Determination of Effective Routes for Tourism Mass Transportation in Bandung City using Network Analyst and GIS

Yackob Astor¹,*, Asrie Purwandhari¹, Krisna Reva Aprian¹

¹Department of Civil Engineering, Bandung State of Polytechnic, Bandung 40559, Indonesia
*Corresponding author. Email: yackobastor@polban.ac.id

ABSTRACT
The implication of Bandung as a tourism destination is the increase in traffic flow during weekends and vacation times due to the increasing number of private vehicles of domestic and foreign tourists entering Bandung. Therefore, an action is needed in the form of providing mass transportation modes for tourism and determining effective routes that connects leading tourist destinations in Bandung. This study use Geographic Information System (GIS) as a tool to map the locations of tourist attractions and road networks, as well as the Network Analyst to determine the effective route of mass transportation. There are 2 effective route obtained from this study. First, effective route from train station to 11 tourism attraction. Second, from city center to 10 tourism attraction This route is expected to make tourists choose mass transportation for tourism activities instead of private vehicle which can decrease traffic congestion in Bandung.

Keywords: Tourist Attraction, Effective Route, Network Analyst

1. INTRODUCTION
Geographic information systems (GIS) and Network Analyst have developed rapidly, marked by rapid methodological and scientific progress in recent years. Geographic information systems (GIS) are digital computer applications that designed to capture, store, manipulate, analyze, and display geographic information [1]. In [2] the authors create a GIS database for tourist attractions in the city of Kanchipuram by using spatial and non-spatial data to show information such as tourism locations, ATMs, fuel, police stations and hospital locations. Network Analyst in GIS able to solve prominent network routing problems such traveling salesman problems, vehicle routing problems, and shortest path problems with time [3]. In [4] the authors provide an enhanced Network Analyst that uses the ability of GIS to identify the best route from the incident location to health care location in the Greater Cairo metropolitan area. The use of Network Analyst tools for transportation routing problem also shown in [5] and [6]. In [5] the author determined 3 (three) integrated mass transportation routes in Malang, Indonesia with network analyst by combining spatial and tourism attraction data. In [6] the author determined alternative route for garbage truck in Bogor area. The difference between this research and the studies above lies in the effective route carried out based on the existing traffic and the dimensions of the existing road in accordance with the mass transportation used. In this study, the effective route not only connects a starting point with a destination point, but a starting point that connects several points. The starting points used were 11 primary tourism attractions located in Bandung stated on West Java Governor Regulations Number. 93 year 2017 about Development and Management for Tourism Destination [7]. The mass transportation used is medium bus with size of Length: 2,151m, Height: 3,151m, and Width: 2,151m stated in [8]. This effective routes is also a developed version of shortest route in [9] and [10] which only determined by shortest travel length (L) between two nodes, but this effective route will connects 11 tourism attraction and provides effective travel time (L/V) so tourists will choose mass transportation rather than using private vehicles.

2. OBJECTIVES
The objectives of this study is to build information about tourism attractions in Bandung and to create the effective route of mass transportation for tourism by
using Network Analyst and Geographic Information System (GIS)

3. METHODS

3.1. Data Preparations

Starting with data preparation, this step includes preparing road network data of Bandung region in the form of shapefiles (shp), the data were collected through Indonesian Geospatial Information Organization, another data collected were 11 coordinates of tourism attractions located in Bandung that already stated in West Java Governor Regulations Number. 93 year 2017 [7], traffic conditions in some major road in Bandung are also collected to complete the attribute for the network database.

3.2. Network Topology and Creating Network Database for Network Analysis

Using ArcMap 10.6 the databases for road network created to be processed by Network Topology. This process could find errors in the data and corrects it for further analytical process [11]. Usually, the road networks that collected through website are not connected with each other which can mess the process. The results of Network Topology process are a new road network that connects with each other. It can be seen on figure 1.

After Network Topology process, network dataset created to input road network attributes such as name, classification, and minimum requirement of speed according to road classification. The result of network dataset process shown in Figure 2.

3.3. Mapping Tourism Attraction and Traffic Congestion

The process of plotting the coordinate points of tourist attraction is carried out by entering the attribute table for the coordinates of the tourist attraction points that have been obtained based on the survey results. The results of coordinates insertion were shown as red dots in figure 3.

Tourism attraction layer map were created by entering coordinates to database process. For traffic mapping, typical traffic in several major roads in Kota Bandung were collected from google maps during weekend for 1 (one month). These traffic condition were classified with high and medium traffic conditions. From these traffic condition, a new layer of traffic map created.
The road network database, tourist attraction coordinates, and new layer of traffic congestion map then combined to form a new network database as shown in figure 5.

Figure 5. Combined road network database, tourist attraction database, and traffic map database

Figure 5 show the combination between road network database, tourist attraction database, and traffic map database in Bandung area. This map could be processed through network analysis process.

3.4. Network Analysis and Effective Route

After the network database created, Network Analysis process could be performed through ArcMap 10.6. The results of network analysis process are travel time and distance. The objectives of this study is to find effective road which is a developed form of shortest route and best route [12] To find the effective route for tourism mass transportation, the results of the process should be adjusted with speed, waiting time, delays, and stops time stated in [8] Based on the previous process the effective route can be calculated using the following function:

\[
\text{Effective Route} = DL + [(Ln/Vn) + WTn + STn + Dn + OTTn] + Ln/Vn + DL \leq \text{condition: 10 hours (1)}
\]

\[DL = \text{Departure Location}\]
\[D = \text{Delay}\]
\[WT = \text{Waiting Time}\]
\[V = \text{Velocity}\]
\[OTT = \text{Optimal Travel Time}\]
\[N = \text{Tourism Attraction}\]
\[ST = \text{Stop Time}\]

The value of maximum conditions (10 hours) adjusted with tourism attraction operational hours, which mostly start at 10am to 8pm. In addition, the duration of the tour must not exceed 10 hours in 1 day, it is considered as the best duration for tourists who do not have a long vacation time.

4. RESULTS

There are 2 effective route results for tourism mass transportation. First, effective route from station to 11 tourism attraction. Second, from city center to 10 tourism attraction.

Figure 6. Alternative 2 effective route from the Train Station to 11 tourism attractions in Bandung

This route crosses 11 tourist attractions without stopping (at each location of the tourist attraction) has a distance of 49km and a travel time of 1 hours 38 minutes. In Figure is depicted with a purple line, the following is information on the order of the street names:

Stasiun - Jl. Nurtanio Utara - Jl. Abdul Rahman Saleh - Jl. Pajajaran - Jl. Cihampelas - Jl. Wastukencana - Jl. L.L.R.E Martadinata - Kawasan Belanja L.L.R.E Martadinata - Jl. L.L.R.E Martadinata - Jl. Banda - Jl. Hayam Wuruk - Museum Gedung Sate - Jl. Hayam Wuruk - Jl. Cilaki - Jl. Citarum - Jl. Diponegoro - Museum Geologi - Jl. Diponegoro – Jl. Surapati - Jl.
Martadinata - Jl. Merdeka - Jl. Veteran - Jl. Jend. Ahmad Yani - Jl. Asia-Afrika - Museum Konferensi Asia Afrika – Alun-alun Bandung.

Table 1. Comparison of Distance and Travel Time based on Location of Departure and Number of Travel Destinations

| No | Departure Location         | Number of Destination | Length (km) | Travel Time |
|----|---------------------------|-----------------------|-------------|-------------|
| 1  | Downtown/ City Center     | 10                    | 39          | 1 hr 19 min |
| 2  | Train Station/Airport      | 11                    | 49          | 1 hr 38 min |

Table 1 shows that alternative routes from the city center have longer travel distances and longer travel times without stopping even though there are fewer tourism destinations. This condition is influenced by real conditions such human activity, the number of vehicles, and land use in the city center. High traffic congestion decrease the speed of mass transportation at these location.

Table 2. Total Travel Duration

| No  | Departure Location | Travel Time + Min Stop and Delay Time. | Travel Time + Max Stop and Delay Time. | Total Min Duration (Includes Visit Duration) | Total Max Duration (Includes Visit Duration) |
|-----|--------------------|----------------------------------------|----------------------------------------|---------------------------------------------|---------------------------------------------|
| 1   | Airport            | 3 hr 42 min                             | 5 hr 10 min                             | 17 hr 42 min                                | 19 hr 10 min                                |
| 2   | Downtown/ City Center | 3 hr 48 min                           | 5 hr 08 min                             | 16 hr 49 min                                | 18 hr 09 min                                |

Table 2 shows Total Duration Time which is the accumulation of Travel Time for Mass Tourism Transportation using Effective Route, Delay Time, Stop Time, and Visit Duration for each tourism attraction.

5. CONCLUSION

There are 2 effective route results for tourism mass transportation. First, effective route from station to 11 tourism attraction. Second, from city center to 10 tourism attraction. The effective also calculated with standard service of mass transportation. The results of the overall calculation are two alternatives route with
a minimum of 16 hours 49 minutes and a maximum of 17 hours 42 minutes for tourist to enjoy 11 tourism destinations in the city of Bandung. Based on the results it takes a minimum of 16 hours and a maximum of 19 hours to visit 11 tourism attractions. However, the optimal time for a tourism visit in one day is 10 hours. Therefore, to meet the optimal time, if tourist choose to use mass transportation with effective routes they must choose 4 to 6 tourism attractions only to fulfill the effectiveness.

REFERENCES

[1] Longley, P. A., Goodchild, M. F., Maguire, D. J. and Rhind, D. W. (2001) Geographic Information Systems and Science . Chichester.

[2] Sureshkumar. M., Balusa Uttej., Dhaya Baran. S., Mahadevan. K. (2017). Application of GIS for Tourism. International Journal of Latest Engineering and Management Research (IJLEMR) ISSN: 2455-4847

[3] Fischer, MM. (2003). GIS and Network Analyst. Department of Economic Geography & Geoinformatics, Vienna University of Economics and Business Administration. Appear in: Handbook 5 Transport Geography and Spatial Systems. Hensher D., Button K., Haynes K. and Stopher P. (eds.); Pergamon, 2003

[4] Ahmed. S., Ibrahim. F.R., Hefny. H.A. (2017). GIS-Based Network Analyst for the Roads Network of the Greater Cairo Area. Proceedings of the International Conference on Applied Research in Computer Science and Engineering ICAR’17, Lebanon, 22-06-2017, published at http://ceur-ws.org

[5] Huda, S. (2017). Penyusunan Rencana Rute Angkutan Umum Terintegrasi di Kota Magelang. Yogyakarta: Universitas Negeri Yogyakarta.

[6] Apriyanti, D., Kresnawati, D., and Diniyah., W. (2018) Utilization of Georaphic Information System for Analysis of Waste Transport Truck Routes in Bogor City. Seminar Nasional Geomatika 2018: Penggunaan dan Pengembangan Produk Informasi Geospasial Mendukung Daya Saining Nasional.

[7] West Java Provincial Government (2017). Peraturan Gubernur Jawa Barat Nomor 93 Tahun 2017 Tentang Standar Pembangunan dan Pengelolaan Daya Tarik Wisata.

[8] Indonesian Ministry of Transportation (2012) Peraturan Menteri Perhubungan Republik Indonesia Nomor 10 Tahun 2012 tentang Standar Pelayanan Minimal Angkutan Massal Berbasis Jalan.

[9] Buana, W.P. (2010) Penemuan Rute Terpendek Pada Aplikasi Berbasis Peta. Lontar Komputer Vol.1 Desember 2010. ISSN; 2088-1541

[10] Permana, S, Triyatno., Nofrizal. A. Y (2019) Pemanfaatan Network Analysis Dalam Mengidentifikasi Objek Wisata Budaya di Kabupaten Tanah Datar. Jurnal Sains Informasi Geografi Vol.2. No.1

[11] Esri Network Analyst Tutorial. 2010. Retrieved from:http://help.arcgis.com/en/arcgisdesktop/10.0/pdf/network-analyst-tutorial.pdf

[12] Esri ArcGIS Product. 2020. Retrieved from https://www.esri.com/enus/arcgis/products/arcgis-network-analyst/features