



AN INVESTIGATION OF CRIMES RATES USING CO-KRIGING AND INVERSE DISTANCE WEIGHTS IN KATSINA STATE, NIGERIA.

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ABSTRACT

The aim of the study is to investigate and predict the spatial variability of crimes rates using Co-kriging and inverse Distance Weight (IDW) in ten (10) Selected Local Government in Katsina State. The reported crimes to the Katsina State Police Command Consists of grievous hurt and Wound, Cattle rustling, Rape, Kidnapping, Assaults, Stealing and Burglary. The data is collected from Criminal Investigations Department Unit in Katsina State Command from 2010 to 2019. The method applied for this study was Co- Kriging Model (CK) and Inverse Distance Weight (IDW) to test the fitted Variogram Model and Spatial dependencies of variables examined. The findings predicted that, from the study areas the crimes rates likely happen in Dantamba, Seme, Dofar-Mato, Gunya, Dankar, Rubau, Sawai, Wurma, Birinya Tsakatsa, Dankamtsa, Gardawa, and Katsalle Villages in a long run. The results also confirmed that, high level of unemployed youth and poverty rate in the study areas have a positive impact on socio-economic factors that influenced the crimes rates. The study suggests Government should encourage the youth in such localities by providing social amenities, employment opportunities, Good education, access of Road, Nearby Police stations and police outpost should be provided in each study areas. Peaceful campaign programs on dangers of Drug abuse and Trafficking, Illegal sects and sensitization of the communities on the need for peaceful co-existence. The study suggests the Government to put more emphasis on border patrol especially Kaduna, Niger, Sokoto, and Zamfara to avoid the such occurrence of crimes in the State and Local Government.

Keyword: Assault, Burglary, Co-Kriging (CK), Crime rate, Cattle rustlers, Grievous Harm and Wounding (GHW), Inverse Distance Weight (IDW), Kidnapping, Rape, Stealing, Variogram.

1. INTRODUCTION

Crime is a disease that bedeviled the society and development of any country. News increases on the Nigeria news headlines, Local, National and international media stations report crimes about Nigeria and recently it has extended to blogs. It can be deduced that crime rate in Nigeria needs serious attention by everybody in the community. Crime analysis is an investigative tool, defined as the set of systematic, analytical processes that provide timely, relevant information about crime patterns and crime-trend correlations. It uses crime data and police reports to study crime problems, including the characteristics of crime scenes, offenders and victims. Crime patterns are analyzed in terms of their socio-demographic, temporal and spatial qualities, and may be represented visually using graphs, tables and maps (Wang and Brown 2011). The Nigeria security agencies appear to be ill equipped with the task of maintaining law and order through crime detection, prosecution, prevention and control. This is as a result of bad flow of information between the agencies and the public as well as collective mobilization in their respective spatial location. In the developed nations, the automated systems are used by law enforcement agencies. As a result of current security challenges facing the country the Nigeria police force spent over 600 million for the procurement and maintenance of foreign dogs in the last few years. The hasty increment in police operating budget and expenditure is as a result of rising crime challenges in our communities. Under reporting of crime incidents is a serious challenge many police departments have been facing. However, the police departments are restricted to crime reported and recorded only and crime is

widespread than those reported or recorded by the police. Victims and witnesses of a crime may not report the incident to the police for a variety of different reasons. Those affected by a crime may be too scared to come forward and to report it, fearing potential retaliation for their actions. Others may feel that certain crimes, such as vandalism or petty theft, are not of a serious enough to merit being reported to the police. There may be simply wish not to be associated with a crime, or prefer to avoid going through the hassle of filing a formal police report. Conclusions drawn from the International Crime Victim Survey show that high crime rates is a statistically normal characteristic of nations all over the world (Zhou and Zhang, 2008). Crime analysis assist to understand the happening of a crime and it is a significant practice to law enforcement. The diverse differences in geographical areas in terms of population density, demographic characteristics, natural vegetation, location and socio-economic characteristics has rendered crime rate unevenly distributed globally. The report of international crime victim survey (ICVS) has confirmed the situation. The report which was conducted on six major world region including Africa, Asia, central and eastern Europe, Latin America, and western Europe for the 1989 – 1996 period as shown that more than half of the urban respondents reported being victim at least once regardless of what part of the world they inhabit (Ackerman and Murray, 2004).

The causes of crime are multiple and could be traced to bio-genetic factors, such as genetic mutation and heredity (Horton, 1939), psychological factors, such as personality disorders and sociological factors, such as learning and environment

(Sutherlands, 1939). Over the decades the rate of crimes in Nigeria was continuously increasing where several studies on crimes rates have been carried out both in rural and urban areas but little has been achieved to curtail the dangers of crimes committed. However, the Nigerian Police Force and other law enforcement agency boosted more effort to fight crime with the help of more perfect and sophisticated weapons. This has led to the formation of various vigilante groups, to combat crimes in some parts of the country (Fajemirokun, Adewale, Idowu, Oyewusi, & Maiyegun, 2006).

(Gupta, Rajitha, Basu, & Mittal, 2012). Conducted a study on crime analysis in Jhunjhuna district of Rajasthan, India and demonstrated that capability of kriging as well as weighted overlay analysis for identifying crime patterns by integrating socio-economic factor in Geographical Information System domain. The finding shows that, the Socio factors have a positive correlation with different types of crime.

(Hafiz, 2016). Conducted a study on Geostatistical approach to map out the crime rate and applied two Geo-statistical techniques i.e. Getist-Gi and kernel density estimation were applied to determine the spatial distribution and pattern of crime Hotspot. The results show that, both Gi and kernel density estimate have the capability to show the aggregate of crime in area of interest for setting new police station at the area.

(Khalid, Shoaib, & Qian, 2017). They conducted a research in the city of Faisalabad Pakistan, evaluated and generated hotspot of crime. The finding shows that, the street crimes are strongly concentrated in the central part of the city whereas the results manifested that, the functional nature of different urban land use affects the frequency of crime event. They finally concluded that, the hotspot analysis has real potential, impacting the police patrolling protocols.

(Gulumbe, Dikko, & Bello, 2012). Used crime dataset in Katsina state which consists of the average of eight major crimes reported to the police from 2006–2008. Principal component analysis (PCA) and Correlation analysis were employed to

explain the correlation between the crimes and to determine the distribution of the crimes over the local government of the state. The finding has shown a positive correlation between robbery, theft and vehicle theft. The PCA has suggested that, to retaining four components that explain about 79% percent of the total variability of the data set.

(Matijosaitiene, Zhao, Jaume, Gilkey, 2019). They applied crime prediction method using land-use data with the help of machine learning algorithms. The finding shows that, the crime prediction identified the exact hours of crime occurring using hotspot analysis and logistic regression to determining the precise time of the next crime but the prediction results can be enhanced using advanced methods of machine learning.

(Volasik, 2018). Conducted a study to determine the application of Risk Terrain Modeling to predict gang assault and gang Homicide. The results indicated that, the places spatially vulnerable to experiencing a gang assault are in close proximity to where gang members are observed loitering by police and metro rail stops while also contending with residential concentration of local gang members. However, the findings indicated that areas most at risk of experiencing a gang Homicide cope with residential concentration of local gang members and gang -set space (i.e. Gang hangouts).

(Gimenez, Alejandro, Caplan, & Grant, 2018). They conducted a study to identifying a Risky places for violent crime victimization in Bogota, Colombia, the three forms of crime are (i.e. Homicide, assault and theft). The finding shows that, the poorest areas in the city are most spatially vulnerable to Homicide and assaults. However, thefts were more prevalent near the city Centre, where economic activity is carried out.

2. THE STUDY AREA

The study area comprises of thirty (30) sampled locations and a grid of 30 Un-sampled location. Katsina State which lies between latitude 11°.3'N and 13°15' and longitude 6°.52'E and 9°.20'E. The map of the study is shown in figure 1 below.

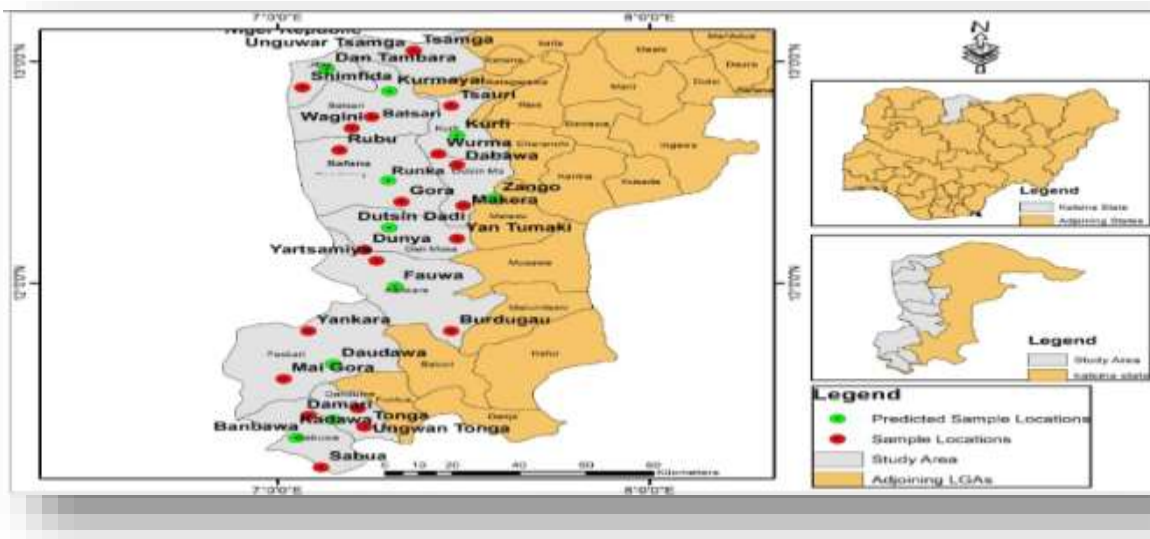


Figure 1. Map of the study areas shows (30) sampled and predicted locations in Katsina State Local Government.

2.1. METHODOLOGY

In this study thirty samples and predicted locations used in ten selected Local Government Areas in Katsina State were analyzed. The data set comprises crime rate data.

2.2. Co-Kriging MODEL

Co-kriging is a Geostatistical techniques developed to improve the prediction of a variable using the information on other spatially correlated variables which are generally more densely

sampled. In Geostatistics approach predictions are commonly made by calculating some weighted average of the observations (Webster, and Oliver, 2001):

$$\hat{Z}(s_o) = \sum_{i=1}^n \lambda_i Z(s_o) \quad (1)$$

Where $\hat{Z}(s_o)$ is the predicted value of the variable at unvisited location is s_o , gives its map geo-reference the sample data $Z(s_1), Z(s_2), \dots, Z(s_n)$ and their geo-references, the weights λ_i are chosen such that the prediction error variance is minimized producing weight that depend on the spatial autocorrelation structure of variable. The first step in kriging is the calculation of the experimental Semi-Variogram using the following equation.

$$\gamma(h) = \frac{1}{2n(h)} \sum_{i=1}^{n(h)} [(Z(X_i + h) - Z(X_i))^2] \quad (2)$$

where $\hat{\gamma}(h)$ is the estimated value of the semi-variance for lag h , $n(h)$ is the number of experimental pairs separated by vector h , $Z(X_i)$ and $Z(X_i + h)$ are the value of the variables Z at X_i and $X_i + h$ respectively, X_i and $X_i + h$ is the position in two dimension.(Webster, & Oliver,2001). A co-kriging estimate is a linear combination of both primary and secondary data values as shown by (Isaaks, and Srivastava, 1989):

$$\hat{y}(s_o) = \sum_i^n a_i U_i + \sum_j^m \tau_j V_j \quad (3)$$

Where $\hat{y}(s_o)$ is the estimate of y at location O , U_1, \dots, U_n are the primary data at n nearby locations, V_1, \dots, V_m are the Secondary data at m nearby location, a_1, \dots, a_n and τ_1, \dots, τ_m are the Co-kriging weights to be determined. The development of the ordinary kriging system, the definition of estimation error is stated as:

$$R = \hat{y}(s_o) - y(s_o) = \sum_i^n a_i U_i + \sum_j^m \tau_j V_j - y(s_o) \quad (4)$$

Where U_1, \dots, U_n are the random variables representing U at the n location and V_1, \dots, V_m are the random Variables representing V at m locations. An expression for the variance of the estimation error in term of the Co-kriging weights and the covariance between the random variables are:

$$Var(R) = \sum_i^n \sum_j^n a_i a_j Cov(U_i U_j) + \sum_i^m \sum_j^m \tau_i \tau_j Cov(V_i V_j) + 2 \sum_i^n \sum_j^m a_i \tau_j Cov(U_i V_j) - 2 \sum_i^n a_i Cov(U_i U_o) - 2 \sum_j^m \tau_j Cov(V_j U_o) + Cov(U_o U_o).$$

Where $Cov(U_i U_j)$ is the auto-covariance between U_i and U_j , $Cov(V_i V_j)$ is the auto-covariance between V_i and V_j , and $Cov(V_i V_j)$ is the cross covariance between V_i and V_j .

The set of Co-kriging weights thus, must satisfy two conditions; first, the weights must be such that, the error is unbiased. Second the weights must be such that the error variance given in equation (5) is the smallest possible. One way of guaranteeing unbiasedness is to ensure that the weights in the term sum to 1 while those in second sum to 0 (Wackernagel, 1995 and Wellmer,2002).

$$\sum_{i=1}^n a_i = 1 \quad \text{And} \quad \sum_{i=1}^m \tau_j = 0 \quad (6)$$

The Langrange multiplier method may be used to minimize error variance with two constraints. To implement the method we simply equate each nonbiased condition to 0, multiply by a langrange multiplier and add the result to equation (5).This gives the following expression:

$$Var(R) = W^t C_z w + 2\mu_1 \left(\sum_{i=1}^n a_i - 1 \right) + 2\mu_2 \left(\sum_{j=1}^m \tau_j \right) \quad (7)$$

Where μ_1 and μ_2 are the langrange multiplier. The minimize error variance can be calculated using equation (5) or it can be simplified by making substitutions using the langrange multipliers. The simplified version is:

$$Var(R) = Cov(U_o U_o) + \mu_1 - \sum_i^n a_i Cov(U_i U_o) - \sum_j^m \tau_j Cov(V_j V_o) \tag{8}$$

Co-kriging is the method having the best theoretical foundation meaning that no assumptions are made on the nature of the correlation between the two variables. It exploits more fully the auxiliary variable and measuring the degree of spatial association with the primary variable through the cross-semivariogram. The technique of Co-kriging improves the estimation and reduces the variance of the estimation error, but the same time is much more demanding than ordinary kriging. The calculation of the cross-semivariogram and the fitting of a theoretical model becomes very difficult, particularly when the two variables are not strongly correlated. (Kalivas D. P., Triantakonstantis D. P. and Kollias V. J, 2002).

2. 3. INVERSE DISTANCE WEIGHT (IDW)

The Inverse Distance Weight method estimates the values of an attribute at un-sampled points using a linear combination of values at sampled points weighted by an inverse function of the distance from the points of interest to the sampled points. The assumption is that points closer to the sampled point are more similar to those further away in their values. The weight can be expressed as:

$$\hat{Q}_p = \sum_{i=1}^n w_i Q_p \tag{9}$$

(9)

Where \hat{Q}_p is the unknown crime rate data, Q_p is the crime rate data of known samples location, and to determine the weight of known values were used this formula. (Webster, & Oliver, 2001).

$$w_i = \frac{d_i^{-p}}{\sum_i^n d_i^{-p}} \tag{10}$$

(10)

Where n the number of is sampling points used for the estimation, d_i is the distance from each crime rate location sites and p is the power parameter known.

3. RESULTS

Experimental Variogram of predicted Variables understudy

np	dist	gamma	dir.hor	dir.ver	id
1 6	6235.44	5353.867	0	0	var1
2 20	11687.20	4945.151	0	0	var1
3 27	21091.06	6597.303	0	0	var1
4 47	30889.14	7273.794	0	0	var1
5 54	43675.73	5862.805	0	0	var1
6 34	57064.03	5735.959	0	0	var1
7 99	81899.65	5021.662	0	0	var1
8 62	122590.17	3677.009	0	0	var1
9 29	166675.57	1697.133	0	0	var1

Variogram Model

model	psill	range
1 Nug	4634.252	0.00
2 Sph	1598.316	28320.28

Sum Of square error

[1] 0.2084486

The above table shows the result of an Experimental and Predicted Variogram Model of the samples locations from the study areas and it is observed that, the model was significant and best fitted

Experimental variogram and fitted variogram model

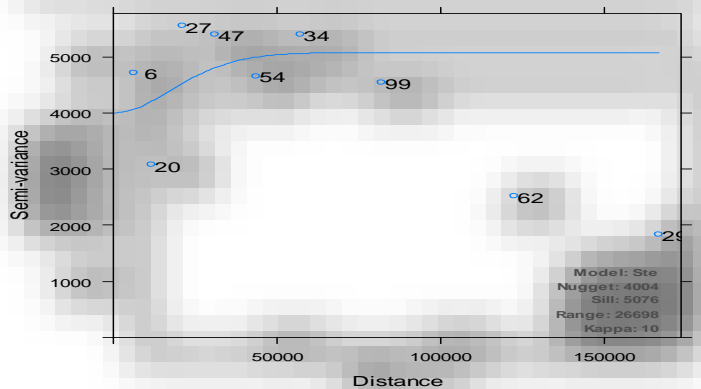
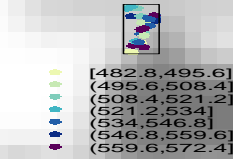
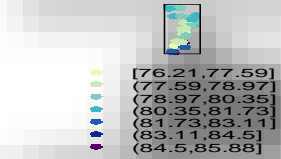


Figure.2. The experimental and Fitted Variogram of Crimes Rates. From the Figure 2 above shows an experimental and fitted Variogram model from the study areas. However, it is observed that, the model was fit

Kriging prediction



Kriging standard error



Experimental variogram and fitted variogram model

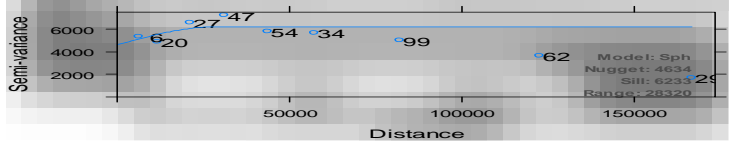


Figure.3. The CoKriging Prediction and CoKriging Standard Error of Crimes rate.

The Figure 3. above shows the spatial prediction of Crimes rates from the study areas. It is observed that, the prediction Map indicates the study areas are likely to experience frequent number of Crimes the villages are: Maidabino, Yantumaki, Shakafito, Garin labo, Makwamashi, Shinge, Dantudu, Wurma, Dandire and Zurun kutum Villages.

4. DISCUSSION

From the results obtained, we have seen that the crimes rates from the study areas are likely to experience the incident of crime. It also observed that, from the study areas the local Government areas likely to experience the rates of crimes are Kankara, Faskari, Safana, Jibia and Danmusa because of the big forest located in each Local Government which give the criminal to commit a crime and hide easily. It also observed from the prediction results that, there is a chance of occurrence of crimes nearby villages. Finally, from the findings indicated that, most of crimes committed within the study areas were as a of Unemployment and Poverty rate among the youth which led the occurrence of various crimes committed both in State and Local Government. It also concluded that, Co-Kriging is the best efficient model in geostatistical modelling.

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