Assessing the Effects of Road Conditions on Police Response in Nigeria

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Abstract The quick response of the police to emergency calls can save lives and property. However, one key factor that affects police emergency response time, with limited focus in the literature, is the effect of the poor condition of the road. Thus, this study aims to examine the effect of poor road conditions on the response of the Nigeria Police to emergency calls in Ijebu-North Local Government Area (INLGA), Ogun State, Nigeria. The study is based on the range concept of the Central Place Theory. Data on the locational coordinates of three (3) police stations, sixty-five (65) identified settlements, and road networks in INLGA were obtained from topographic maps. The p-median and maximal covering location models were used for data analysis. The study showed that the average emergency travel time of the police can be reduced by 33.01% if the poor roads, in the study area, are improved. It was also shown that emergency response time, by the police, to the farthest settlement can be reduced by 55.47 percent if the poor roads are fixed. The study also revealed that 27.7 percent of all settlements can be covered by the police within five minutes under the actual condition of the roads, and this can be increased to 30.77 percent assuming all roads are in good condition. The study further revealed that total coverage of settlements can be achieved within 45 minutes under the actual road condition and within 20 minutes if the roads' condition is improved. The study demonstrated that the response of the police to emergency calls will be improved if the poor roads are fixed; consequently, citizens' protection and the state of security in the Country will improve.

Keywords Emergency Service, Police, Maximal Covering Location Problem, Network Analysis, Road Condition

JEL H54, R41, R42

1. Introduction

The police is one of the three primary emergency services that can be summoned directly by the public. Others are the fire and emergency medical services. The police is an organization for maintaining law and order. It is a civil organization whose members are given special legal powers by the government and whose task is to maintain public order and to solve and prevent crimes [1]. Timely response by the police to emergency calls is very crucial and can save lives and property.

A common measurement in benchmarking the efficacy of emergency services is response time. It is the amount of time it takes an emergency service from the receipt of a call to arrive at the scene of an incident. Some factors can prevent the police from achieving a targeted response time. These factors include the condition of the police vehicle, the ability to use technology to find addresses, traffic congestion in urban areas, the condition of the roads, etc. There is limited research on the effect of poor road conditions on police emergency services in developing countries. The effect of road conditions on emergency service delivery can be impactful in many developing countries. Roads in some regions of such countries are known to be in a poor state, particularly in rural areas. It was observed that poor roads in Nigeria significantly delay the movement of security operatives to crisis scenes, particularly in remote and insecure regions where timely intervention is essential to prevent loss of life and property. [2], [3].

There are few studies on the response time of emergency services in African countries [4]. Most of the available studies focused on the response time of emergency medical service (EMS). Limited attention has been paid to how poor road conditions directly affect police response time. Thus, this study will examine the effect of road conditions on the emergency response time of the police, using Ijebu North local government area in Ogun state, Nigeria as a case.

2. Literature: Emergency Service Location Planning

The Central Place Theory (CPT) is fundamental to explaining the location of services. The CPT explains the size, numbers, and spacing of central places (in this case, police stations) supplying goods/services to the surrounding population [5]. The range concept of the CPT specifies that there is a distance from the provider of a service beyond which the service will become irrelevant to the consumer. The range

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concept is particularly relevant to explaining the maximal service distance in emergency service planning. There is always a distance or time that will render an emergency service irrelevant. Thus, the guiding principle in assessing the delivery capability of the police emergency service is to minimize the distance between police stations and the people and properties they are supposed to protect. The assessment of the locations of police stations vis-à-vis the people they are to protect can be carried out using the location-allocation models. The location-allocation (L-A) models are designed to find the location for facilities (e.g. police stations) and at the same time allocate demand or users to them in a way to achieve stated goals such as minimizing distance or time travelled. Location-allocation methods can be used to solve a variety of problems such as finding location for new facilities, find location for additional facilities. Location-allocation methods can also be used to find locations for new facilities to replace badly located ones (re-organization problem) and to determine a minimum number of facilities that are needed to service a population distribution. The p-median of the L-A modelling is to locate a given number of facilities (e.g. police stations) and allocates demand nodes (e.g. settlements) to the facilities to minimize the total distance or time between the facilities and the consumers.

In planning the location of emergency services, location-allocation methods are used to find locations of facilities to deliver services in an emergency within a given response time. The coverage models, of the L-A modelling approach are commonly used to solve emergency facility location problems because they aim to maximize coverage of the population within a 'maximal service distance'. The maximal service distance is the distance of the farthest user of a service from a facility or service. This distance can be translated to the response time for service delivery. Response time is a common performance measure and is a critical factor in the measurement of the effectiveness of emergency services [6]. It is the amount of time it takes an emergency service from the receipt of a call to arrive at the scene of an incident. A limit on response time is imposed to ensure that no more than a specified time will elapse before an emergency service will get to the location of the emergency event [7]. Safety of lives and properties can be more assured where the total response time of the police is at the minimum as discussed below.

The total response time of a police emergency service is calculated from the time the call for service is answered by a call taker to the time the first police officer arrives on scene. The total response time consists of the call process time, the dispatch time and the dispatch to arrival time. The total response time depends on many factors such as: regulations guiding police operations, the discipline of police officers, speed allowed for emergency vehicles, traffic situation in cities, the state of disrepair of the roads, etc. Emergency response has been noted to be best if it arrives quickly to minimize the impact of the disaster [8]. Response time of the police varies from one country to another, particularly between the developed world and the developing countries. Response time of the police is usually fixed by the government or her regulatory agency, because police service is a type of public service as discussed below.

Police services are public sector-oriented services. They are provided by the government as a public service, funded through taxes. Public service is a service that is found in the public domain because it can only be profitably produced by the government or its parastatals due to their attributes [9]. The objectives in the provision of public goods or service are to ensure equal availability of the services and to maximise societal benefit, while minimizing cost and use resources in the most rational way possible [10]. Pure public goods are characterized by three main properties of (1) non-excludability, (2) joint supply and (3) non-rejectability. Non-excludability or non-exclusion principle implies that if a good is provided for an individual it is impossible to hold it back from any other person. Joint supply, non-rivalrous or shared consumption implies that once a good is made available it is equally available to all other persons at the same time at no extra costs [11]. Finally, the third property of non-rejectability implies that once a good is provided, it must be fully used up by all [10]. Given the three principles, pure public goods are not actually common in reality. Services provided by the police are an example. Once a police station is established, an individual cannot be excluded from using the service; it is also always equally available to everybody and the protection and maintenance of order provided by the police is for everybody in the society.

3. Methods

The study area, type, and methods of data collection and data analysis techniques are discussed in this section.

3.1. The Study Area

Ijebu North local government area (INLGA) in Ogun State is the study area for this work. It was chosen because of the presence of the three types of roads of varying conditions in the local government area. INLGA is approximately located between latitude 6055" and 70 N and between longitude 3045" and 4005"E. The total land area of Ijebu North local government area is about 967 square km. There are sixty-five identified settlements. The study area consists of urban and rural areas. The three urban centres are Ijebu-Igbo (headquarters of INLGA), Ago-Iwoye and Oru/Awa (see figure 1a). The population size of Ijebu North local government area grew from 148,342 (1991 population census) to 280,520 (2006 population census) - an increase of 89.1%. Public facilities are mostly concentrated in urban areas compared to rural areas. Thus, the three police stations are in the three urban centres (See figure 1b). The dominant modes of transport are roads. There are three types of roads in the local government area. The first type is the major road. It is owned and maintained by the Federal government. The major roads usually run across a state to another state. The two major roads in INLGA are the Ilishan/Ijebu-Igbo/Ikire Road and the Ijebu-Ode/Ibadan Road. The second type of road is the secondary road.

Figure 1a. Nigeria and Ogun State Showing the Study Area

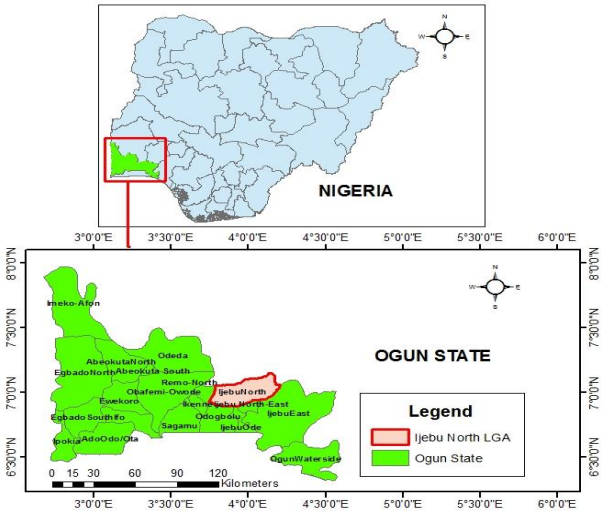
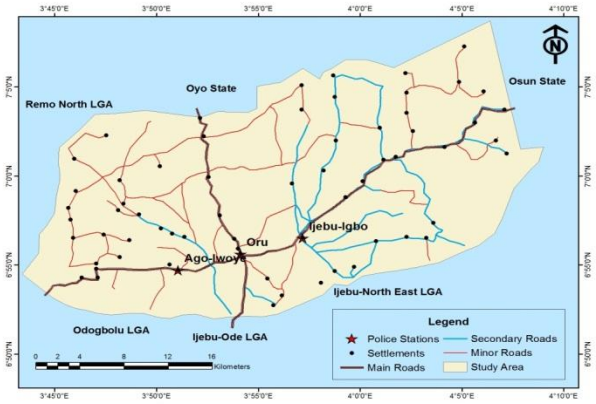


Figure 1b. The Study Area: Ijebu North Local Government Area, Ogun State, Nigeria.



It is owned and maintained by state governments. The third type of road is the local or minor road. The minor roads are owned and maintained by the local governments. Some of the minor roads are former foot/cycle paths that were made motorable, but are mostly not tarred. The above-listed characteristics of Ijebu North local government area made the area theoretically suitable for examining issues about road condition and its effect on service delivery in a regional setting.

3.2. Data for the Study

The data used for the location-allocation modelling in this study consist of the coordinates of the location of the facilities (police stations), the demand points (settlements) and the road networks that facilitate interaction between the demand points and the facilities. The coordinates of the location of the three police stations and the sixty-five settlements in Ijebu North local government area (INLGA) were obtained from a digitized topographic map of the area. The roads from the digitized map of INLGA were used to build the origin-destination matrix for the interactions in the location-allocation modelling.

3.3. Methods of Analyses

The p-median and the maximal covering location models of the location-allocation methods were used to model the interactions between the police stations and the settlements in Ijebu North local government area. The analysis was carried out using the Network Analyst of ArcGIS v10.5. This study is about emergency service delivery by the police, and it is assumed that police emergency vehicles will move freely on good roads. However, since it is not all the roads in INLGA that are good, this study tried to factored the effect of the present state of the roads in the interaction modelling. The approach used is based on the observation that, in the study area, attention is paid more to the major and secondary roads by the Federal and state governments, respectively. The minor roads that are to be maintained by the local government are mostly neglected in INLGA. In this study, the major and secondary roads were assumed to be good. They are all tarred roads and are always getting attention from the Federal and state governments, while the minor roads are neglected. Thus, the minor roads are modelled with an impedance factor of three, that is. It is assumed that it will take thrice the time one will used on a major or secondary road to traverse the same distance on a minor local government road. Thus, to factor in the impedance on the minor roads, the time spent was multiplied by three.

The p-median model of the location-allocation methods was used to find the optimal service pattern from the three police stations to all sixty-five settlements in the study area by allocating each police station to the nearest settlements. The optimal allocation pattern will yield the minimum total and average travel time between the police stations and the settlements.

The maximal covering location model of the location-allocation methods was used to find the proportion of the settlements that could be optimally covered within a given response time. The model was used to compute a table of options in a "what-if-analysis" by generating statistics for different proportions of settlements that can be covered within different response time to emergency by the police.

4. Results and Discussion

The discussions of the findings of this study are in two parts. The first part is the result of the application of the p-median model to optimally allocate the three police stations in the study area to the nearest settlements under two conditions: (1) actual/observed road conditions (major and secondary roads are good and minor roads are poor) and (2) under the assumption that all the roads are good. The second part of the discussion of findings is the result of the application of the maximal covering location model. The model was used to find the proportion of settlements that could be optimally covered under a given response time.

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The results of the application of the p-median model to optimally allocate the three police stations to the nearest settlements are shown in Table 1. It is shown that the time it will take the police to attend to an emergency call from the farthest settlement, travelling on the roads in their present condition, is 41.66 minutes. This will occur where a call from Owode-bale is directed to Ago-Iwoye police station (being the nearest police station to the settlement). Assuming that all the roads are in good condition, the longest time would have been 18.55 minutes, this is also between Ago-Iwoye police station and Owode-bale. Thus, a reduction of 55.47 percent in emergency response time, by the police, to the farthest settlement can be achieved by fixing the roads.

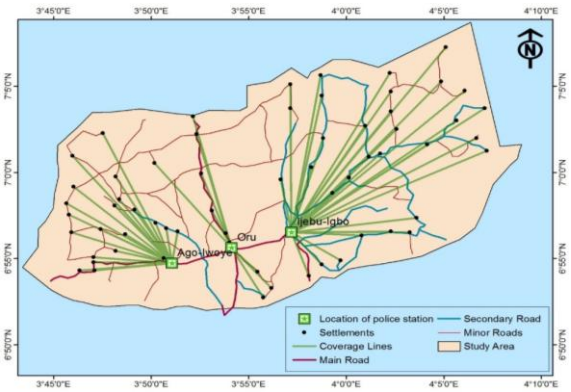
Table 1. Statistics of Police Service Delivery on Actual and Assumed Good Road Conditions

Statistics	Dispatch-to-Arrival Time (in Minutes)		
	Actual Roads Conditions	Assuming All Roads are Good	Percent Change
Number of settlements to be served	65	65	
Maximum time between a police station and a settlement	41.66	18.55	55.47
Average time between police stations and all settlements	12.75	8.54	33.01
Standard deviation of the time between police stations and settlements	11.36	5.18	

Source: Computed with the Minimize Impedance Module in Network Analyst of ArcGIS v10.5

Note: The response time in this study refers to the time between dispatches from the station to arrival at the scene of the emergency.

Figure 2. Total Coverage of Settlements by Police Service on Actual Road Condition



The average time it will take dispatches from the three police stations to all settlements in Ijebu North local government area (INLGA), on the present road condition is 12.75 minutes. This time will be reduced to 8.54 minutes if all roads within the local government area are good. Thus, a reduction of 33.01 percent can be achieved in the average response time by fixing the roads in INLGA.

Emergency services are usually benchmarked based on a fixed response time. However, there is no fixed response time for emergency service provision in Nigeria. A "what-if-analysis" was carried out on different response time for police service delivery in the study area. The analysis was carried out using maximize coverage module in Network Analyst of ArcGIS v10.5. The result of the what-if-analysis is presented in Table 2. The analysis in the table started with a maximum response time of five minutes, which is a common benchmark for most emergency services around the world. The table presents the results of the maximum response time increasing by five minutes until the response that covers all settlements in the study area. It is shown in the table that the police can cover 27.7 percent of the settlements in the study area within a maximum response time of five minutes under the present conditions of roads.

The percentage of covered settlements, within five minutes, can be increased to 30.77 if the roads are fixed. All the sixty-five settlements in the study area can be covered by the police within a maximum response time of 45 minutes under the present road conditions. This total coverage of the settlements could, however, be achieved within 20 minutes if the roads are in good condition.

4.1. Discussion

There are previous studies that have focused on road obstructions that can prevent or delay emergency service delivery in developing countries. Most of these studies are on emergency medical service (EMS) and they focused mostly on the effect of traffic congestion in urban areas and attempted to solve the problem as a traffic routing problem using real-time traffic data [12]. The suggested methods might not be applicable to solving road obstructions due to widespread state of disrepair of the roads, particularly in some developing countries. In such a situation, alternative routes are as poor as the assigned routes.

The size of a lower-case "j" will give the point size by measuring the distance from the top of an ascender to the bottom of a descender.

Table 2. Statistics of Maximal Coverage by Police Service on Actual and Assumed Good Roads Condition

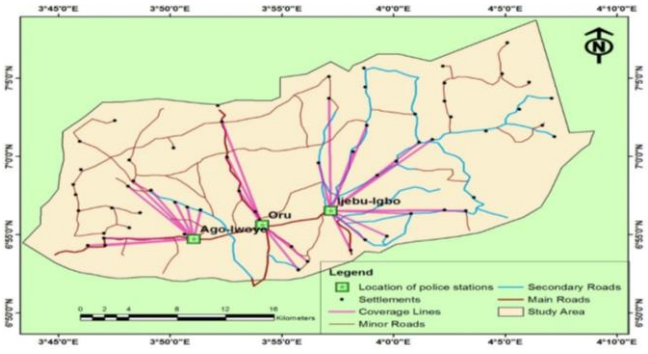
	Statistics Under Actual Condition of Roads			
Sn	Maximum response time (in minutes)	Number of settlements covered	Percent of settlements covered	Average time (in minutes)
1	5	18	27.70	2.74
2	10	36	55.38	4.87
3	15	45	69.23	6.27
4	20	51	78.46	7.50
5	25	54	86.08	8.35
6	30	56	86.15	9.00
7	35	59	90.77	10.11
8	40	62	95.38	11.40
9	45	65	100	12.75
Statistics Assuming all Roads are in Good Condition				
Sn	Maximum response time (in minutes)	Number of settlements covered	Percent of settlements covered	Average time (in minutes)
1	5	20	30.77	2.76

2	10	42	64.62	5.32
3	15	56	86.15	7.16
4	20	65	100	8.54

Source: Computed with Maximize Coverage Module in Network Analyst of ArcGIS V10.5

Figure 3. Maximal Coverage of Settlements by the Police

(A) Maximal Coverage of Settlements by Police Service on the Present Road Condition



(B) Maximal Coverage of Settlement by Police Service, Assuming all Roads are Good

Another focus of the literature on obstructions to emergency service delivery is street flooding [6], [11]. The use of some newly developed accessibility models and OpenStreetMaps to solve accessibility problem to emergency services was suggested, particularly in developing countries. The approach is described as quick and cost-effective [13].

The approaches adopted by most studies of road obstructions to emergency service delivery assumed that the conditions of the roads are uniform, apart from locations where there are obstructions. It has been shown in this study that there are different categories of roads, and speed and time used by emergency vehicles will vary according to the state of disrepair of the type of road.

It is suggested that further studies can be carried out on other factors that can affect police emergency service delivery. Researchers can look at duration and causes of delays that occur while processing incoming emergency calls by police (e.g. poor telecom signal) and while preparing emergency crews and vehicles for dispatch in developing countries.

5. Conclusions

It has been observed that poor road conditions can prevent the police from getting to an emergency scene on time to save or assist those affected [3]. This study has demonstrated that the response of the police to emergency calls will be improved if the bad roads are fixed, and thus citizens' protection and the state of security in the Country can be improved.

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