



## Spatial Analysis on Road Traffic Accidents in Kebbi State Using Universal Kriging

\*Abubakar, M. and Umar, M.

Department of Mathematics, Federal University Birnin Kebbi, Kebbi, Nigeria

### ABSTRACT

This study aimed at carrying out a spatial analysis on road traffic accident in Kebbi State for the year 2020. The study area comprises of fifty (50) sample points located in Jega Local Government, Kebbi State of northern Nigeria. The area is characterized as one of the centers of commerce in the State. The data used for this study involves direct collection of information on the field using GPS (Global Positioning System) and observations, which includes the geographic coordinates of the selected traffic corridors and traffic count along the corridors, and it involves sourcing information from existing records. Such data includes: traffic situations reports from Federal road safety corps Jega division. The technique of Universal Kriging was used to develop empirical semivariogram model to predict the occurrence of road traffic accident. The result shows that the prediction variability in the road traffic accidents increases at southern part of the study area.

**Keywords:** Road Accidents, Variogram, Universal Kriging

### INTRODUCTION

Road traffic accidents occur when a vehicle collides with another vehicle, pedestrian, animal, road debris, or other stationary obstruction, such as a utility pole or tree. Worldwide, road traffic accidents lead to mortality and disability as well as financial cost to both government and the individual involved. There is a general increase incidence, morbidity and mortality rates of road traffic accidents. People are injured due to road accidents every day more so in developing countries like Nigeria. The problem is that the enormity of the problem is not appreciated and enough preventive measures are not taken. A corps marshal of the Federal Road Safety Corps Osita Chidoka (2018) said that 1300 road accidents have claimed 51251 persons injured in Nigeria in the past three years. He further explained errant petroleum tankers drivers were responsible for most of the accident in Nigeria, he said that in the first three months of the year 2018, 2119 accidents involving tankers drivers claimed 301 lives meanwhile; one analyst has said the figure of fatalities by the police is a gross under – estimation of the death resulting from accident. Adegbenro (2009) studied the road accidents trends in Nigeria, his study reveals a sharp increase in fatal accident occurrence. Eke *et al.* (2005) observed that most of the factors involving in road accidents are created and control by man. Man initiated the process that may yield a road accident by traveling, he/she may travel as a pedestrian as a passenger in a vehicle or as the operator of the vehicle. Gundogdu (2014) applied Ordinary Kriging (OK) to explore the spatial distribution of traffic accidents in Konya, Turkey. The database used consisted of 10 years of information and it was based on the Accident Criteria (AC) determined as follows: fatal victims, injuries, accidents with damage and total number of accidents. Results obtained from the Kriging maps enabled the author

to identify the areas of greatest risk of crash occurrence. In addition, the results contributed to determining new routes and safety zones. Erdogan *et al.* (2008) performed a research in Turkey to evaluate accidents distribution in a highway, located in the entrance of Afyonkarahisar city.

This research used two different methods of Kernel Density Analysis and after identification of hotspots, accidents' conditions were considered hourly, daily and seasonal basis. Moreover, introducing three important hotspots, the researchers offered a number of strategies to the traffic departments in order to solve the problem. Loo and Yao (2013) analyzed 603 simulated patterns of traffic crashes in three simplified hypothetical networks and the empirical crash pattern in Hong Kong in 2 years. They used the link-attribute approach and the network-constrained event-based approach to identify hot zones. The results suggested that the link-attribute approach and network constrained event-based approach are usually consistent but there are major differences between these two approaches. The road traffic environments in Nigeria are environments dominated by abundant combination of largely illiterate or inexperienced or drunk or overconfident of drivers, unconcerned about the line of other road users knowing nothing more than the rudiment of money a vehicle and sounding their horn with reckless abandon, meanwhile operating poorly maintained vehicle on high quantity poorly designed ill maintained roads a society that is devoid of traffic law enforcement service and that is ill equipped with emergency Road Safety facilities where Government, Police, and Military driver flout traffic laws with immunity where paramedical personnel are sometimes called and unconcerned about the agonies of road accident victims (Odeleye, 2003).

\*Corresponding author. E-mail: [muddassir.abubakar@fubk.edu.ng](mailto:muddassir.abubakar@fubk.edu.ng)

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Baratian-Ghorghi *et al.* (2015) ranked the high-crash locations by developing a new methodology to predict the first and second possible entry points based on the crash locations and distance from upstream interchanges. There are rural-urban differences. In urban areas, there are more accidents, lower degree of injury while in rural areas; there are lower accident levels but more serious fatalities (Komba, 2006). A study on traffic accidents using GIS and spatial-temporal methods was done by Jones *et al.* (1996) in 1996 at Norfolk, UK. In the study K function analysis method was used for identifying the presence or absence of hotspots clustered. The World Health Organization (WHO, 2015) estimated that about 1.17million deaths occur each year worldwide due to road traffic accidents. A breakdown of the figure indicates however, that about 70

percent of the deaths occur in undeveloped countries. The increased rate of fatal road traffic accident worldwide has been attributed to population eruption and increased motorization. Increased motorization may be characterized briefly as the “automotive revolution”, that is the motorizing of urban population especially in the developing countries.

**MATERIALS AND METHODS**

The study area comprises of fifty (50) sample points located in Kebbi State of northern Nigeria. The study area falls between latitude 11°55'0" to 12°18'0" N and longitude 4°17'0" to 4°32'0" E. The area is characterized as one of the centers of commerce in the State. The map of the study area is shown in Figure 1. The Accidents happened in Jega district in year 2020 with their absolute locations are shown in Figure 2.

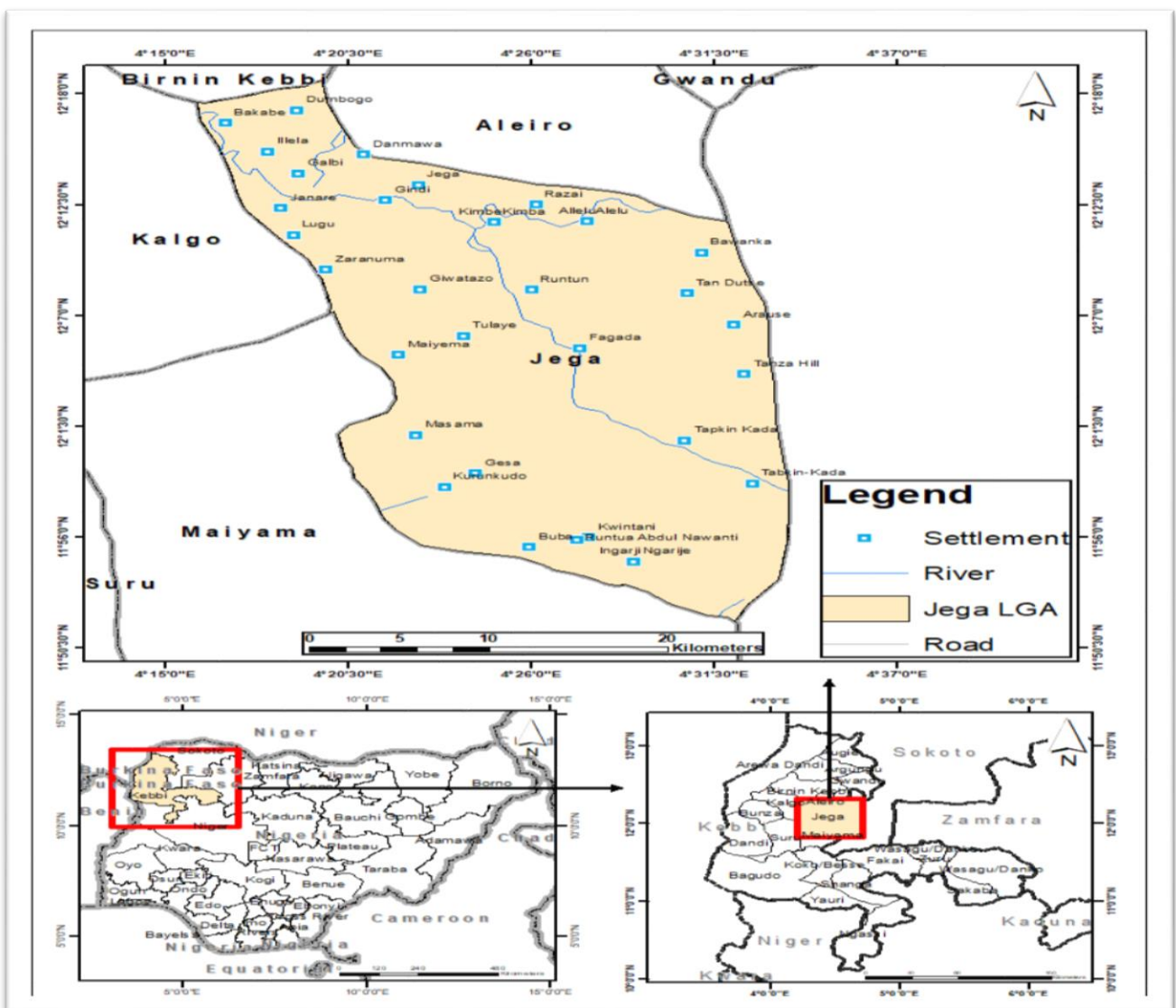
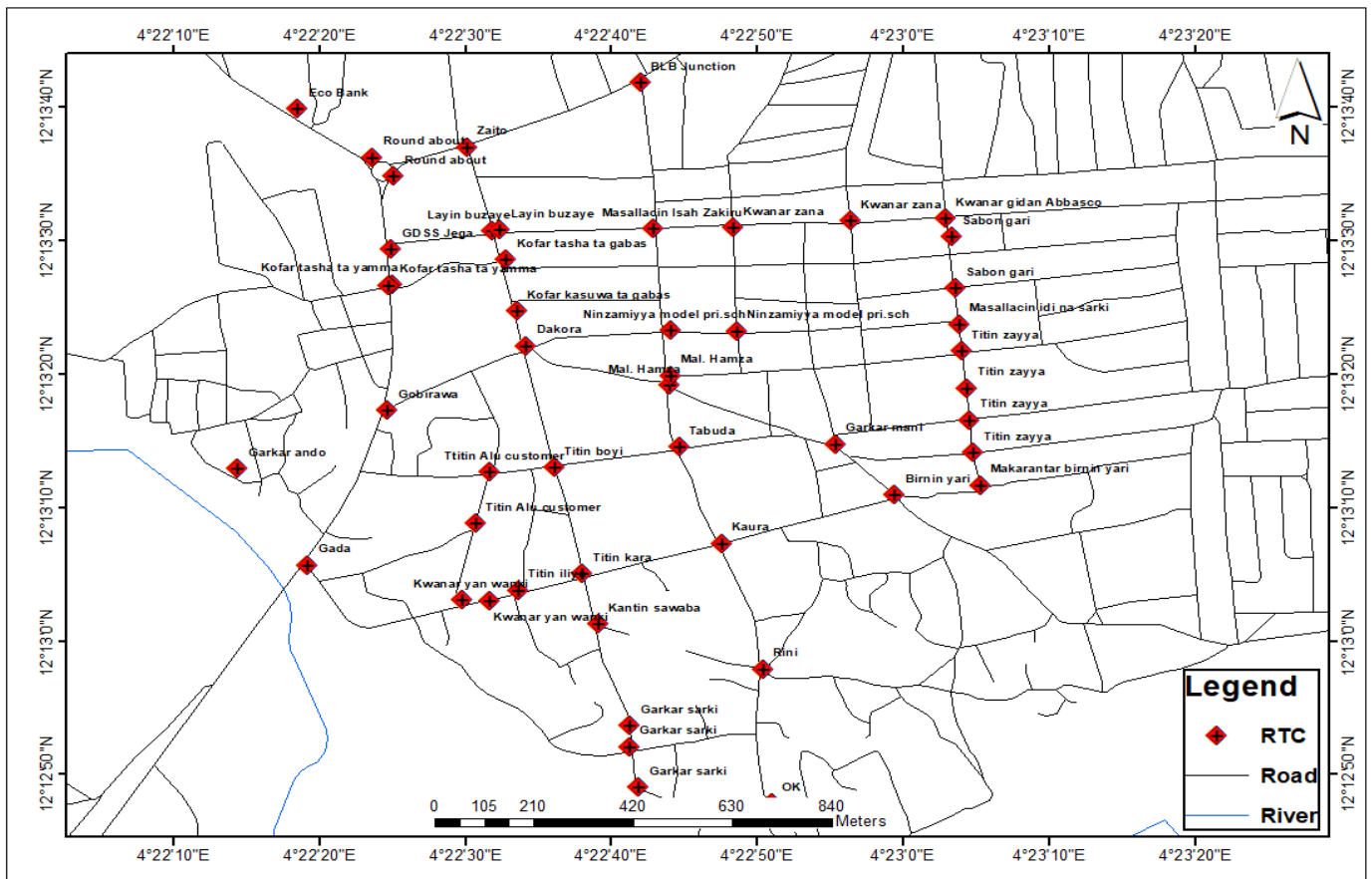


Figure 1: The map of the study area



**Figure 2:** The map of the accidents locations showing fifty (50) sample points in Jega Local Government

**Data and Methods**

In this research, the data recorded in fifty (50) sample points located in Jega Local Government, Kebbi State, Nigeria were analyzed. The data set contains as input

variable for the analysis. Other datasets utilized in this study are Elevation and Geo-coordinates location. The data used for this study is given in Table 1.

**Table 1:** Data set for the study

S/No	Area	Location	No. of RTC occurred	Altitude	Elevation
1	Titin Alu customer	Lat 12.220195 Lon 4.375462	3	254	212
2	Garkar Ando	Lat 12.220265 Lon 4.370650	5	250	211
3	Gobirawa	Lat 12.221484 Lon 4.373514	5	206	214
4	Kofar Tasha ta Yamma	Lat 12.224106 Lon 4.373606	2	192	218
5	Kofar Tasha ta Yamma	Lat 12.224082 Lon 4.373529	1	194	218
6	GDSS Jega	Lat 12.224842 Lon 4.373583	2	195	221
7	Round about	Lat 12.226359 Lon 4.373630	3	196	223
8	Round about	Lat 12.226755 Lon 4.373228	4	203	218
9	Zaito	Lat 12.226966 Lon 4.375025	3	211	222

Table 1 contd.

10	Layin Buzaye	Lat 12.225223 Lon 4.375511	3	213	223
11	Layin Buzaye	Lat 12.225242 Lon 4.375655	1	212	222
12	Masallacin Isah Zakiru	Lat 12.225264 Lon 4.378570	3	205	221
13	Kwanar Zana	Lat 12.225294 Lon 4.380096	2	203	219
14	Kwanar Zana	Lat 12.225439 Lon 4.382343	1	204	218
15	Kwanar Gidan Abbasco	Lat 12.225482 Lon 4.384143	2	206	216
16	Sabon Gari	Lat 12.225098 Lon 4.384269	3	202	213
17	Sabon Gari	Lat 12.224031 Lon 4.384349	1	201	215
18	Masallacin idi na sarki	Lat 12.223278 Lon 4.384402	1	200	212
19	Titin Zayya	Lat 12.222713 Lon 4.384454	3	198	208
20	Titin Zayya	Lat 12.221942 Lon 4.384556	2	197	209
21	Titin Zayya	Lat 12.221283 Lon 4.384610	2	197	209
22	Titin Zayya	Lat 12.220594 Lon 4.384682	1	195	209
23	Makarantar Birnin Yari	Lat 12.219916 Lon 4.384807	2	193	207
24	Birnin Yari	Lat 12.219722 Lon 4.383180	1	192	210
25	Garkar Mani	Lat 12.220775 Lon 4.382047	2	192	210
26	Tabuda	Lat 12.220723 Lon 4.379067	3	195	209
27	Mal. Hamza	Lat 12.222004 Lon 4.378886	2	182	212
28	Mal. Hamza	Lat 12.222202 Lon 4.378908	2	185	210
29	Ninzamiyya Model Pri.Sch	Lat 12.223142 Lon 4.378900	2	187	212
30	Ninzamiyya Model Pri.Sch	Lat 12.223139 Lon 4.380182	1	192	220
31	Dakora	Lat 12.222822 Lon 4.376158	4	196	215
32	Kofar Kasuwa ta Gabas	Lat 12.223552 Lon 4.375976	4	212	218
33	Kofar Tasha ta Gabas	Lat 12.224618 Lon 4.375767	3	206	219
34	Titin Boyi	Lat 12.220290 Lon 4.376698	2	204	214
35	Titin Kara	Lat 12.218080 Lon 4.377230	2	212	221
36	Kantin Sawaba	Lat 12.217021 Lon 4.377519	1	210	209
37	Garkar Sarki	Lat 12.214911 Lon 4.378129	2	196	207
38	Garkar Sarki	Lat 12.214468 Lon 4.378115	2	191	207
39	Garkar Sarki	Lat 12.213621 Lon 4.378290	1	192	202
40	OK	Lat 12.213292 Lon 4.380827	2	192	204
41	Rini	Lat 12.216087 Lon 4.380660	2	191	207
42	Kaura	Lat 12.218705 Lon 4.379883	4	201	209
43	Titin Iliya	Lat 12.217727 Lon 4.376000	2	209	204
44	Kwanar Yan Wanki	Lat 12.217507 Lon 4.375466	2	204	207
45	Kwanar Yan Wanki	Lat 12.217531 Lon 4.374936	2	198	207
46	Titin Alu customer	Lat 12.219118 Lon 4.375188	2	201	210
47	Gada	Lat 12.218251 Lon 4.371984	8	243	209
48	De'Blue	Lat 12.237356 Lon 4.363080	5	209	220
49	BLB Junction	Lat 12.228315 Lon 4.378345	4	210	223
50	Eco Bank	Lat 12.227773 Lon 4.371796	3	202	212

**Universal Kriging Modeling**

There are a few model assumptions on the underlying random function  $Z(x)$  for universal kriging varying from the assumptions of simple and ordinary kriging. These are presented in Cressie (1993) and Webster and Oliver (2007) and we summarize them in the following assumption:

**Assumption (Model for universal Kriging)**

- I. Assume that  $Z(x)$  can be decomposed into a deterministic, i.e. nonrandom trend function  $\mu(x)$ , and real-valued residual random function  $Y(x)$ , such that

$$Z(x) = \mu(x) + Y(x) \dots\dots\dots(1)$$

- II.  $Y(x)$  is supposed to be intrinsically stationary with zero mean and Variogram function  $\gamma_Y(h)$ , called residual variogram function of  $Z(x)$ :

$$IE[Z(X)] = IE[\mu(X)] + IE[Y(x)] = \mu(x) \dots\dots\dots (2)$$

And

$$\gamma_Y(h) = \frac{1}{2} \text{Var}(Y(x+h) - Y(x)) = \frac{1}{2} IE[(Y(x+h) - Y(x))^2] \dots\dots\dots(3)$$

- III. Finally let  $f_0, f_1, \dots, f_L$  be deterministic functions of the geographical coordinates  $x \in D$  with  $L \in \mathbb{N}$  the number of known and selectable basic functions  $f_l : D \rightarrow \mathbb{R}, l = 0, \dots, L$ . We assume  $\mu(x)$  to be a linear combination of these functions evaluated at  $x$   
 $\mu(x) = \sum a_l f_l(x) \dots\dots\dots (4)$

**Figure 3:** Experimental and fitted Variogram of Road traffic accidents.

With unknown coefficients  $a_l \in \mathbb{R} \setminus \{0\}$  for all  $l = 0, \dots, L$  and suppose  $f_0(x) = 1$  constant by convention.

**Universal Kriging Prediction**

In total, we observe the “optimal”, that is to say the best linear unbiased predictor (BLUP)  $Z_{wUK}^*(x_0)$  of universal kriging by inserting the above results of Cressie (1993):

$$Z_{wUK}^*(x_0) = \sum_{i=1}^n w_i^{UK} Z(x_i) = w_{UK}^T Z = [\gamma_{Y,0} - F(F^T \Gamma_Y^{-1} F)^{-1} (F^T \Gamma_Y^{-1} \gamma_{Y,0} - f_0)]^T \Gamma_Y^{-1} Z \dots\dots\dots(5)$$

With corresponding kriging variance and finally with kriging estimate  $Z_{wUK}^*(x_0)$  at the location of interest  $x_0$

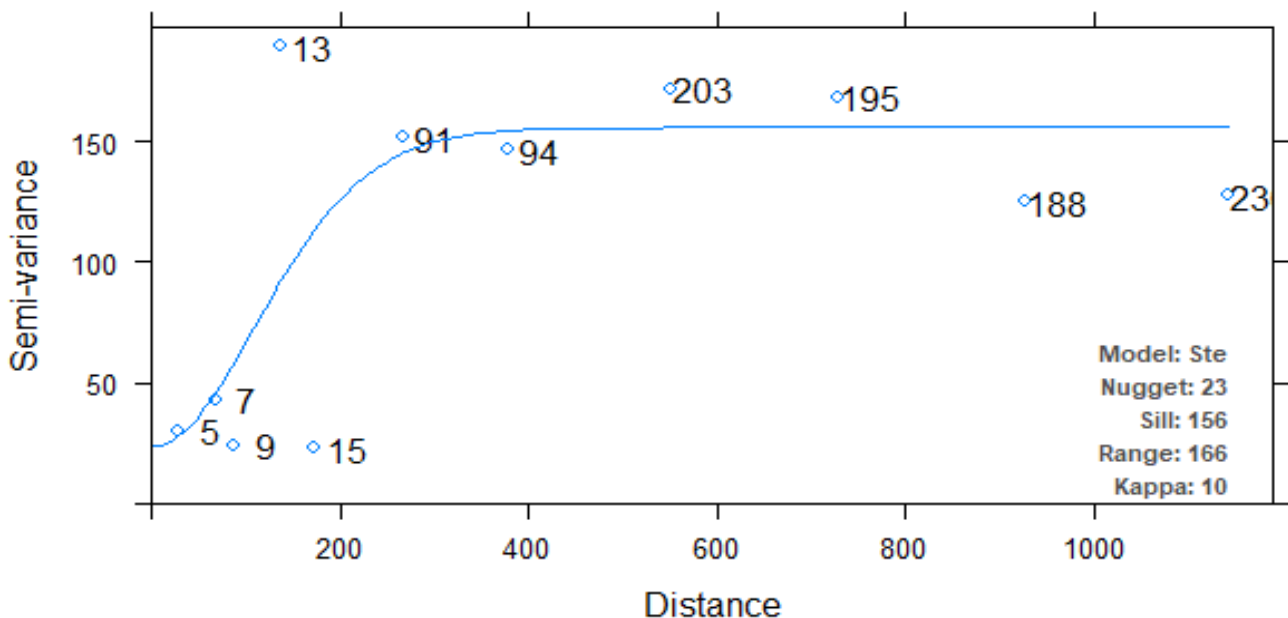
$$Z_{wUK}^*(x_0) = \sum_{i=1}^n w_i^{UK} z(x_i) = w_{UK}^T z = [\gamma_{Y,0} - F(F^T \Gamma_Y^{-1} F)^{-1} (F^T \Gamma_Y^{-1} \gamma_{Y,0} - f_0)]^T \Gamma_Y^{-1} z \dots\dots\dots(6)$$

**RESULTS AND DISCUSSION**

The experimental Variogram of Road traffic accidents is shown in Figure 3. The Variogram model indicated that there is a spatial autocorrelation in the model and also it illustrates three important parameters that control the fit of the Variogram model, those parameters are: Nugget, sill and range.

From the result presented in Figure 4, it is indicating that the prediction variability in the road traffic accidents increases at southern part of the study area. It was observed that from the Universal Kriging prediction map, the highest occurrence of the road traffic accident was found at Garkar Ando, Gada, and Titin Alu customer, and the lowest was found at Ninzamiyya, Mal. Hamza and Tabuda.

**Experimental variogram and fitted variogram model**



### Kriging prediction

●	[182,192.3]
●	(192.3,202.6]
●	(202.6,212.9]
●	(212.9,223.1]
●	(223.1,233.4]
●	(233.4,243.7]
●	(243.7,254]

### Kriging standard error

●	[3.984e-16,4.171e-08]
●	(4.171e-08,8.343e-08]
●	(8.343e-08,1.251e-07]
●	(1.251e-07,1.669e-07]
●	(1.669e-07,2.086e-07]
●	(2.086e-07,2.503e-07]
●	(2.503e-07,2.92e-07]

**Figure 4:** Kriging prediction and Kriging standard error for the Road traffic accidents.

### CONCLUSION

Based on the results obtained from the analysis, it can be concluded that the road traffic accidents increase at southern part of the study area along Garkar Ando, Gada, and Titin Alu customer. It is also concluded that the occurrence of the road traffic accidents in the region are as a result of the wrong over taking, dangerous driving, loss of control and lack of good roads in the region. It can be generally concluded that Universal Kriging is the efficient and essential geostatistical technique to model the environmental data.

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