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# Spatial Analysis on the Crimes Rate Using Regression Kriging Model. (A Case Study of Katsina State)

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**ABSTRACT**

*The aim of the study is to investigates and predict the spatial variability of crimes rate using Geostatistical techniques in Katsina State. The reported crimes to the Katsina State Police Command Consists of Grevious hurt and Wounded, Cattle rustlers, Rape, Kidnapping, Assaults, Stealings and Burgulary. The data is collected from Criminal Investigations Department Unit in Katsina State Command from 2010 to 2019. The method applied for this research was Regression-Kriging Model (RK) to test the fitted Variogram Model and Spatial dependencies of variables examined. The results predicted that, the crimes rate were found in Dantamba, Sheme, Dofar-Mato, Gunya, Dankar, Rubau, Sawai, Wurma, BirinyaTsakatsa, Dankamtsa, Gardawa, and Katsalle Villages will increases in a long run. The findings also confirmed that, high level of unemployed youth and poverty rate in the study areas have a positive impact on socio-economic factor that influenced the crimes rate.*

**Key words:** Spatial Analysis, Crimes Rate, Regression Kriging Model

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## 1. INTRODUCTION

Crime has no universal definition. This is as a result of changes in social, political, psychological and economic conditions. An act may be a crime in one society, but not in another [1]. For example, prostitution, adultery and homosexuality between consenting adults have been wholly or partially removed from the criminal law in USA [2] but are considered as crimes in Muslim communities such as Saudi Arabia and others.The high crime rate in any nation is major sources of insecurity and fear to the public welfare and morals of its citizens. Crimes are the most common social issues nowadays, affecting the economic growth, quality of life and economy of any country. Crimes affect the reputation of a country on an international scale and affect the economy of the country by placing a financial burden on the government in hiring additional police forces. For the eradication of crimes, the government needs to adopt some optimized strategy and sustainable e-governance information systems.

Crime also takes place in areas where there are high population densities, swift changes in social environments and poor living conditions. For instance, many immigrants in urban areas experience new urban life where relationship is based on momentary, superficial and impersonal interactions. This then produce anonymity among urban dwellers, diabolical socio–economic, high cost of living and socially disorganized, thereby turning some to steal, rob, become drunkards, drug pushers andprostitutes to make ends meet. This idea is supported by Soh [3] who states that "secondary relations eventually lead to family breakup, alcoholism, crime, and other negative aspects of urban life". One of the highest crime rates in the world are found in Nigeria Financial, [4]. Incidence of crime by property and by self are positively correlated

to the increase in poverty among population. South Africa also has a high prevalence of murder and violent crime rate (30.9) per 100,000 populations [5].

Nigeria has one of the highest crime rates in the world [6]. Cases of armed robbery attacks, pick-pockets, shop breaking and internet frauds have increased due to increased poverty among population as well as an alarming rate of unemployment among our youth and economics recession in the nation. This has brought about the establishment of various vigilante groups in different states, to combat crimes in those states in Nigeria. However, the introduction of modern scientific and technical methods in crime prevention and control has proved to be effective. In addition to these measures, the police force is closely monitoring the activities of these registered vigilante groups nationwide to ensure their full compliance with statutory rules and regulations.

Crime-solving is a complex task that requires human efforts and intelligence for the processing of criminal data.The causes of crime are multiple and could be traced to bio-genetic factors, such as genetic mutation and heredity, psychological factors, such as personality disorders and sociological factors, such as learning and environment.

Gupta, R., Rajitha, K., Basu, S. & Mittal, S.K. [7] 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 A.U. [8] 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 *et al.,* [9] 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 *et al.,* [10] conducted study in Katsina State using Principal Component Analysis to determine the distribution of the crimes across the all local government areas in Katsina State from 2006 to 2008. The various crimes committed are robbery, auto theft, house and store breakings, theft/stealing, Grievous hurt and wounding, murder, rape, and assault. The finding shows that, Musawa Local Government Area has the lowest crimes rate, while Katsina Local Government Area has the highest crime rate in the State. Robbery wasmore prevalent in Danmusa Local Government Area, Rape in Jibia Local Government Area, and grievous hurt and wounding in Dandume Local Government Area.

Volasik., M. [11] conducted a study to examine the application of Risk Terrain Modeling to predict gang violence (i.e. gang assault and gang Homicide).The finding shows that, 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. 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 *et al.,* [12] conducted a research and identifying a Risky places for violent crime victimization in Bogota, Colombia, influence of the physical environment of Bogota, Colombia on three form of crime (i.e. Homicide, assault and theft) is a assessed through Risk terrain modeling .The finding shows that, the poorest areas of the city are most spatially vulnerable to Homicide and assault, However, thefts were more prevalent near the city Centre, where economic activity is carried out. This study also offers a unique approach by examine the impact of violent crime in different socio-economic strata. One of the fundamental techniques to fight criminal activities is the better known of the dynamics nature of crime. Crime is often known of as a moral threat and injurious to the society. It causes damages the personality of individual and his property and lessens trust among members of the society [13]. Crime-solving is a complex task that requires human efforts and intelligence for the processing of criminal data. In KatsinaState the different crime committed is persistent both Rural and Urban areas. Crime is threat to economic, Political and social security of a nation and a major factors associated with underdevelopment because it discourages both local and foreign investments, reduces the quality of life, destroy human and social capital, damages relationship between citizen's and the state. Over the years the rate of crimes in Nigeria has been on the increase and these crimes are being carried out with more perfect and sophistication. This has led to the formation of various vigilante groups, to combat crimes in some parts of the country [14].

## 2. AIM AND OBJECTIVES OF THE STUDY

The aim of this study is to investigate and predict the Crimes rate in some Selected Local Government in Katsina State, Using Spatial analysis and Regression Kriging Model. The data used for this study were collected from the State Police Headquarters (CID), Katsina state from 2010 to 2019 on different crimes committed in Katsina state. With a view to achieving the following objectives to:

i. Fitting the Variogram Model of the crimes rate dataset.
ii. Determine which socio-economic variables that may influence the crimes rate in the study areas.
iii. Make prediction on crimes rate in various geographical areas in the study areas using Regression Kriging.

## 3. CLASSIFICATION OF CRIME

The classification of crime differs from one country to another. In Nigeria, the police classification of crimes also depends on what law prescribed. In Nigeria Police Abstract of Statistics (NPACS), offences are categorized in to four main categories:

- ✓ *Offences against persons* includes: manslaughter, murder and attempted murder, assault, rape, child stealing, grievous hurt and wounding, etc.
- ✓ *Offences against property* includes: arm robbery, house and store breakings, forgery, theft/stealing, etc.
- ✓ *Offence against lawful authority* include: forgery of currency notes, gambling, breach of peace, bribery and corruption, etc.
- ✓ *Offences against local act* include: traffic offences, liquor offences, etc.

## 4. REGRESSION KRIGING

In the real geostatistical approach the prediction are usually made by computing some weighted average of the observation of the observations [15].

$$\hat{Z}(s_o) = \sum_{i=1}^{n} \lambda_i . z(x_i) \tag{1}$$

Where $\hat{Z}(s_o)$ is the predicted value of the target variable at unvisited location $(s_o)$ given its map coordinates, the sample data $Z(x_1), Z(x_2), Z(x_3), .....Z(x_n)$ and their coordinates? The weights are chosen such that the prediction error variance is minimized, yielding weights that depend on the spatial autocorrelation structure of the variable. This interpolation procedure is popularly known as ordinary kriging (OK).

An alternative to kriging is the regression approach which makes prediction by modeling the relationship between the target and auxiliary environmental variables at samples locations and applying it to unvisited locations using the known value of the auxiliary variable at those locations.Common auxiliary environmental predictors are land surface parameters, remote sensing images, and geological, soil and land uses map [16]. A common regression approach is linear multiple regression [17-18], where the prediction is gain a weighted average this time of the predictors:

$$\hat{Z}(s_o) = \sum_{k=1}^{n} \hat{\beta}_k . X_k(s_o),\ X_o(s_o) = 1 \tag{2}$$

Where $x_k(s_o)$ are the value of the auxiliary variables at the target location, $\hat{\beta}_k$ are the estimated regression coefficient and n is the number of predictors or auxiliary variables. Regression krigingcombines these two approaches. Regression is used to fit the explanatory variation and SK with expected value 0 is used to fit the residual, i.e. unexplained variation [19]:

$$\hat{Z}(s_o) = \hat{\alpha}(s_o) + \hat{e}(s_o)$$

$$\sum_{k=0}^{n} \hat{\beta}_k X_k(s_o) + \sum_{i=1}^{n} \lambda_i e(s_i) \tag{3}$$

Where $\hat{\alpha}(s_o)$ is the fit drift, $\hat{e}(s_o)$ is the interpolated residual, $\hat{\beta}_k$ are estimated drift model coefficient, $\lambda_i$ are kriging weights determined by the spatial dependence residual at location $x_i$. The regression coefficients $\hat{\beta}_k$ are estimated from the sample by some fitting method ordinary least squares [20].

$$\hat{\beta}_{GLS} = \left(x^T w^{-1} x\right)^{-1} x^T w^{-1} \tau \quad (4)$$

Where $\hat{\beta}_{GLS}$ is the vector of estimated regression coefficient, $w$ is the covariance matrix of the residual, $X$ is a matrix of predictors at the sampling locations, and $\tau$ is the vector of measured values of the target variable [17].

$$\hat{Z}\left(s_o\right) = X^T \hat{\beta}_{GLS} + \lambda_o{}^T \left(\tau - X.\hat{\beta}_{GLS}\right) \quad (5)$$

Where $\hat{Z}\left(s_o\right)$ = the predicted value at location is $s_o$, $X$ is the vector of $n+1$ predictors, and $\lambda_o$ is the vector of $n$ kriging weights used to interpolate the residuals. This predictions model has an error that reflects the position of new locations in both geographical and features space.

$$\delta^2_{RK}\left(s_o\right) = \left(w_0 + w_1\right) - w_o^{-1}.w^{-1}.w_o + \left(X_o - X^T.w^{-1}.w_o\right).\left(X^T.w^{-1}X\right)^{-1}.\left(X_o - X^T.w^{-1}.w_o\right) \quad (6)$$

Where $w_0 + w_1$ is the sill variation, and $w_o$ is the vector of covariance of residuals at the un-visited location.

## 5. THE STUDY AREA

The study area comprises of thirty (30) sampled locationsand 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.

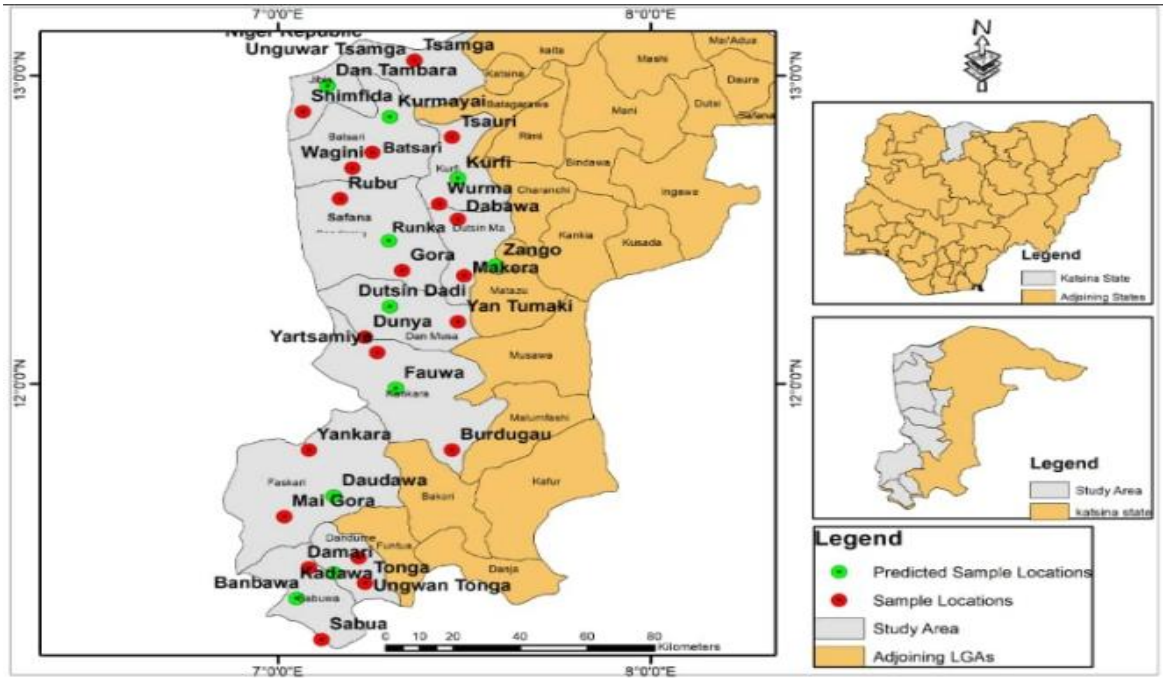



**Fig. 1** Map of the study areas showing (30) sampled and predicted locations in Katsina State Local Government

## 6. DATA AND METHODS

From the selected samples and predicted locations located in ten selected Local Government Areas in Katsina State were analyzed. The data set comprises crime rate data.

## 7. RESULTS AND DISCUSSION

The experimental Variogram of crimes rate in ten selected Local Government Areas in Katsina State shown in Figure 2. The Variogram model indicated that, there is spatial autocorrelation of all examined variables. However, the spatial prediction of crime rate shows that, the crimes rate will be increase in Faskari, Jibia, Batsari, Danmusa and Safana Local Government Areas.

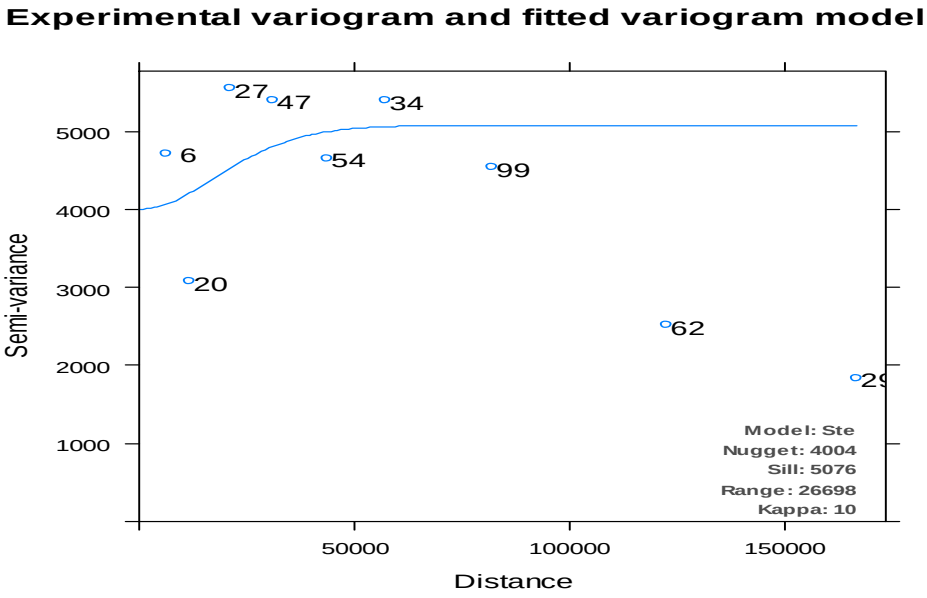
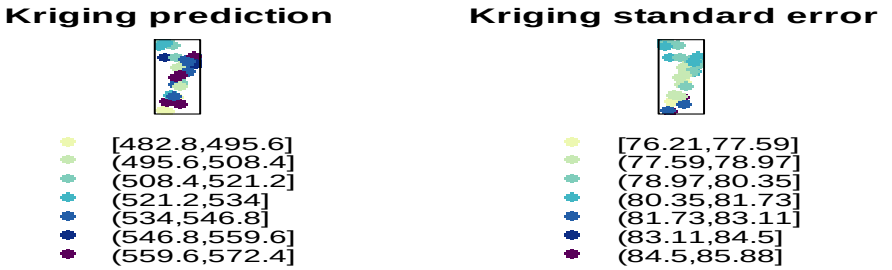



**Fig. 2** The experimental and Fitted Variogram of Crimes rate



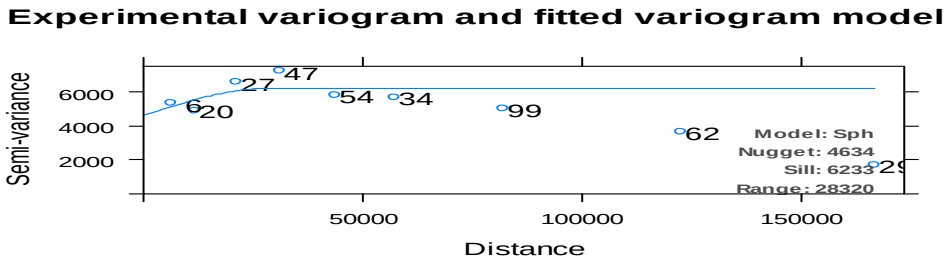




**Fig. 3** The Regression Kriging Prediction and Kriging Standard Error of Crimes rate

From the findings of Figure 3. Presented it shows that, the prediction variability of crimes rate in all the study areas increases. It is observed that, from the kriging predicted Map the highest study area with crimes rate will be found in Maidabino,Yantumaki,Shakafito,Garin labo,Makwamashi,Shinge,Dantudu,Wurma, Dandire and Zurun kutum Villages.

## 8. CONCLUSION

From the results obtained,It can be deduced that, the hotspot areas were found in Kankara,Faskari,Safana, Jibia and Danmusa. It can also be concluded that, most of crimes committed in the study areas were as a results of Unemployment and Poverty rate among the youth.Similarly, Regression kriging is the best efficient model used in geostatistical techniques for prediction .

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