IMPLEMENTATION OF ORIGIN-DESTINATION COST MATRIX INTELLIGENT TRANSPORT SYSTEM FOR PORT HARCOURT METROPOLITAN CITY OF RIVERS STATE, NIGERIA.

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The recent increase in the cost of the Premium Motor Spirit (PMS), otherwise known as fuel in Nigeria has necessitated rapid cost of transportation of goods and services hence, resulting to economic hardship on the populace. Obviously, there is need for a careful analysis of destination of travel and the associated cost, as measure of survivor in face of the economic hardship. The research focused on the implementation of Origin-Destination Cost Matrix for purposes of intelligent and cost effective transportation in the Metropolitan City of Port Harcourt. The methodology involves the acquisition of the map of the study area and relevant road network data. Overlay operation was done on the data using ArcGIS 10.5 and the network data prepared. This was achieved through; the acquisition of road network, waterway network and social facilities; conversion of the data into compactable format; calculation of impedance attributes; definition of assigned attributes, as well as verification and refinement of the network. The study stimulated a case of a courier service at a given destination designated to deliver parcels to six different locations. The Origin-Destination (OD) cost matrix analysis revealed the shortest distances of 4.15km, 7.71km, 8.22km, 10.17km, 11.37km, and 22.10km to the six different locations, making a total distance of 63.72km. This information is significant as it can help the courier service to plan and optimize their delivery routes, reducing travel time, increase efficiency, improves service delivery and customer satisfaction, reduces fuel consumption, and saves cost. The study further re-iterates the importance of Intelligent Transport System (ITS) service delivery, and cost reduction.

Keywords: Origin-Destination Cost Matrix, Intelligent Transport System, Network Analysis.

1.0 Introduction

Transportation problem is fast becoming one of the social menaces in urban centres around the country, due to the rural-urban drift in search of greener pasture. The movement puts immense pressure on the available facilities in the city centres, including transportation systems. The problem of transportation in Port Harcourt City include, congestion at the peak periods due to

volume of traffic on the major routes, non-availability of up-to-date road network maps and absence of an Intelligent Transportation System. People waste a lot of man-hours in traffic at peak periods; goods and services suffer due to transportation challenges, it is either there is a traffic jam or the vehicles are not available. (Obafemi, et al, 2011).

Keeping traffic moving is a big challenge that all levels of government are facing worldwide. Private travellers, commercial road users, and the public sector are continually searching for new and faster travel routes. Without quality and dynamic data, route selection is often a hit and misses guessing game. The old adage, 'knowledge is power' is the obvious solution to the traffic problem. Customers want real-time information to help them select the best route to take at any given time. They need to know traffic speeds, incidents (accidents or lane closures), and road conditions. (Ogochukwu, et al, 2018).

There is widely accepted link between economic well-being and good transportation. However, the picture is not all rosy. There is a price to pay for good transportation. This comes in the form of undesirable side effects such as environmental impacts, energy consumption, land take, congestion, casualties and money required to build infrastructure. Growing concern about the impact of these undesirable side effects has influenced most developed countries to move away from the "build it and they will come," infrastructure-intensive, capital-intensive transportation strategies, toward more balanced and sustainable transportation solutions. (Olujimi, 2009).

Nigerians are recently experiencing more economic hardship due to hike in transportation fair, which is primarily occasioned by the increase in the cost of petroleum product. The cost of goods and services has increased uncontrollably. There is need for the implementation of an of an informed and cost efficient transportation system across cities in the country. Intelligent Transport System has been identified to be a viable tool in providing easy, coordinated and cost effective mobility of goods and services. In addition to supporting specialization, informed

transportation provides us with the sort of mobility and accessibility we need to live our lives in a smarter manner. (Ajie and Igbokwe, 2023).

Intelligent Transport Systems is the name given to the application of computer and communications technologies to transport problems. In a rapidly changing society, the emphasis on road technology improvements to assist in road management has been identified. The rapid advances in ITS technologies have enabled the collection of data or intelligence which provides relevant and timely information to road managers and users. (Jonkers and Gorris, 2015).

According to Jonkers and Gorris (2015), Advanced Traveller Information Systems (ATIS) enables drivers to make informed and better decisions for route estimation and travel time determination. Fast and accurate information translates into several benefits for ATIS customers such as reduction in travel time, reduction in stress levels, the avoidance of congestion, and perhaps the most important benefit and the avoidance of unsafe driving conditions. The ultimate solution requires critical features that include accuracy, timeliness, and reliability.

Origin-destination (OD) cost matrix analysis is a network analysis tool in ArcGIS that helps to determine the travel time or distance between a set of origins and destinations in a network dataset. It is also referred to as network OD cost matrix analysis. It is a table that contains the travel time and travel distance from each origin to each destination. Additionally, it ranks the destinations that each origin connects to in ascending order based on the minimum time or distance required to travel from that origin to each destination. The best path on the street network is discovered for each origin-destination pair, and the travel times and travel distances are stored as attributes of the output lines. Even though the lines are straight for performance reasons, they store the travel time and travel distance along the street network, not straight-line

distance. The OD matrix, in combination with information regarding the availability of the different transport modes, user preferences, and speed flow curves, is used to assign travel according to modes and itineraries; assign traffic and vehicle flow to each link of the road network, and calculate travel times. (Mahmoud, 2022).

Origin Destination Matrix is a description of movement in a certain area and is used to assess the demand for transportation. In an OD Matrix each cell is an intersection of a trip from an origin to a destination, and the higher the number of these trips the more this route is in demand. Origin-destination *(O-D)* flow data is another type of data that is frequently used in transportation studies. Such data have been traditionally represented in matrix forms, a two-dimensional array, for analysis. Unfortunately, the relational data model widely adopted in most commercial GIS software does not provide adequate support for handling matrix data. Some GIS-T software has developed additional file formats and functions for users to work with matrix data in a GIS environment. Conventional GIS approaches can thus be further extended and enhanced to meet the needs of transportation applications. The creation and expansion of add-ons for GIS software represent a way that specific methods and models can be implemented in existing packages.

2.0 The Study Area

The Metropolitan City of Port Harcourt consists mainly of the entire Port Harcourt City Local Government Area and the Obio/Akpor Local Government Area, as well as part of Ikwerre and Eleme Local Government Areas, all of Rivers State, as illustrated in Figure 1 & 2 . In the nearest future, the urban city will further sprawl to the other local government areas that made up the Greater Port Harcourt City, established in the GPHCDA Law, 2009 of Rivers State Government. Port Harcourt is located within latitudes longitude 6° 58′ and 7° 06′ East of the Greenwich Meridian and Latitude 4° 40′00” and 4° 55′ North of the equator. It is bounded by

Etche and Ikwerre Local Government Areas, Eleme Local Government Area and the Emohua Local Government Areas in the north, east and west respectively, while in the south it lies along the Bonny River. (Ajie and Igbokwe, 2023).

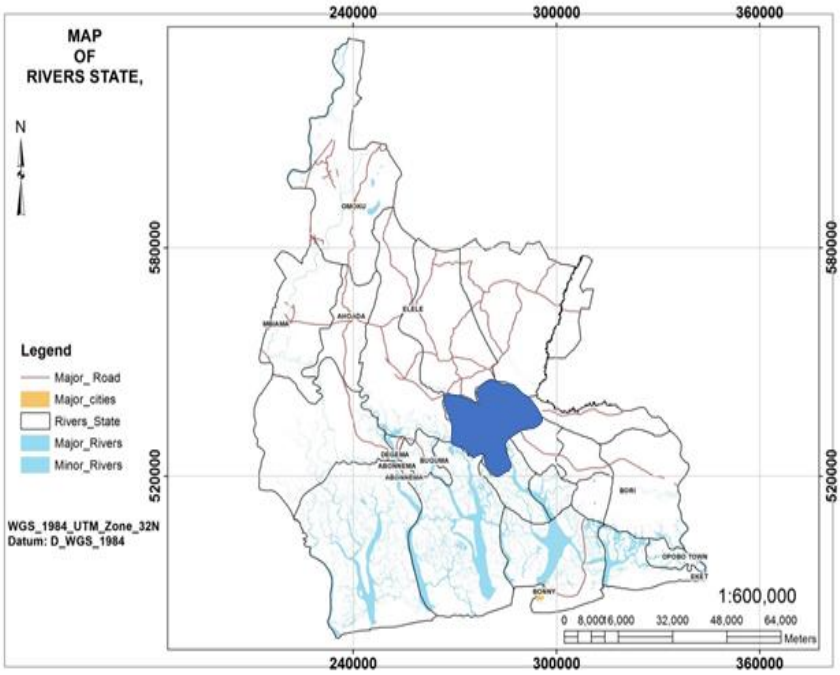


Figure 1: Map of Rivers State highlighting Port Harcourt City

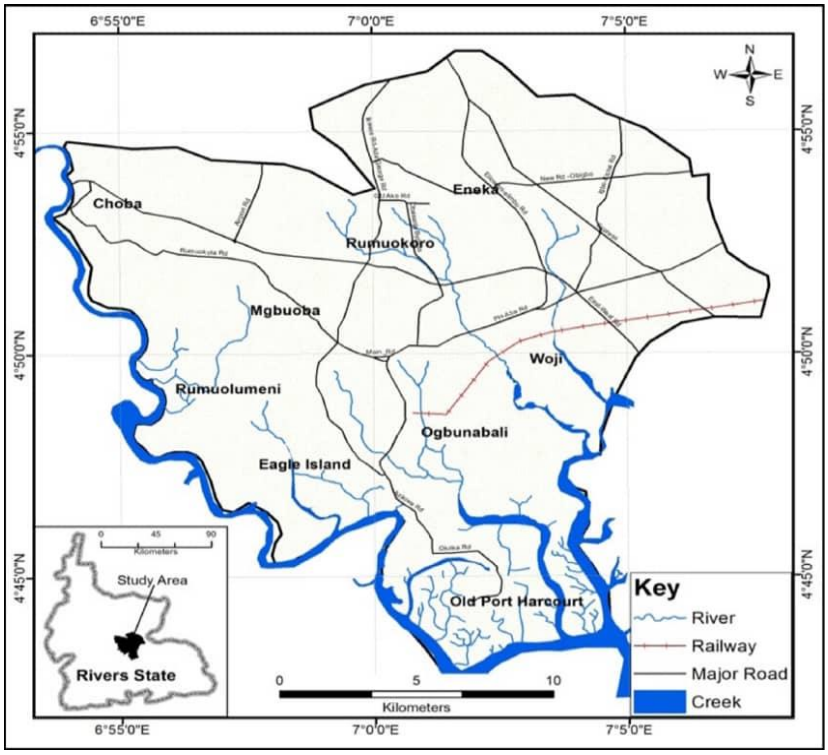


Figure 2: Map of Port Harcourt City

3.0 Materials and Methods

The data used for this research includes road network and digital globe imagery. These were obtained from the Office of the Surveyor General of Rivers State and www.digitalglobe.com, respectively. An overlay operation, using ArcGIS 10.5 software was performed on the abstracted data.

The network data was prepared using ArcGIS 10.5. In achieving this, the acquisition of road network, waterway network and social facilities of the study area was first carried out, followed by conversion of the data into compactable format. The impedance attributes were calculated by determining the length of each line segment in the road network and waterway networks. The derived length in meters is the required cost parameter on which the analysis was dependent on. After creating the network dataset, the network attributes such as speed, travel time, and distance were used to define the assignment of the attributes to the network features such as roads, intersections, and transit stations achieved. The network was verified by running test analysis to ensure that the network is accurate and complete. Errors or issues with the network were refined by adjusting the network attributes or modifying the network features.

To perform the Origin-destination (OD) cost matrix analysis, the following steps were taken, as shown in figures 3 below.

Origin-Destination
Cost Matrix Analysis

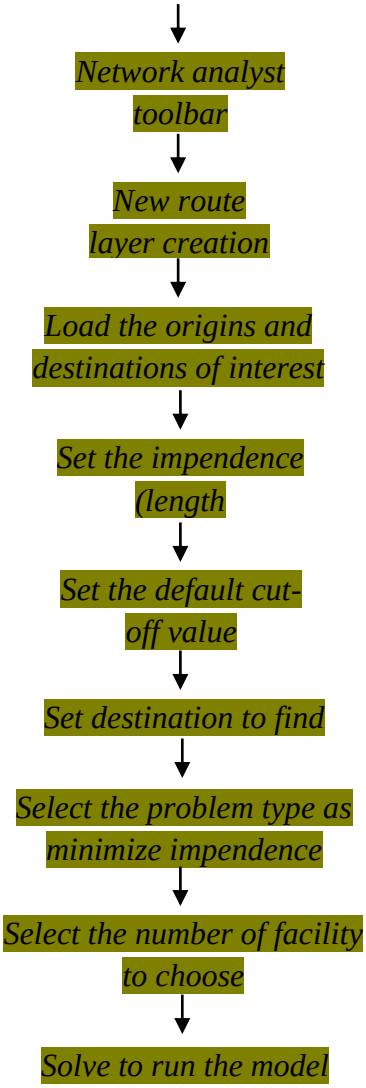


Figure 3: OD Cost Matrix flowchart.

4.0 Results and Discussion

OD Cost Matrix analysis in an Intelligent Transport System (ITS) is used to determine the distance and time between all possible origin-destination pairs within a network. The tool calculates the cost, in terms of travel time or distance, for each possible route between two locations in a network. To illustrate this application, the study makes use of the case of a Courier Service at No.1 Bishop Johnson Street, delivering parcels to six different locations (Rumuibekwe off Aba Road, Shell Gate, East West Road by Rumuodara Junction, Choba /

Uniport, 47 Herbert Macaulay Street Flat, Old G.R.A, No 152 Tombia Street G.R.A Phase II Oromeruezimbu and Plot 12/6 Bishop Dimeri Str, Off Evo Road G.R.A Phase II).

The OD Cost Matrix tool can be used to optimize the delivery routes. The tool would calculate the shortest or fastest route between each origin-destination pair, taking into account traffic conditions, road closures, and other factors that may affect the delivery time. This can help the courier service to plan and optimize their delivery routes, reducing travel time and increasing efficiency. Moreover, the OD Cost Matrix can be used to estimate the delivery time and cost for different delivery options, such as express delivery or standard delivery. This can help the courier service to offer their customers different delivery options with varying delivery times and costs, improving their service quality and customer satisfaction. The result is shown in figure 4.

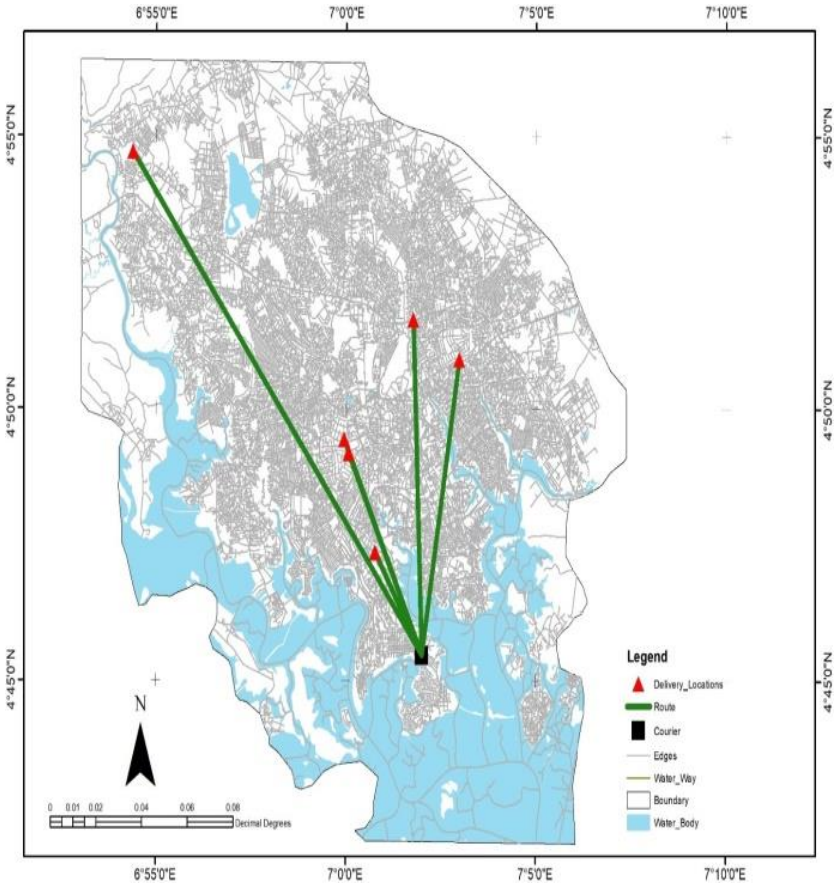


Figure 4: OD Cost Analysis

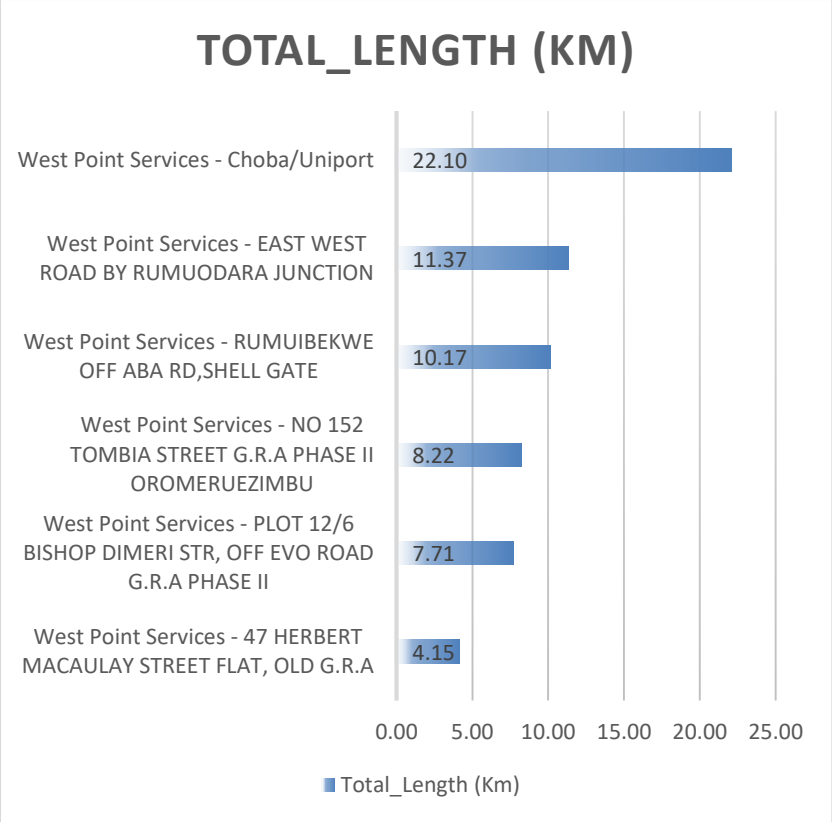


Figure 5: The shortest distance covered by the courier service to delivery destination

The OD Cost matrix analysis (Figures 4 and 5) for the courier service (West point services) reveals the shortest distances and total distance to be covered while delivering parcels to six different locations. The shortest distances to the destinations were 4.15km to 47 Herbert Macaulay Street Flat, 7.71km to Plot 12/6 Bishop Dimeri Str, Off Evo Road G.R.A Phase II, 8.22km to No 152 Tombia Street G.R.A Phase II Oromeruezimbu, 10.17km to Rumuibekwe off Aba Road, Shell Gate, 11.37km to East West Road by Rumuodara Junction, and 22.10km to Choba / Uniport, Old G.R.A.

The results indicate that the courier service will travel a total distance of 63.72 km to deliver the parcels to the six destinations. This information is significant as it can help the courier service to plan and optimize their delivery routes, reducing travel time and increasing efficiency. By considering the shortest distances to each destination, they can minimize the time and fuel required for each delivery, resulting in cost savings and improved service quality.

Moreover, this analysis can be used to estimate the delivery time and cost for different delivery options, helping the courier service to offer their customers different delivery options with varying delivery times and costs, improving their service quality and customer satisfaction.

5.0 Conclusion

This result recorded in this research is significant as it can help the courier service to plan and optimize their delivery routes, reducing travel time and increasing efficiency. By considering the shortest distances to each destination, they can minimize the time and fuel required for each delivery, resulting in cost savings and improved service quality. Moreover, this analysis can be used to estimate the delivery time and cost for different delivery options, helping the courier service to offer their customers different delivery options with varying delivery times and costs, improving their service quality and customer satisfaction.

The results have demonstrated that the intelligent transport system can significantly improve the efficiency and effectiveness of transportation services in the region. It can help to minimize travel distances, reduce travel time, and increase service quality, resulting in cost savings, improved customer satisfaction, and better patient outcomes.

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