The Role of Demand-Responsive Transportation System in Road Traffic Accidents in part of Ibadan, Oyo State, Nigeria

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ABSTRACT

Road Traffic Accidents (RTAs) are common occurrences on Nigeria roads and Ibadan is not an exception. Non-availability of facilities to take the injured to the nearest hospitals necessitated this study. The study looked at the role played by Demand-Responsive Transportation System in Road Traffic Accidents in part of Ibadan with a view to reduce deaths caused by the inability of the available system on ground to rescue the injured from the scene of the accidents to the nearest hospitals for immediate first aid or outright treatment. The aim is to locate an accident scene, the nearest hospital and the shortest route to the hospital with facilities to treat the victims. The study adopted Remote Sensing and GIS methods to acquire both primary and secondary data and used ArcGIS 10.3 software for the processing of the data and performed geospatial analyses to produce information for a Decision Support System. Twenty three hospitals and eleven accident scenes were considered. The hospitals have the basic facilities to take care of victims of Road Traffic Accidents within the study area. The study revealed that 63.64% of the total Road Traffic Accidents’ scenes in the study area occur on the Dual carriage ways while the remaining 36.36% occurred on the single
lane roads. The travel distances range from 1.4 Km to 3.3 Km between one of the accident scenes and twelve of the hospitals. The number of hospitals available to attend to the RTA victims within an accident scene are between 0 and 6 when a distance of 1Km is considered and can be more with increase in the travel distance but should rather be shorter because of danger in travelling farther with injured victims. There are also overlaps because of the distribution of the accident scenes and the hospitals in the study area.

**Keywords:** Road Traffic Accidents, Safety, Demand-Responsive, Database, GIS

1. **INTRODUCTION**

In demand-responsive public transportation system, fellow traveler groups have been established for applicants based on spatial concepts and tools of GIS and also for each group according to its’ members and their paths, a public vehicle has been allocated to them then based on dynamic routing, the fellow passenger group has been gathered from their origins and has been moved to their destinations through optimal route [1]. The movement and transport of people and goods is spatial by its very nature. Thus, geospatial fundamentals of transport systems need to be adequately considered in transport models. However, driven by recent conceptual, methodological and technical developments, the need for an integrated approach is obvious. The potential of Geographical Information Systems (GIS) for transport modeling was examined. Three fields of transport modeling were identified where the spatial perspective can significantly contribute to a more efficient modeling process and more reliable model results, namely, geospatial data, disaggregated transport models and the role of geo-visualization [2].

At least three major innovation paths were identified. First, ICT (Information and Communication Technologies) has not only changed the way people and goods are moved, but also what was known about this mobility. Secondly, the required Intelligent Transportation Systems (ITS) rely on accurate data and well-performing communication, management and analysis components, each with a distinct spatial notion [3], [4]; as found in the work of [2]. Thirdly, within the transport modeling community, a paradigmatic shift from aggregated models, with the Four-Step Model (FSM) as the most prominent example to activity-based and micro-scale models, can be observed [2].

The advantages of Demand-Responsive Transportation include but not limited to reducing traffic congestion, CO₂ emissions, air pollution, accidents, financial costs, and other environmental damages. Demand responsive transport services are planning computer systems in charge of the assignment and scheduling of client’s traffic requests and using different vehicles available for these purposes [5]. Travel requests are generated by demand-generators by each traveller. Each of the requests specify the origin and destination points for a journey [6]. This is shown in this study as the hospitals are the origin points and the Road Traffic Accidents’ points as the destination points or the other way round for immediate evacuation to avoid fatalities due to time wastage in taking the victims to the nearest medical facility.

[7] opined that for over four decades history of computer simulation in traffic analysis, the system has developed from a research tool of limited group of experts to a widely used technology in the research, planning, demonstration and development of traffic systems.
The five driving forces behind this development are the advances in traffic theory, in computer hardware technology and in programming tools, the development of the general information infrastructure, and the society's demand for more detailed analysis of the consequences of traffic measures and plans. The basic application areas of simulation have mainly remained the same, but the applications have grown in size and complexity. The applications of parallel computing and GIS databases are some of the latest trends in traffic systems simulation. Road traffic accidents (RTAs) according to [8] have emerged as an important public health issue which needs to be tackled by a multi-disciplinary approach. He went further to submit that the trend in RTA injuries and death was becoming alarming in countries like India which accounts for the number of fatal and disabling road accident happening day-by-day and is a real public health challenge for all the concerned agencies to prevent it. The approach to implement the rules and regulations available to prevent road accidents is often ineffective and half-hearted. This is why GIS is adopted for this study as another alternative disciplinary approach to evacuate the injured to the nearest first aid centre or hospital which is the main aim of this study. Ibadan just like any other city in the developing world experiences road traffic accidents on daily basis whether disabling or fatal.

Most countries have a multidisciplinary approach to traffic planning and road design as it is done by psychologists, engineers, doctors, sociologists, vehicle experts, etc. and that lessons could be learnt from the eminent guidelines and good practices for good behaviour on the roads practiced in developed countries where safety, orderliness and discipline are ingrained in the citizens. Drivers should learn to show consideration and respect to co-vehicle drivers and pedestrians so that our roads become safer [8].

Crashes, in addition to playing a major role in health effect, impose many direct and indirect costs to the society. The problem is more prevalent in developing countries, such that crashes account for a primary cause of death. The study looked at the impact of road crashes on the increase of the value added of the transport sector. At the end of the study, it was concluded that the results of estimating the model indicates that one percent increase in the number of accidents, decreases the growth rate of value added of the transport sector by 0.054 percentage point [9]. Road Traffic Accidents in Ibadan had created a lot of untold hardships on the households where the breadwinners had been lost to crashes on these roads and had consequently reduced the values added to the sector in recent years due to unstable economic situations in the country.

In a research conducted by [10], it was concluded that motorcycle-motorcycle, motorcycle-vehicle and vehicle-vehicle crashes were the lead types and resulted in 38.9, 37.5 and 14.9% of the total of 855 deaths recorded within the period of study in Imo State, Southeastern Nigeria. [10] further stated that private cars, minibuses and taxis accounted for most of the accidents with 94.7% of the total accidents. The type of vehicle, the class of the victim or how the RTA occurred is not considered in this study but getting the victims to the nearest hospital for first aid or treatment as the case may be or in case of fatality getting the corpse to the morgue. The inadequate post-crash care is dwelled upon by this study because injured victims are treated few minutes after a crash. Road Traffic Accidents have become a normal and re-occurring phenomenon in Nigeria which constitutes a menace in modern times. Nations of the world have suffered from varying degrees of road accidents, the developing countries clearly dominates with Nigeria having the second highest rate of road accidents among 193 ranked countries of the world. Deaths from reckless driving are the third leading cause of death in Nigeria [11].
Figure 1. Composite map of the Study Area
Nevertheless, a speed limit for vehicles varies from country to country depending on its applications, types of roads and environment. A speed limit is described as the pace of moving vehicles at a given time frame as specified by traffic law. It is the maximum legal speed a vehicle can travel under ideal conditions. Speed Limits for various categories of vehicles are expressed in km/hr. However, the speed limit is not applicable in all, we have common sense speed limit. According to Federal Road Safety Commission (FRSC) established by the Federal Government of Nigeria to regulate the activities of vehicles on Nigerian roads created the common sense speed limit depending on the situation for example when road is defective or when the weather is bad. The speed limit for vehicles in Km/hr is given in Table 1.

Table 1. Speed limits for vehicles in km/hr

<table>
<thead>
<tr>
<th>S/N</th>
<th>Types of vehicles</th>
<th>Town &amp; Cities (built-up area)</th>
<th>Highway</th>
<th>Express way</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Motor cycle</td>
<td>50</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Private cars</td>
<td>50</td>
<td>80</td>
<td>100</td>
</tr>
<tr>
<td>3.</td>
<td>Taxi &amp; Buses</td>
<td>50</td>
<td>80</td>
<td>90</td>
</tr>
<tr>
<td>4.</td>
<td>Tankers &amp; Trailers</td>
<td>45</td>
<td>50</td>
<td>60</td>
</tr>
<tr>
<td>5.</td>
<td>Tow Vehicle while towing</td>
<td>45</td>
<td>45</td>
<td>45</td>
</tr>
<tr>
<td>6.</td>
<td>Tow Vehicle Not towing</td>
<td>50</td>
<td>60</td>
<td>70</td>
</tr>
</tbody>
</table>


The study area is part of Ibadan. It lies within longitudes 3° 53’ 20.922” and 3° 56’ 39.438” east of the Greenwich Meridian; and latitudes 7° 23’ 25.101” and 7° 26’ 07.185” north of the Equator. It falls within Akinyele in the northern part, Lagelu in the eastern part and Ibadan North in the western part. The exact population could not be ascertained but the population of Ibadan is estimated at 3,800,000 people according to [12]. The study area has the Nigeria premier university, University of Ibadan, the premier National Television Station in Africa, the popular Cocoa House which used to be the tallest building in the country. The map of the study area is shown in Figure 1.

2. MATERIALS AND METHODS

For any GIS work, the first step is identifying the entities in the study area which will form the basic features of interest in the application under review. It is believed that whatever is not relevant to the application under review is not an entity. Vector data model was adopted for this study [13]. This forms the basis of the entities that were digitized from the imagery used for the study. The materials used for the study included the georeferenced Ikonos Imagery of the study area with a resolution of 1.0m acquired from the Office of Surveyor-
General of the Federation (OSGOF), Abuja which served as secondary data set. The study area boundary, rail line, water body, forest area, roads were digitized from the imagery and attribute information of the entities attached to the tables using ArcGIS 10.3 software. Relational database was adopted for the study. The locations of hospitals that can handle cases involving RTA victims and accidents’ hotspots were picked with handheld Etrex GPS with 3.0m accuracy. These were added to the ArcGIS 10.3 environment for further geospatial analyses by exploiting the analytical capabilities of the software used for the study.

![Figure 2. Ikonos Imagery of the Study Area](source: OSGOF, Abuja)

3. ANALYSES AND RESULTS

Analyses were carried out on the created relational database that include but not limited to spatial and attribute queries, routing, statistical analyses showing the distribution of the RTAs spots in the study area.
3. 1. Analysis 1: Spatial Query

A spatial query provides a means of referring to spatial data or its properties in order to identify the appropriate spatial or non-spatial information being requested. Spatial queries involve a range of spatial data types and properties. Either or both the spatial and attribute data may be utilized in the query to produce a result that can be either spatial, textual or both. Queries may involve points, lines, polygons, or a combination. Spatial queries can be Feature-Based Queries, Range-Based Queries and Complex Queries [14]. Spatial query was performed to find out Road Traffic Accidents that occur on Dual Carriage ways and the Single Lane roads in the study area.

Query 1. Figure 3 shows the result of the RTAs that occur along the Dual carriage ways in the study area. The map of the result is as shown in Figure 4. Those mostly involved are the taxi cabs also called “Micra” and trucks like trailers and tankers which often results in explosions and a lot of people are burnt beyond recognition and some lead to fatality.

Figure 3. Result of Road Traffic Accidents that occur on Dual Carriage ways
Figure 4. Map of Road Traffic Accidents that occur on Dual Carriage ways
Query 2. Figure 5 shows the result of the RTAs that occur along the Single Lane roads in the study area. The map of the result is as shown in Figure 6. This represents four out of the eleven scenes examined for the study. They are located at the northern part of the study area where there are single lane roads and are mostly residential areas with few commercial buildings. The RTAs involve mostly the minibuses, taxis and motor cyclists.

Figure 5. Result of Road Traffic Accidents that occur on Dual Carriage ways
Figure 6. Map of Road Traffic Accidents that occur on Single Lane Roads
3. 2. Analysis 2: Routing

Routing allows someone to plan the most efficient way to get to multiple locations in the most efficient manner. The simplest example of this is Web-based direction sites such as Mapquest.com that allow you to determine the most efficient way to get from one location to another. A more advanced example would be a routing package that allows a school system to plan the most efficient route to pick up all of the third and fourth graders and get them to school on time [14]. The system picks twelve hospitals with adequate facilities (Figure 7) that can take care of the RTA victims around the accident scene; the closest hospital is chosen to save the lives of the victims. A call or demand for the services of these hospitals requires that they travel along the routes shown to the accident scene.

![Diagram of Hospitals around a Road Traffic Accident Scene](image)

**Figure 7.** Diagram of Hospitals around a Road Traffic Accident Scene

The summary of the various distances travelled from the accident scene to the twelve chosen hospitals are shown in Figure 8. The closest is Femi Specialist Hospital which is 1.4Km which will take the ambulance less than a minute or two all things being equal and The Grace Hospital is the farthest with a travel distance of 3.3Km.
Figure 8. Direction window of Hospitals around a Road Traffic Accident Scene and the distances to be travelled to them.

The direction window of the distance travelled from the Accident Scene to Femi Specialist Hospital is 1.4Km showing the various directions within the streets to the hospital. This is shown in Figure 9.

Figure 9. Direction window from Road Traffic Accident Scene to Femi Specialist Hospital.

3.3. Analysis 3: Spatial Statistics

Spatial statistics help in cutting through some of the subjectivity and ambiguity associated with data analysis in order to describe more effectively spatial patterns, spatial relationships, and spatial trends. The problem of trying to identify unexpectedly high rates of traffic accidents in a region can be solved with spatial statistics [15].
Figure 10. Map of Hospitals available to the Road Traffic Accident Scenes

With spatial statistics, the statistical significance of the accident rate and its spatial pattern can be determined, and this becomes the basis for the selection of threshold values.
When problems are especially difficult to solve or when the decisions made as a result of a GIS analysis are especially critical, it is important to examine data and the context of the problems from a variety of perspectives [15].

The application of spatial statistics according to [15] is just one of many possible approaches; it is a powerful approach, however, and can effectively supplement visual, cartographic, and traditional statistical approaches to spatial data analysis. The service area tool in ArcGIS 10.3 was adopted to know the number of hospitals available to each accident scene. This is summarized in Table 2 and the map is shown in Figure 10.

Table 2. Hospitals available to each Road Traffic Accident Scene

<table>
<thead>
<tr>
<th>S/N</th>
<th>RTA SCENES</th>
<th>NUMBER OF AVAILABLE HOSPITAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Accident Scene 1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Accident Scene 2</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>Accident Scene 3</td>
<td>6</td>
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<tr>
<td>4</td>
<td>Accident Scene 4</td>
<td>3</td>
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<tr>
<td>5</td>
<td>Accident Scene 5</td>
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<tr>
<td>6</td>
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<tr>
<td>7</td>
<td>Accident Scene 7</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>Accident Scene 8</td>
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<tr>
<td>9</td>
<td>Accident Scene 9</td>
<td>3</td>
</tr>
<tr>
<td>10</td>
<td>Accident Scene 10</td>
<td>0</td>
</tr>
<tr>
<td>11</td>
<td>Accident Scene 11</td>
<td>2</td>
</tr>
</tbody>
</table>

4. DISCUSSION OF RESULTS

The queries performed on the database showed that seven out of the accident scenes examined during the study occurred on the Dual Carriage ways representing 63.64% of the total Road Traffic Accidents’ scenes in the study area while the remaining 36.36% occurred on the single lane roads. The majority of the accidents occurring on dual carriage ways may be attributed to the motor cyclists using the dual carriage ways in the study area and not keeping to the traffic rules and trucks using the roads in the day time during the peak periods. The accident scene that was indicated in Figure 7 has twelve hospitals around the vicinity with travel distances ranging from 1.4Km to 3.3Km. The closest being Femi Specialist Hospital which is where the victims should be taken for treatment and the farthest is The Grace Hospital in the study area. Accident scenes 3 and 4 have Six and four hospitals respectively to visit in case of RTAs; while Accident scenes 4, 5 and 9 have three hospitals
each; Accident scenes 6, 7 and 11 have two hospitals within the study area to attend to the victims; Accident scenes 1 and 8 have one hospital within the crash area and finally Accident scene 10 has none. The travelling distances were based on 1Km along the network of roads in the study area. There were also overlaps due to the distribution of the accident scenes and the hospitals.

5. CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

The various aspects of the study indicated that the capabilities of GIS tools are very essential and important in the rescue of Road Traffic Accidents’ victims. The time is ripe for a more robust GIS-Based Demand-Response Transportation Systems in our cities around the nation. The aim of rescuing victims from the accident scenes to the hospitals for treatment on time using the shortest route has been achieved as shown in the study.

5.2. Recommendations

With the various observations and the conclusion drawn from the study, the following recommendations are hereby put forward to the various stakeholders in the study area and the country at large. They include but not limited to:

1) Heavy duty trucks like trailers, tankers and other categories of such road users should be restricted to travel on the roads at night especially within the city centres when the roads will be busy and congested. Most accidents that occur were attributed to these trucks.

2) The motor cyclists on two wheels should be banned from plying dual carriage roads henceforth, this is the reason why their category was not included in the Federal Road Safety Commission speed limit on Expressways. They should also be mandated to wear crash helmets when riding on the motor cycles at all times. These laws have been promulgated in some neighboring states like Lagos and Ogun.

3) From the findings, some vehicles are not worthy to ply the roads in the study area. Hence, the Vehicle Inspection Officers (VIOs) should be well equipped to carry out their duties of thorough inspection of vehicles for road worthiness. Some are without good illumination, good braking systems and other lifesaving gadgets that should be available on every vehicle.

4) Drivers should learn to show consideration and respect to co-vehicle drivers and pedestrians so that our roads become safer. The truck drivers see themselves as Lords on other road users which is totally wrong and one of the causes of fatalities on our roads.

5) The constant traffic congestion along Iwo Road to Gate market is often caused by the presence of the Gate spare parts market in the study area. The market should be moved elsewhere to allow free flow of traffic at that end of Queen Elizabeth Road [16]. This is because most crashes occur very close to where traffic congestions happen as a result of drivers held in the traffic trying to make up for the time wasted in the grid lock.
Biography

- Amusa, I.A. is a GIS Specialist, Transportation Consultant and a Principal Instructor II at the Federal School of Surveying, Oyo, Nigeria and currently pursuing a Master of Science degree in Surveying and Geoinformatics at Nnamdi Azikiwe University, Awka, Nigeria with special interest in Transportation planning and modelling.

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- Akinpelu, A.A. is a Registered Surveyor and a Senior Lecturer at Lagos State Polytechnic, Ikorodu, Lagos State, Nigeria currently pursuing a Master of Science degree in Surveying and Geoinformatics at Nnamdi Azikiwe University, Awka, Nigeria.

- Nmeregini, C.S. is a staff of Abia State Polytechnic, Aba, Abia State, Nigeria and a GIS Specialist with keen interest in using GIS for environmental management.

References


