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DETERMINING SHORTEST POSSIBLE ROUTES FOR MAJOR HEALTHCARE EMERGENCY PROVIDERS IN THE CITY OF LAHORE-PAKISTAN: A GEOGRAPHICAL APPROACH

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ABSTRACT

In an emergency, it becomes difficult to find the incident/destination location in urban centers like Lahore-Pakistan. Therefore in this writing, an attempt has been made to access the health care facility from the incident location with the shortest route in a minimum period by taking time as their basic parameter instead of the distance. The main purpose of using GIS in this research is to access the short distant approach of a health care emergency service in the city of Lahore in case of any incident or emergencies like a roadside accident, sudden health issues (strokes, cardiac issues, or injuries in inter-personal conflicts/disputes). One of the objectives of this research is to create a GIS-based system for network analysis that will provide the best route from the emergency healthcare providers' location toward the incident location. The closest facilities analysis has been performed that can be of foremost significance to target an incident location in a definite time from an emergency service provider. The resulting facility thus, shortens the time, effort, and resources and will be very significant for saving people's life. Secondly, the closest facility analysis shows the main routes between instances and services. Thirdly, this research work will provide a complete methodology to create the shortest road network for different purposes, which are best in terms of both time and distance to reach the destination as fast as possible. As per results, almost all the major locations in Lahore can be covered within seven minutes by taking standard speed according to road type.

KEYWORDS: Emergency Healthcare Providers, GIS Techniques, Incident location, Network Analysis.

1. INTRODUCTION

The Geographic Information System is very impotant ital, especially when it comes to planning. It has been used in a variety of industries to help in planning and monitoring (Ahmadi et al., 2017). It has been widely used in

Telecom and network services, Urban planning, Transportation Planning, Environmental impact analysis, Agricultural planning, Land use planning, Surveying, Fire equipment response analysis, Forest fires hazard zone mapping and planning, Traffic density planning, Space utilization planning, regional planning, and Disaster and business community planning, etc. Network analysis is one of the most significant functions of GIS (Forkuo and Quaye-Ballard, 2019). Different types of analysis are performed in GIS i.e., hotspot analysis, buffer analysis, service area analysis, and accessibility analysis (Ahmed et al., 2018, 2017). The main purpose of using GIS in this research is to access the short distant approach of a health care emergency service in city Lahore in case of any incident or emergencies like a roadside accident, sudden health issues (strokes, cardiac issues, or injuries in inter-personal conflicts / disputes) (Forkuo and Quaye-Ballard, 2019; Ghavami, 2019; Gu et al., 2018). Professionals use the GIS technique for better planning the public health issues and reach better decisions related to public health issues. Below mentioned are some works are done by researchers on Emergency Response System (Audu et al., 2021; Barták et al., 2016; Chowdhury et al., 2018; Comber et al., 2011).

In this writing an attempt has been made to access the health care facility from the incident location with the shortest route in a minimum period by taking time as their basic parameter instead of the distance. Other parameters like average speed, road width, waiting time were also used in the analysis to reach the destination through the path, which takes minimum time. In this research traffic congestion and the population was not considered (Gu et al., 2018; Gubara et al., 2015; Hu et al., 2020; Humagain et al., 2020) have taken Aurangabad, India as a study area to use the shortest route to find the specialized hospitals. The software used was ArcGIS and Dijkstra's algorithm that provides the nearest destination from the origin point (Jalil et al., 2018). And the distance was taken as their base parameter. Road state and road congestion were two flaws of the paper.

In research work by (Mar and Ne, 2019; Murad, 2018; Nicoară and Haidu, 2014) GIS-based fire emergency response service analysis was applied on Kumasi Metropolis, Ghana. This system was used by Ghana National Fire Service (GNFS) to identify the better route toward the incident destination. Distance, time, and delay in time were all used to model the optimal route (Obaid Alshwesh, 2018).

Based on all the above-mentioned researches, no such approach was made by any researcher which fills the gap for Emergency Response System using all necessary parameters (like Distance, time, the population on roads, and road condition) to reach the destination through the

shortest route in a short period (Obaid Alshwesh, 2018; Parvin et al., 2021; San Hay Mar Shwe, 2019; Silalahi et al., 2020). Therefore, a new way analysis was used in this paper by taking Distance, time, the population on road and road condition as parameters, and Emergency Healthcare facilities in the Lahore region were taken as a case study (Wan et al., 2021; Yun et al., 2020). The main objective of the study are determine the accessibility to the healthcare facilities with respect to time, distance and speed. Highlight the non accessible area which is not in responce time zone and extract shortest feasible route to approach the healthcare facilty.

1.1. STUDY AREA

For this research, Lahore was taken as a study area, which is the capital of the province of Punjab, Pakistan. Lahore is extended between 31.5204°N to 74.3587°E. The area of Lahore is 1,772 km². It is the country's second-most populous city and according to 2017, its population is 11.13 million. The contribution of Lahore to the national economy is estimated to be 11.5% and 19% to the provincial economy of Punjab. It is a very old city with a multicultural society (Muslim, Hindu, Christian, etc.), speaking many languages and practicing a great variety of traditions and customs. The road networks and major healthcare emergency centers in Lahore were used for the emergency response system analysis. Fig. 1 represents the map of the study area (Rana & Bhatti, 2018).

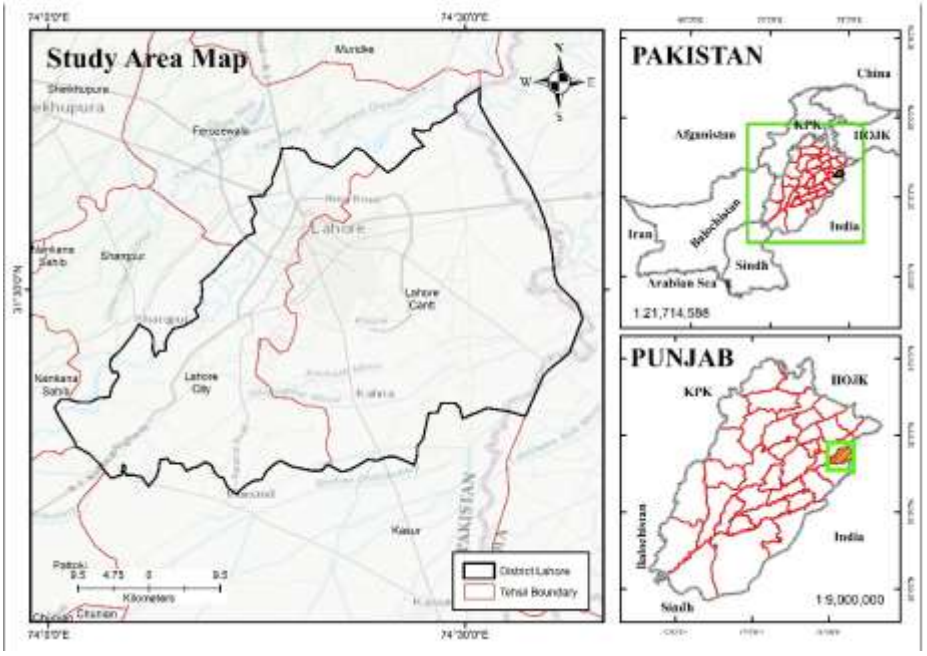

Fig. 1. Study Area Map

2. MATERIALS AND METHODS

In this research, Fig.2 shows the flow chart of the network analysis methodology to find out the shortest access of the emergency service provider to the incident point. This methodology involves following important steps, the first important step of this research is data collection which is downloaded from DIVA-GIS. With the help of this data maps of the area are created and it is used for analysis (like the study area base map, the road network data, population data, location of service provider Data) after this Geo-referencing was done for the study area base map(Murad, 2018; Nicoară and Haidu, 2014; Obaid Alshwesh, 2018). The next step is to digitize the data in the extent and then the shapefiles of major localities of Lahore, locations of emergency service provider and Road network are created as point, point, and line data respectively using Arc Map (Parvin et al., 2021; San Hay Mar Shwe, 2019; Silalahi et al., 2020). These shape files thus created, proceed with the data analysis Creating Network topology, finding the errors among point and line shapefiles, and correcting them by applying different rules. Make sure there are no dangles in the road network, or the roads do not intersect or overlap with each other. Correction of errors is followed by building network datasets. The network analyst extension is used in ArcGIS for this purpose. Following analyses are performed to find out the best results of the corresponding article (Wan et al., 2021). The closest facilities analysis is performed to perceive the closest facilities that can be target an incident location in a specific period from an emergency service provider based on travel, time, and traffic information available. The closest facility analysis shows the paramount routes between instances and services(Yun et al., 2020). To search the closest facility; it is mandatory to specify limitations, as in cutoff cost because facilities will not be explored in ArcGIS Network Analyst beyond this limit(Ahmadi et al., 2017; Ahmed et al., 2019, 2018, 2017; Amrapali C. Dabhade, 2014). An organization Service territory is that district that establishes all the available emergency facility providers and medical care units inside a specific zone. The Service Area solver is additionally founded on scheduled time and speed (Audu et al., 2021; Barták et al., 2016). The principal objective of the administration zone is to restore a subset of associated edge highlights with the end goal that they are inside the predefined network distance or cost cutoff; what's more, it can restore the lines arranged by a bunch of breaks esteems that an edge may fall inside (Chowdhury et al., 2018; Comber et al., 2011; Forkuo and Quaye-Ballard, 2019). Below mentioned flow chart illustrates the results from the network analysis performed using GIS software.

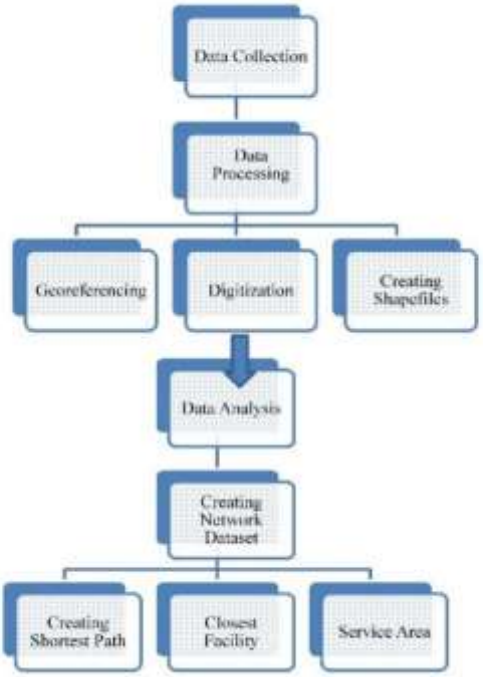

Fig. 2. Network Analysis Flow Chart

3. RESULTS AND DISCUSSION

In this research, four different types of analysis were performed. As it is the priority of healthcare emergency service providers to reach the destination point in the minimum time possible. The first analysis done was to analyze the total area covered by these healthcare emergency service providers in the period of three, five, and seven minutes (Which is considered as the maximum time to reach destination/incident)(Ghavami, 2019; Gu et al., 2018; Gubara et al., 2015). Fig. 3 shows that almost all the major locations in Lahore can be covered within seven minutes by taking standard speed according to road type. Some areas are closed to healthcare facility but the approach to these areas takes more time according to the road condition and average speed of the road. i.e. central Lahore areas are congested and take more than the proposed time while areas on the outer side of Lahore are isolated and average road speed is also more, which make it easy for an emergency service provider to reach distant areas within time(Hu et al., 2020; Humagain et al., 2020; Jalil et al., 2018; Lei Win, 2018).

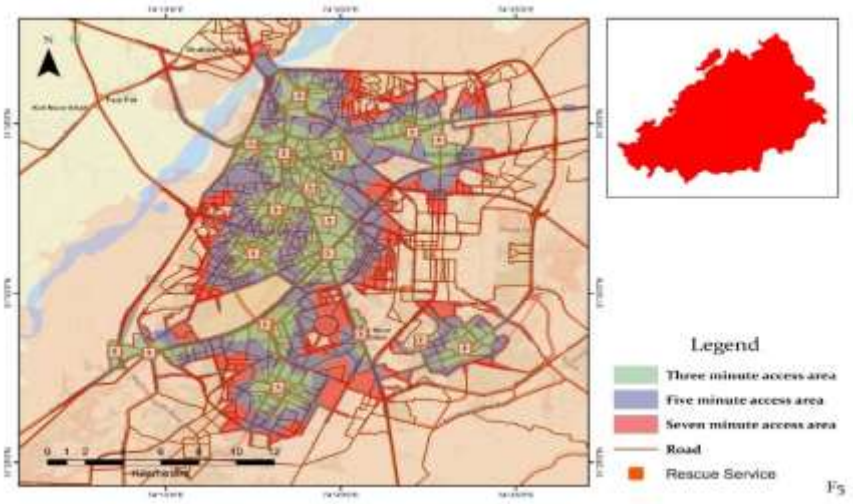

Fig. 3. Buffer analysis map for areas covered by Emergency Healthcare services

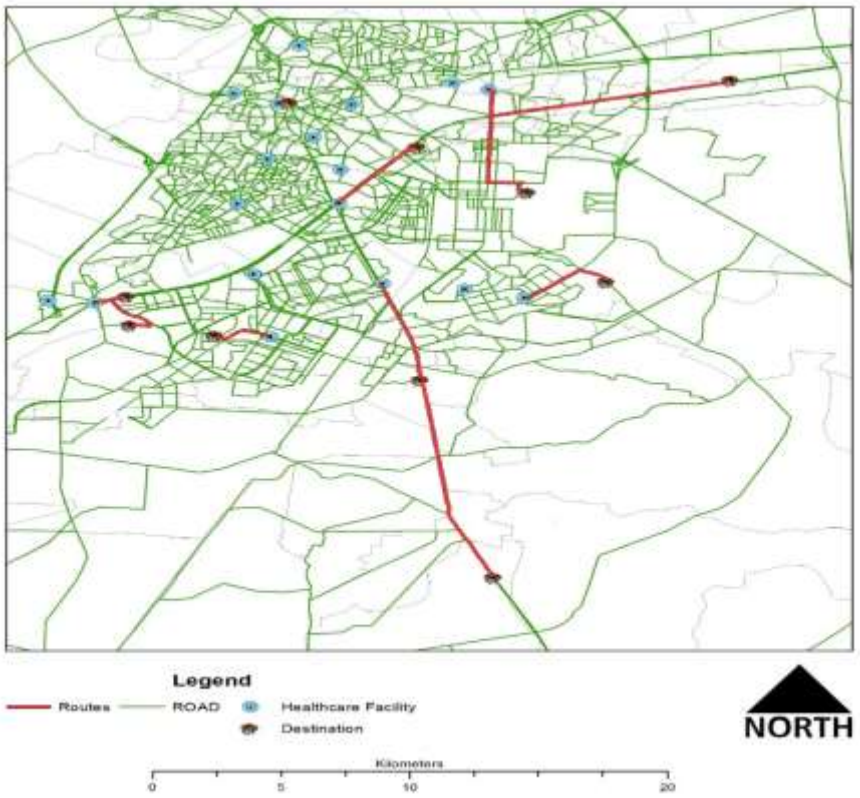

Fig. 4. Map of Emergency Healthcare facilities to the nearest Destinations (imaginative).

Some major societies of Lahore were taken as a destination/incident point. In Fig. 4 it can be seen that in congested areas of Lahore, many health care facilities are available to a single incident point. While on the outer side of Lahore there are also facilities that are far away from the major healthcare facilities(Mar and Ne, 2019). But the availability of emergency services to these areas is also made possible within time because of the better road condition and average road speed. Fig. 5 shows the road network covered by accident/incident points within seven minutes. Some accident points are covered by more than one emergency service while some have no emergency access while going away from the accident point(Murad, 2018; Nicoară and Haidu, 2014).

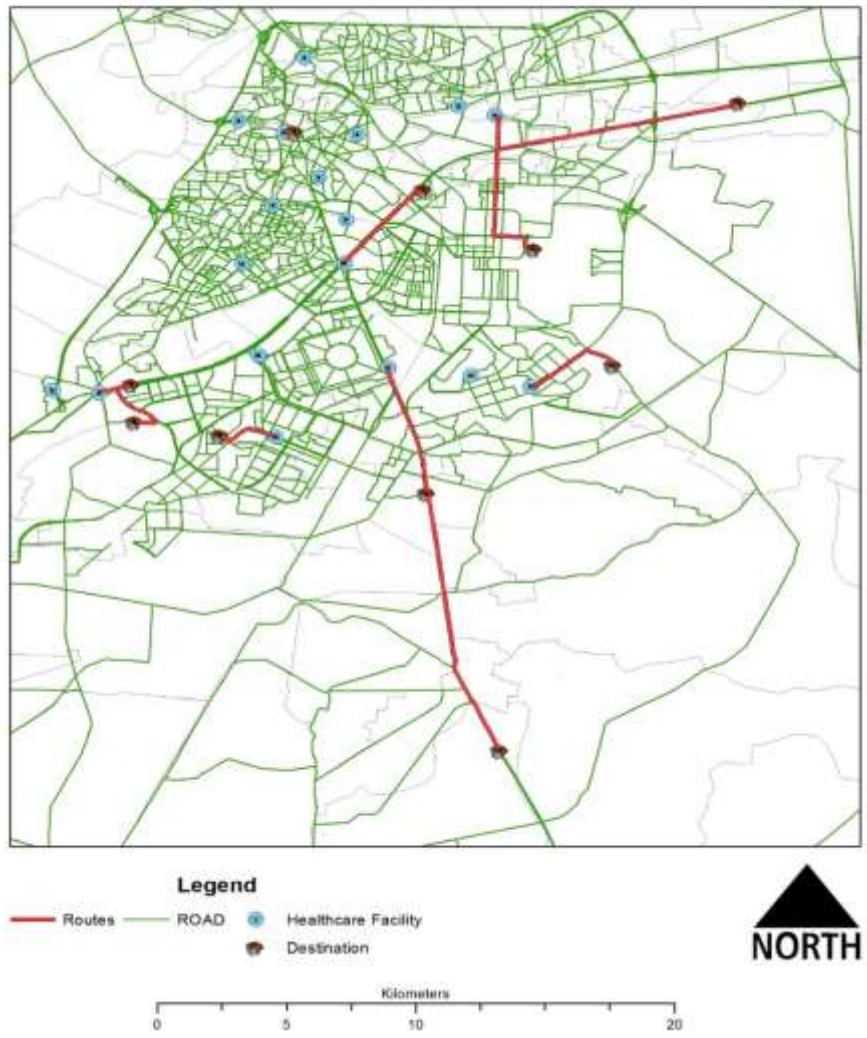

Fig. 5. Map of area covered by Destination points within 7 minutes

Fig. 6 shows the shortest route of emergency service to destination/incident points. Healthcare emergency providers can find the shortest route to accident points to provide health facilities within minimum time. In this analysis, single emergency services are available for more than one location while in some places there are also emergency services that are free (Obaid Alshwesh, 2018; Parvin et al., 2021; San Hay Mar Shwe, 2019; Silalahi et al., 2020). But again, here will come the point of population density, as denser will be the population high will be the demand of emergency services i.e., most accidents are noticed in populated areas.

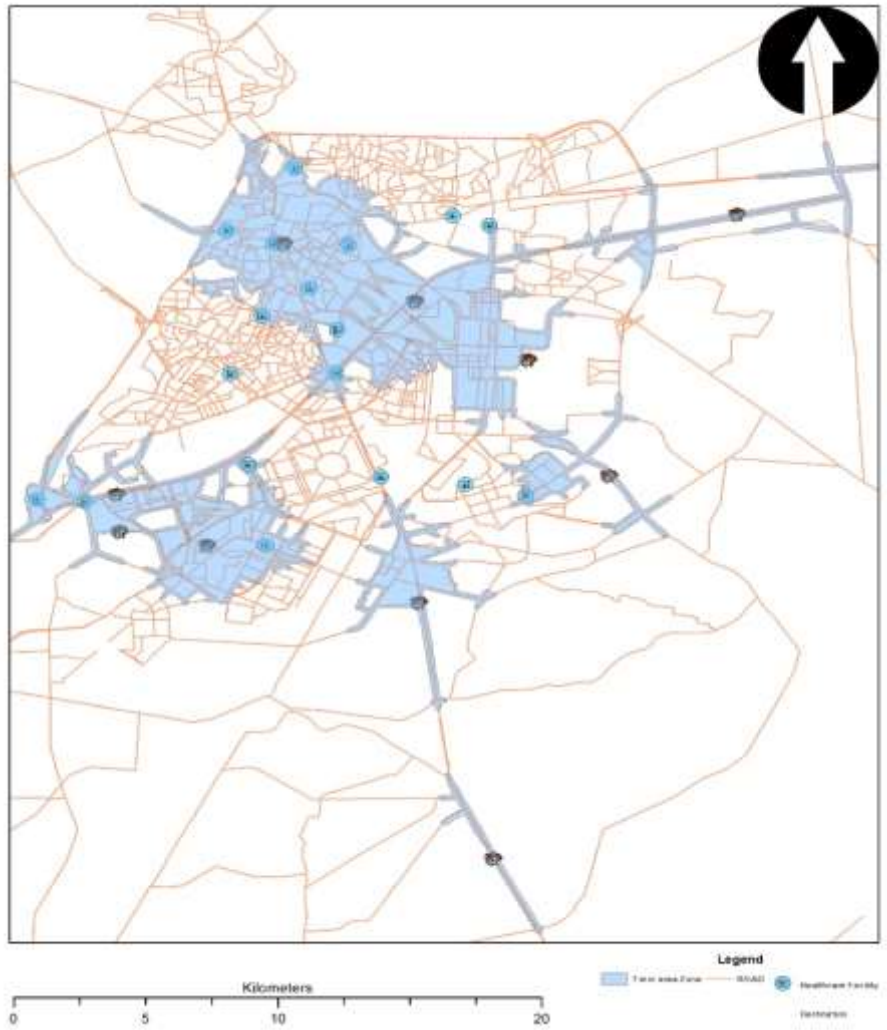

Fig. 6. Nearest Healthcare facility to Destination/Incident Map

Fig. 7 shows the possible shortest route for the incident points. In the map, purple square points are some of the imaginaries that show some accident or demo happenings near the road network and the purple lines on the road network show the shortest route that can be followed for accessing the incident point for the shortest distance and time. It is also useful to see which rescue station is nearest to approach the incident point (Ahmed et al., 2019; Amrapali C. Dabhade, 2014; Audu et al., 2021; Barták et al., 2016; Chowdhury et al., 2018; Comber et al., 2011; Forkuo and Quaye-Ballard, 2019; Ghavami, 2019; Gu et al., 2018; Gubara et al., 2015).

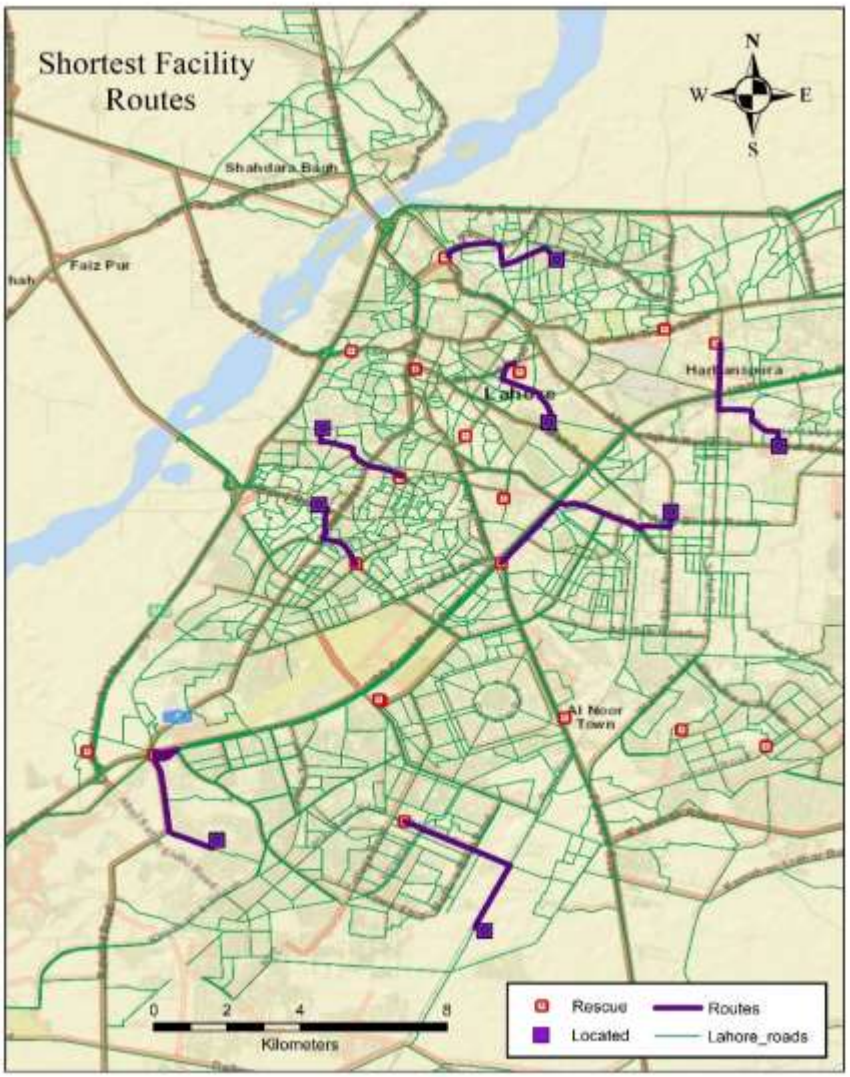

Fig. 7. Shortest Facility Routes Map 2020

4. CONCLUSION

Based on the above-mentioned purpose of this paper all parameters like distance, time, and road condition were used for the analysis of emergency healthcare availability by using GIS techniques in Lahore. The purpose was to use a new way GIS-based analysis to better access accident/incident points, which can be helpful and can be used by emergency care providers by taking all parameters under consideration. Far away areas were also defined by examples and possible accessibility was also proposed in this paper. This paper can prove to be helpful for professional planners to plan the allocation of new major emergency care provider centers using GIS techniques in Lahore to make them accessible to the maximum of the population. The goal was to better access accident/incident locations using a novel GIS-based analytical method that can be used by emergency care professionals when all factors are taken into account. In this research, examples were used to characterise remote regions as well as make suggestions about their potential accessibility. In order to make new major emergency care provider facilities in Lahore accessible to the greatest number of people, professional planners may find this document to be beneficial in their planning efforts. (Ahmadi et al., 2017; Ahmed et al., 2019, 2018, 2017; Amrapali C. Dabhade, 2014) attempted to address the problem of finding a specialty hospital in Aurangabad, Maharashtra, India, and determining the fastest route to reach it. To identify the closest hospital to a user's location, we employed an ArcGIS program and Dijkstra's algorithm, which provides the shortest path between two locations. Road length was used to determine the shortest path. Traffic jams and road conditions were not taken into account.

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