_4) - 0.42(X_5) + \textbf{0.72(X_6)} - 0.16(X_7)$$

$$PC3 = -0.16(X_1) - \textbf{0.68(X_2)} + 0.04(X_3) - 0.14(X_4) + \textbf{0.54(X_5)} - 0.26(X6) + \textbf{0.75(X_7)}$$

where: X_1- Murder; X_2- Homicide; X_3- Rape; X_4- Lascivious Acts;

X_5- Physical Injuries; X_6- Robbery; X_7- Theft

Table 6. Principal Component Loadings (unrotated, rotated) of the different crimes committed by individual from January to December (2004-2007)

	UNROTATED			ROTATED		
	COMPONENT					
CRIMES	PC1	PC2	PC3	PC1	PC2	PC3
Murder (X1)	-0.509	-0.356	-0.337	**-0.678**	-0.119	-0.158
Homicide(X2)	0.696	0.250	-0.568	0.576	-0.262	**-0.684**
Rape (X3)	0.295	-0.623	0.538	-1.08E-3	**0.873**	3.925E-2
L.A. (X4)	0.845	0.392	0.147	**0.927**	0.104	-0.139
P.I. (X5)	-7.51E-2	0.755	0.268	0.422	-0.422	**0.540**
Robbery (X6)	0.581	-0.486	0.260	0.246	**0.715**	-0.264
Theft (X7)	-0.374	0.438	0.509	5.487E-2	-0.158	**0.750**

*L.A. - Acts of Lasciviousness
*P.I.- Physical Injuries

The crimes that highly load in the first component are murder and acts of lasciviousness in a bipolar direction. As shown in Figure 2, acts of lasciviousness was prevalent in November while murder was prevalent in the months of February, March, June, July and September.

Rape and robbery highly load in the second principal component and it was observed that the two crimes were prevalent in the month of May (Figure 2).
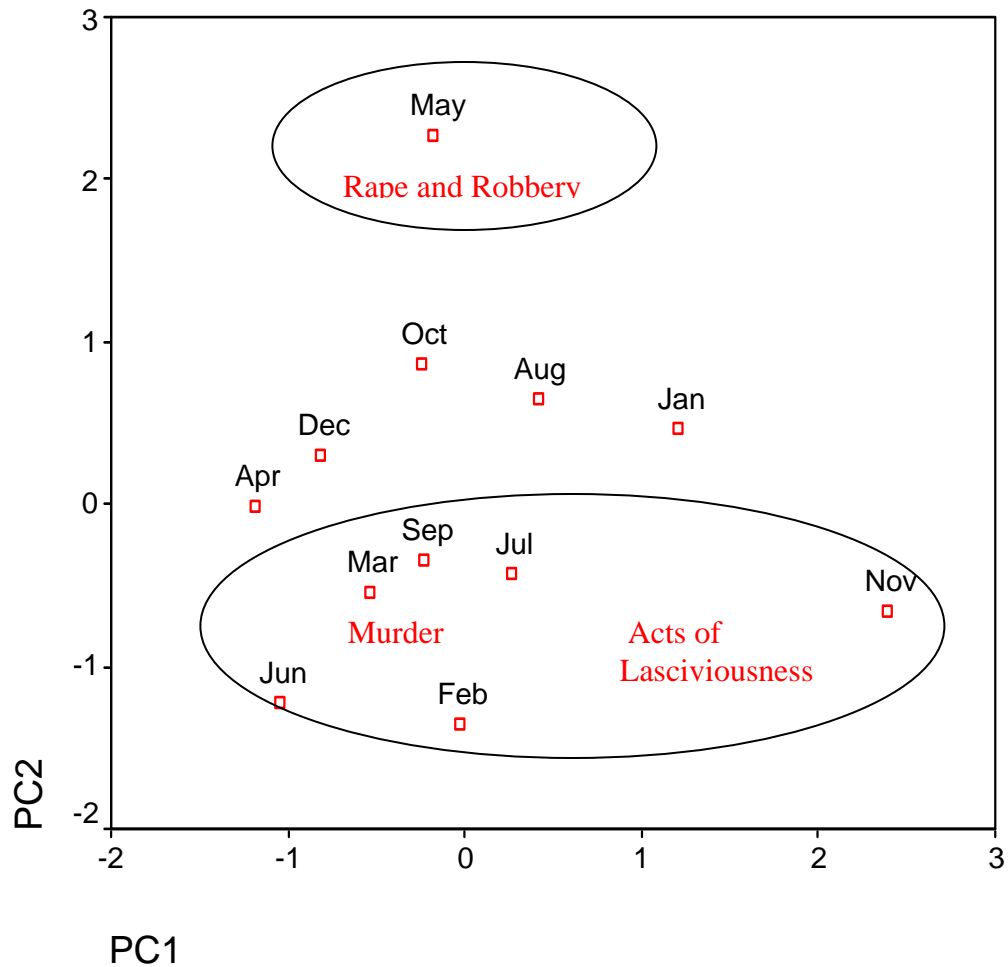
Figure 2.   A scatter plot of PC2 versus PC1

Theft, physical injuries and homicide are the crimes that highly load in the third component in an opposite direction. Theft and physical injuries had high occurrences in the first and last quarter of the year, respectively while homicide was prevalent in the second quarter of the year (Figure 3).
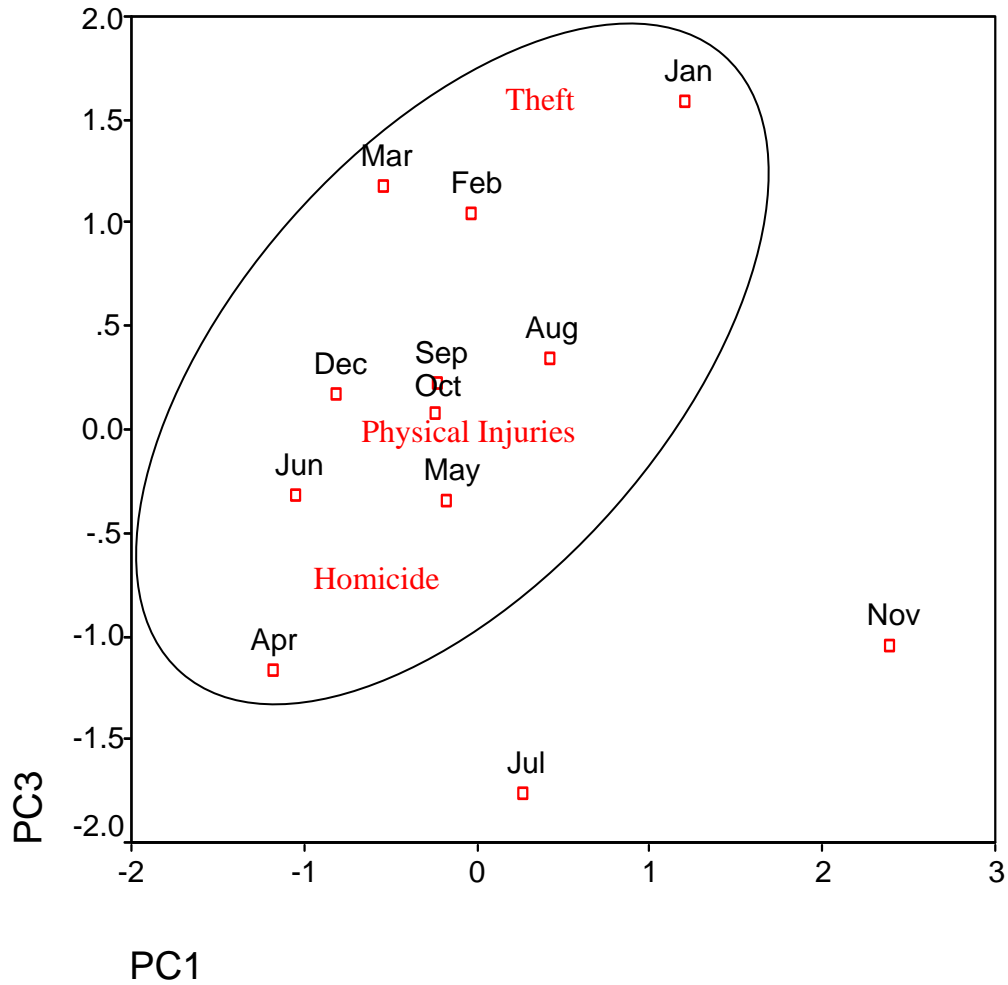
Figure 3.   Scatter plot of PC3 versus PC1

Mean Number of Crime Occurrences in the
Different Barangays of La Trinidad (2005-2008)

The mean number of occurrences of the different crimes over the 16

barangays of La Trinidad, Benguet ranged from 0.25% to 6.81% (Table 7). The

most committed crime with 6.81% of occurrence was theft followed by robbery then homicide. Malicious mischief was least committed.

Table 7.   The Prevalence of the different crimes averaged over the 16 barangays of La Trinidad, Benguet

	Mean	Standard Err.	95% Confidence Interval	
Homicide	4.81	1.43	1.77	7.86
Murder	1.50	0.41	0.63	2.37
Physical Injuries	3.19	1.03	1.00	5.37
Rape	1.56	0.39	0.74	2.39
Robbery	6.00	1.79	2.18	9.82
Theft	6.81	2.77	0.90	12.72
I.P.F.A.	1.00	0.39	0.17	1.83
Carnapping	0.38	0.20	-0.05	0.80
Illegal Drugs	0.19	0.14	-0.10	0.48
V.M.O.	1.63	1.14	-0.81	4.06
Women Abuse	1.88	0.56	0.68	3.07
Child Abuse	0.88	0.42	-0.01	1.76
Adultery	0.44	0.26	-0.11	0.99
Malicious Mischief	0.25	0.11	0.01	0.49

*IPFA- Illegal Possession of Fire Arms
*VMO- Violation of Municipal Ordinance

<u>Component Loadings for the PCA Performed</u>
<u>on the Occurrences of Crimes in the Different</u>
<u>Barangays of La Trinidad, Benguet (2005-2008)</u>

Performing a Principal Component Analysis on the data on the different crimes committed in the different barangays of La Trinidad, Benguet (2005-2008), two principal component models were extracted as shown in Table 8.

Table 8.   Principal Component Loadings (unrotated, rotated) of the different crimes committed in the different barangays of La Trinidad, Benguet (2005-2008)

| CRIMES | UNROTATED | | ROTATED | |
| | COMPONENT | | | |
	PC1	PC2	PC1	PC2
Homicide (X1)	0.97	-0.13	**0.83**	0.53
Murder (X2)	0.82	0.21	0.49	**0.68**
Physical Injuries (X3)	0.83	-0.01	**0.64**	0.53
Rape (X4)	0.79	0.40	0.35	**0.81**
Robbery (X5)	0.94	-0.09	**0.78**	0.54
Theft (X6)	0.88	0.25	0.51	**0.76**
I.P.F.A. (X7)	0.83	-0.44	**0.92**	0.20
Carnapping (X8)	0.65	-0.63	**0.90**	-0.07
Illegal Drugs (X9)	0.50	0.71	-0.08	**0.86**
V.M.O. (X10)	0.95	-0.13	**0.80**	0.51
Women Abuse (X11)	0.95	-0.10	**0.79**	0.53
Child Abuse (X12)	0.91	-0.32	**0.90**	0.34
Adultery (X13)	0.78	0.46	0.30	**0.86**
Malicious Mischief (X14)	0.78	0.11	0.53	**0.58**

*IPFA- Illegal Possession of Fire Arms
*VMO- Violation of Municipal Ordinance

The first Principal Component (PC1) accounted for about 70% of the variations in the percent occurrences of the different crimes. The addition of the second Principal Component (PC2) produced a model that covers about 82% of the variations in the percent occurrences of the different crimes. The extracted models are shown below:

$$PC1 = \mathbf{0.83(X_1)} + 0.49(X_2) + \mathbf{0.64(X_3)} + 0.35(X_4) + \mathbf{0.78(X_5)} + 0.51(X_6)$$
$$+ \mathbf{0.92(X_7)} + \mathbf{0.90(X_8)} - 0.08(X_9) + \mathbf{0.80(X_{10})} + \mathbf{0.79(X_{11})}$$
$$+ \mathbf{0.90(X_{12})} + 0.30(X_{13}) + 0.53(X_{14})$$

$$PC2 = 0.53(X_1) + \mathbf{0.68(X_2)} + 0.53(X_3) + \mathbf{0.81(X_4)} + 0.54(X_5) + \mathbf{0.76(X_6)}$$
$$+ 0.20(X_7) - 0.07(X_8) + \mathbf{0.86(X_9)} + 0.51(X_{10}) + 0.53(X_{11}) + 0.34(X_{12})$$
$$+ \mathbf{0.86(X_{13})} + \mathbf{0.58(X_{14})}$$

where: X_1- Homicide; X_2- Murder; X_3- Physical Injuries; X_4- Rape; X_5- Robbery; X_6- Theft; X_7- Illegal Possession of Fire Arms; X_8- Carnapping; X_9- Illegal Drugs; X_{10}- Violation of Municipal Ordinance; X_{11}- Women Abuse; X_{12}- Child Abuse; X_{13}- Adultery; X_{14}- Malicious Mischief

The crimes that load highly on the first principal component are homicide, physical injuries, robbery, illegal possession of fire arms, carnapping, women abuse and child abuse. The aforementioned crimes were committed with high frequency of occurrence in Pico and Balili.

In the second principal component, the crimes that load highly are murder, rape, theft, illegal drugs, adultery and maliscious mischief. The occurrences of the

crimes were prevalent in Pico and Betag. Other reported crimes were found to have

been less frequently committed in other barangays (Figure 4).
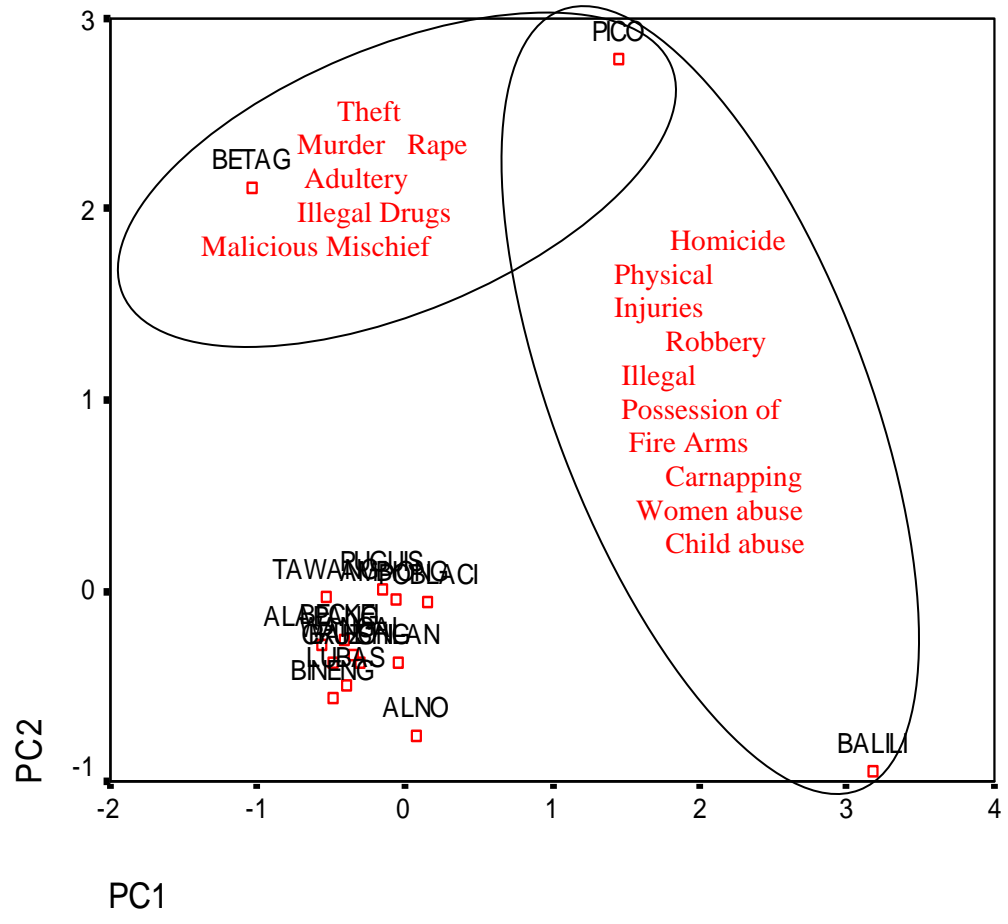
Figure 4.   Scatter plot of the PC2 versus PC1

SUMMARY, CONCLUSION AND RECCOMMENDATION

Summary

Across year, the most prevalent crimes that were committed are theft, robbery and physical injuries. Of the 7 crimes committed at La Trinidad Police District Station, 5 crimes namely: murder, homicide, acts of lasciviousness, robbery, and theft occurred with similar pattern from 2004 to 2008 and accounted 54% of the variation in the percent occurrences. The second group of crimes which accounted 29% variability are rape and physical injury.

Looking across month, three crime clusters was noted. The first group consisiting of acts of lasciviousness and murder were prevalent from February to November. Rape and robbery, the second group of crimes were prevalent in the month of May. The third group comprising theft, physical injury and homicide were prevalent from January to December.

Barangay-wise, homicide, physical injuries, robbery, illegal possession of fire arms, carnapping, women abuse and child abuse showed similar pattern of occurrences in Balili and Pico. Murder, rape, theft, illegal drugs, adultery and malicious mischief were also found to have similar pattern of occurrences in Pico and Betag.

Conclusion

Based on the findings of this study, it is concluded that crime occurrences in La Trinidad, Benguet demonstrate a pattern across year, month and place.

Across the year from 2004 to 2008, crime occurrences were prevalent in 2007.

Across the month, November had the most percentage of occurrences.

Pico, Balili and Betag are the 3 barangays with the most number of crime occurrences.

Recommendation

The researchers recommend that there should be closer partnership between local governments, civil society, local police and business groups. All sectors must cooperate in order to prevent crime occurrences.

It is also recommended that security should be tightened maybe by [putting up additional police outposts. Both local government and the police should strictly impose laws. The barangay "tanods" should perform thei8r tasks.

To the civil society, they must be alert, precautious and must be responsible enough.

And, using similar technique, a similar study may be conducted using more variables and wider scope.

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APPENDIX A

Request Letter to the Chief of Police

Benguet State University
College of Arts and Sciences
Math-Physics-Statistics Department
La Trinidad, Benguet

December 12, 2008

PCINSP MARIO L. MAYAMES JR
Chief of Police
La Trinidad Municipal Police Station
La Trinidad, Benguet

SIR:

We, the undersigned fourth year students taking up Bachelor of Science in Applied Statistics at Benguet State University, are conducting a research entitled "Principal Component Analysis of Crime Occurrences at la Trinidad, Benguet".

In view hereof, we would like to request permission from your good office to gather crime statistics by year, by month and by barangay for the past five years.

Thank you very much for your favorable consideration.

Respectfully yours,

(SGD) ALMERA L. CARIAS

(SGD) JINKY ROSE J. JUSTO

(SGD) LIZEL A. MAXIMINO
Researchers

Noted:

(SGD) DR. SALVACION Z. BELIGAN   (SGD) DR. MA. AZUCENA B. LUBRICA
        Thesis Adviser   Chairman, MPS Department

Approved:

(SGD) PROF. AUREA MARIE M. SANDOVAL
            CAS Dean

APPENDIX B

Crime Statistics by Year (2004-2008)

YEAR	MURDER No.	%	HOMICIDE No.	%	RAPE No.	%	LA No.	%	P.I. No.	%	ROBBERY No.	%	THEFT No.	%
	INDEX CRIMES													
	AGAINST PERSON										AGAINST PROPERTY			
2004	2	14.29	9	16.98	5	12.50	5	45.45	32	23.02	31	22.3	54	32.34
2005	1	7.14	8	15.09	8	20.00	4	36.36	24	17.27	35	25.18	31	18.56
2006	3	21.43	10	18.87	6	15.00	-	-	21	15.11	18	12.95	20	11.98
2007	3	21.43	11	20.75	16	40.00	-	-	42	30.22	31	22.3	27	16.17
2008	5	35.71	15	28.3	5	12.50	2	18.18	20	14.39	24	17.27	35	20.96
TOTAL	14	100.00	53	100.00	40	100.00	11	100.00	139	100.00	139	100.00	167	100.00

APPENDIX C

Total Variance of Crimes Committed by Individuals from 2004-2008

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loading		
	Total	%of Variance	Cumulative %	Total	%of Variance	Cumulative %	Total	%of Variance	Cumulative %
1	3.763	53.756	53.756	3.763	53.756	53.756	3.504	50.062	50.062
2	2.020	28.857	82.612	2.020	28.857	82.612	2.279	32.55	82.612
3	0.965	13.784	96.396						
4	0.252	3.604	100.000						
5	2.32E-16	3.31E-15	100.000						
6	-1.52E-16	-2.17E-15	100.000						
7	-4.88E-16	-6.97E-15	100.000						

APPENDIX D

Crime Statistics by Month

MONTH	INDEX CRIMES													
	AGAINST PERSON										AGAINST PROPERTY			
	MURDER		HOMICIDE		RAPE		LA		P.I.		ROBBERY		THEFT	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Jan	-	-	2	5.26	4	11.43	2	22.22	15	12.61	9	7.83	16	12.12
Feb	-	-	2	5.26	1	2.86	-	-	15	12.61	5	4.35	13	9.85
Mar	1	11.11	1	2.63	1	2.86	-	-	12	10.08	10	8.70	17	12.88
Apr	2	22.22	3	7.89	3	8.57	-	-	8	6.72	10	8.70	4	3.03
May	1	11.11	2	5.26	5	14.29	1	11.11	5	4.20	18	15.65	9	6.82
Jun	2	22.22	4	10.53	1	2.86	-	-	6	5.04	7	6.09	17	12.88
Jul	-	-	5	13.16	2	5.71	1	11.11	6	5.04	9	7.83	2	1.52
Aug	-	-	3	7.89	4	11.43	1	11.11	9	7.56	10	8.70	12	9.09
Sep	2	22.22	2	5.26	3	8.57	1	11.11	17	14.29	9	7.83	7	5.30
Oct	-	-	3	7.89	4	11.43	-	-	6	5.04	11	9.57	12	9.09
Nov	-	-	8	21.05	2	5.71	3	33.33	13	10.92	12	10.43	11	8.33
Dec	1	11.11	3	7.89	5	14.29	-	-	7	5.88	5	4.35	12	9.09
TOTAL	9	100.00	38	100.00	35	100.00	9	100.00	119	100.00	115	100.00	132	100.00

APPENDIX E

Total Variance of Crimes Committed Monthly from 2004-2007

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotated Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.027	28.963	28.963	2.027	28.963	28.963	1.893	27.044	27.044
2	1.728	24.685	53.648	1.728	24.685	53.648	1.57	22.431	49.475
3	1.146	16.371	70.018	1.146	16.371	70.018	1.438	20.543	70.018
4	0.891	12.734	82.753						
5	0.689	9.842	92.595						
6	0.468	6.692	99.287						
7	0.05	0.713	100						

APPENDIX F

Crime Statistics by Barangay

BARANGAY	Homicide		Murder		Physical Injuries		Rape		Robbery		Theft		Illegal Possession of Fire Arms	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
ALAPANG	1	1.30	-	-	-	-	2	8.00	4	4.17	-	-	-	-
ALNO	2	2.60	2	8.33	1	1.96	-	-	1	1.04	-	-	1	6.25
AMBIONG	2	2.60	1	4.17	2	3.92	1	4.00	4	4.17	1	0.92	2	12.50
BAHONG	2	2.60	1	4.17	-	-	1	4.00	1	1.04	3	2.75	1	6.25
BALILI	17	22.08	3	12.50	8	15.69	2	8.00	23	23.96	11	10.09	5	31.25
BECKEL	3	3.90	3	12.50	1	1.96	-	-	1	1.04	2	1.83	-	-
BETAG	6	7.79	3	12.50	4	7.84	3	12.00	13	13.54	9	8.26	-	-
BINENG	2	2.60	-	-	-	-	-	-	1	1.04	1	0.92	-	-
CRUZ	-	-	-	-	1	1.96	1	4.00	3	3.13	2	1.83	-	-
LUBAS	1	1.30	-	-	-	-	1	4.00	2	2.08	2	1.83	1	6.25
PICO	20	25.97	6	25.00	13	25.49	6	24.00	22	22.92	45	41.28	4	25.00
POBLACION	8	10.39	-	-	10	19.61	2	8.00	7	7.29	16	14.68	2	12.50
PUGUIS	4	5.19	1	4.17	3	5.88	3	12.00	2	2.08	7	6.42	-	-
SHILAN	3	3.90	1	4.17	7	13.73	-	-	7	7.29	3	2.75	-	-
TAWANG	4	5.19	2	8.33	1	1.96	2	8.00	2	2.08	4	3.67	-	-
WANGAL	2	2.60	1	4.17	-	-	1	4.00	3	3.13	3	2.75	-	-
TOTAL	77	100.00	24	100.00	51	100.00	25	100.00	96	100.00	109	100.00	16	100.00

APPENDIX F Continued…

BARANGAY	Carnapping		Illegal Drugs		Viol. Of Municipal Ordinance		Women Abuse		Child Abuse		Adultery		Malicious Mischief		TOTAL
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	
ALAPANG	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7
ALNO	1	16.67	-	-	-	-	1	3.33	-	-	-	-	-	-	9
AMBIONG	-	-	-	-	-	-	1	3.33	1	7.14	1	14.29	1	25.00	17
BAHONG	-	-	-	-	-	-	2	6.67	-	-	-	-	-	-	11
BALILI	3	50.00	-	-	10	38.46	7	23.33	5	35.71	-	-	1	25.00	95
BECKEL	-	-	-	-	-	-	1	3.33	-	-	-	-	-	-	11
BETAG	-	-	2	66.67	-	-	4	13.33	-	-	1	14.29	1	25.00	46
BINENG	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
CRUZ	-	-	-	-	-	-	1	3.33	-	-	-	-	-	-	8
LUBAS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7
PICO	1	16.67	1	33.33	16	61.54	7	23.33	5	35.71	4	57.14	1	25.00	151
POBLACION	-	-	-	-	-	-	2	6.67	-	-	-	-	-	-	47
PUGUIS	1	16.67	-	-	-	-	1	3.33	1	7.14	1	14.29	-	-	24
SHILAN	-	-	-	-	-	-	2	6.67	1	7.14	-	14.29	-	-	24
TAWANG	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15
WANGAL	-	-	-	-	-	-	1	3.33	1	7.14	-	-	-	-	12
TOTAL	6	100.00	3	100.00	26	100.00	30	100.00	14	100.00	7	100.00	4	100.00	**488**

APPENDIX G

Total Variance of Crimes Committed by Individuals in the Different Barangays of La Trinidad,
Benguet (2005-2008)

Component	Initial Eigenvalues			Extracted Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	9.76	69.69	69.69	9.76	69.69	69.69	6.43	45.90	45.90
2	1.74	12.42	82.11	1.74	12.42	82.11	5.07	36.22	82.11
3	0.88	6.30	88.41						
4	0.51	3.65	92.06						
5	0.38	2.73	94.79						
6	0.31	2.22	97.01						
7	0.14	1.00	98.01						
8	0.13	0.93	98.94						
9	0.08	0.56	99.50						
10	0.04	0.28	99.78						
11	0.02	0.13	99.91						
12	0.08	0.06	99.97						
13	0.03	0.02	99.99						
14	0.04	2.54E-03	100.00						