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The Analysis of Vehicle Operating Cost (VOC) and the Preparation of Public Transport Information Systems Based on Geographic Information Systems (GIS) in Kupang City

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ABSTRACT
Transportation is one of the most important elements in the economy aspect, because transportation is closely related to community activities, especially in urban areas. The purpose of this study is to provide city transportation data, namely the Vehicle Operating Costs (VOC) of 15 existing routes, and to create a web-based public transportation information system, which can be easily accessed by the public. The VOC analysis and tariffs are based on the Regulation of Direktorat Jenderal Perhubungan Darat Nomor: SK.687 / AJ.206 / DRJD / 2002, while the information system is developed using Quantum GIS software Las Palmas 2.18.2 and sublime text 3.0. The results of the VOC analysis show the smallest operational costs are Rp. 884.41, - per passenger and the smallest fare is Rp. 972.85, - while the largest operational costs are Rp. 2,677.32 per passenger and the largest fare is Rp. 2,945.05, - per passenger. The city transportation information system being composed consists of route maps that are equipped with attributes of road names, road classes, road lengths, operational times, fleet colors and public transportation photos, which can be accessed on the website angkutanumumkotakupang.com.

Keywords— Public Transportation, Vehicle Operating Cost (VOC), tariff, Geographic Information System

1. INTRODUCTION

The city transportation (bemo) in Kupang City, based on Kupang City Transportation Department data in 2017, has 366 (three hundred sixty-six) fleets, which are divided into 15 routes. The tariffs imposed for city transportation services are flat / flat tariffs for public passengers is Rp. 3,000,- for each, and for students is Rp. 2,000. The number of urban transportation operating has not been supported by the availability of adequate information to be accessed by the public. One of the data that is not owned by the Transportation Department is Vehicle Operational Cost (VOC) data for each route, which is useful in determining future city transportation tariff policies. From these conditions, it is necessary to conduct the data collection and the analysis of the VOC, followed by the creation of a web-GIS-based online information system that is easily accessible to public.

2. THEORETICAL BASIS

2.1 Vehicle Operating Costs

The component of vehicle operating costs according to the calculation method based on the Regulation of Direktorat Jenderal Perhubungan Darat Nomor: SK.687 / AJ.206 / DRJD / 2002 on Pedoman Teknis Penyelenggaraan Angkutan Penumpang Umum di wilayah Perkotaan dalam Trayek Tetap dan Teratur [1].

Table I. Direct and Indirect Cost Components based on Cost Grouping

Direct Cost	Indirect Cost
1) Cost of depreciation 2) Capital interest 3) Microbus crew (driver and conductor) i. Salary/wage ii.Operating work allowance iii.Social Benefit 4) Fuel Oil 5) Tires 6) Small Service 7) Large service 8) Overhaul 9) Oil addition 10) Parts and body 11) Wash the bus	1) Employee costs other than the crew of the vehicle a) Salary / wages b) Overtime pay c) Social benefits i. Health care support ii. Official clothes iii. Accident insurance 2) Management costs a) Depreciation of office buildings b) Depreciation of pools and Work shops c) Depreciation of inventory/office equipment d) Depreciation of workshop facilities

Direct Cost	Indirect Cost
12) Terminal Retribution 13) Vehicle Tax 14) Kir 15) Insurance i. Vehicle insurance ii. Bus crew insurance	e) Office administration costs f) Office maintenance costs g) Pool and workshop maintenance costs h) Electricity and water costs i) Telephone and telegram fees j) Cost of official travel other than The crew of the vehicle k) Corporate tax l) Route permission m) Business license n) Marketing costs o) Other

2.2. Transportation Rates

According to the Direktorat Jenderal Perhubungan Darat (2002) the tariff is the amount of fees charged to each passenger of public transport vehicles in rupiah. Calculation of public transport fares is the result of multiplying the basic fare and the average distance (Km) of a trip (BEP rate) and adding 10% to the company's profit service [1].

2.3. Geographic Information System and Web-GIS

Geographical Information Systems (GIS) have the basic ability to integrate various database operations such as queries, analyze and display them in the form of mapping based on their geographical location. A research on the use of GIS in the field of road transportation has been carried out by M.E Bolla (2018) that is to analyze traffic accident-prone roads, as well as to develop a database that provides comprehensive information of the roads. [3]. Web-GIS is a combination of mapping graphic design, digital maps with geographical analysis, computer programming, and a database that are interconnected into one part of web design and web mapping. In building GIS, software that can be used include Quantum GIS (QGIS) and Sublime Text. QGIS is an open source-based software, which has features for georeferencing, creating thematic maps, calculating the extent of an area, and other mapping processing related to spatial and non-spatial data [4]. Sublime Text is an application editor for code and text that can run on various operating system platforms using Python API technology [5]. The display of QGIS Las Palmas 2.18.2 and Sublime Text 3.0 can be seen in Fig. 1 and Fig. 2.

Fig. 1. Display of QGIS Las Palmas 2.18.2

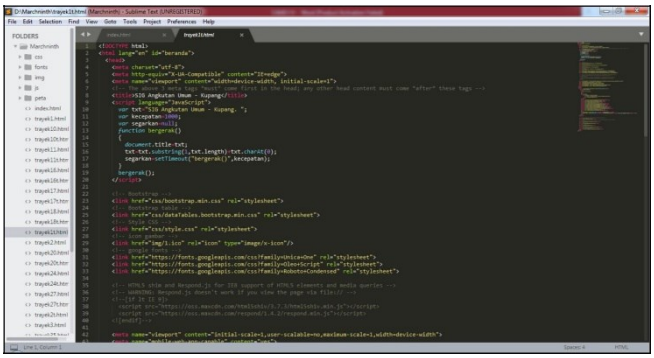


Fig. 2. Display of Sublime Text 3.0

3. RESEARCH METHODS

Flowchart is a method of analytical technique used to describe number of aspects on the information system in a clear, concise and logical manner. The flow chart in this study can be seen in Figure 3.

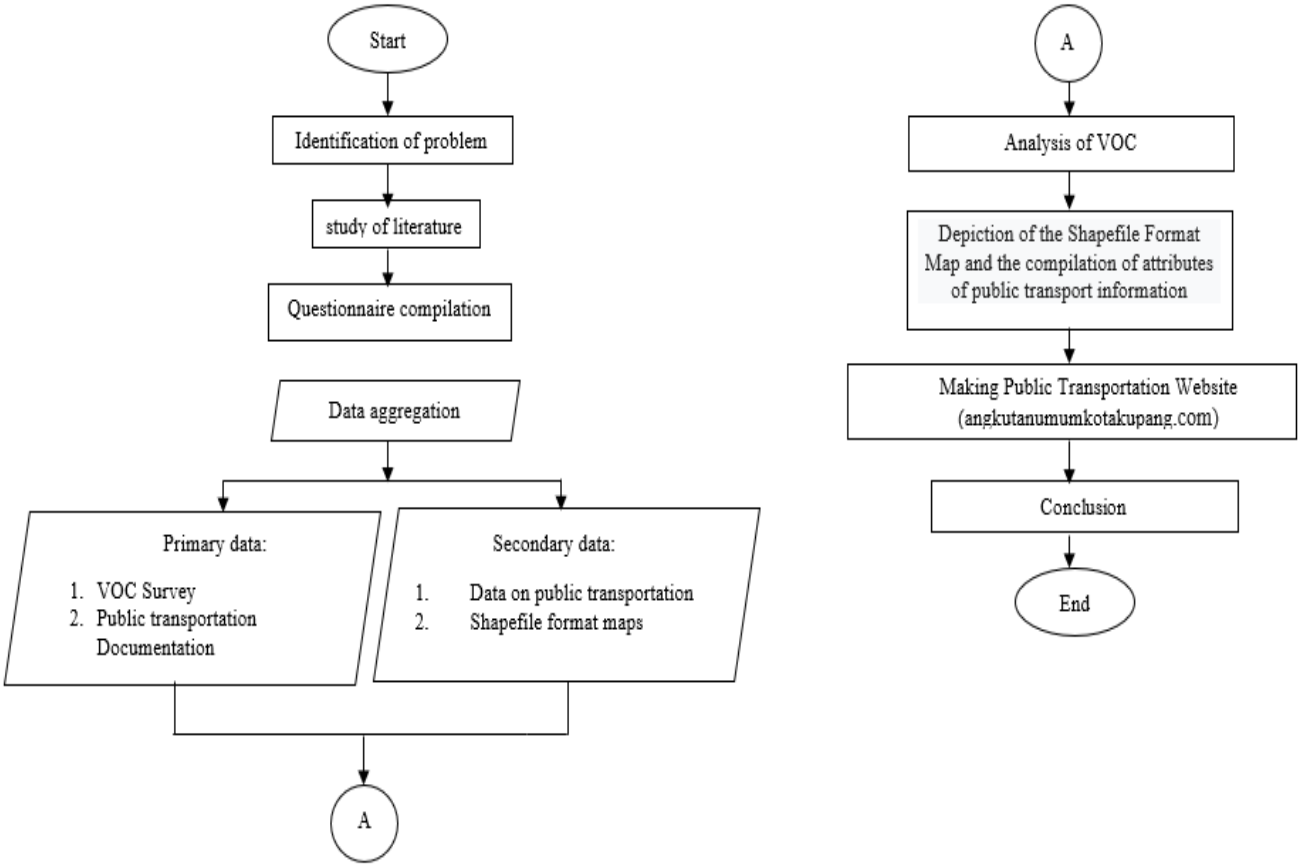


Fig. 3. Flowchart of the study

4. ANALYSIS AND DISCUSSION

The public transportation operated in Kupang City area serves 15 (fifteen) routes symbolized by numbers, namely routes 1, 2, 3, 5, 6, 7, 10, 11, 16, 17, 18, 20, 24, 27 and routes 35. These 15 routes serve transit among 3 terminals, those are Kupang terminal, Belo terminal and Oebobo terminal.

4.1. Vehicle Operating Cost Analysis

Example of VOC analysis is on 1 (one) fleet with the route code 1 and route code 16.

1. Vehicle characteristics
   a. Type ST is for 150 FUTURA SUZUKI brand, as well as for microbuses
   b. The maximum passenger capacity based on the fact in the field is 14 person (not included the driver and conductor)
   c. The capacity of engine oil, garden oil, and transmission oil of these Microbuses are 4 liters, 1 liter and 1 liter respectively.
2. Production per microbus
   a. Km/ route for route 1 is 23.3 Km and 17.4 Km is for route 16 according to the actual route, but because the two routes do route deviations then they are analyzed based on field conditions that is 18 Km.
   b. The frequency of the number of rits in a day are 12 times (24 trips) (interview results)
   c. Mileage/ day = 18 x 12 = 216 Mileage/ day
   d. Day of operation / month
      This microbus is fully operated in one month, which is 30 days.
   e. Mileage/ month = 216 x 30 = 6,480 Mileage/ month
   f. Mileage/ year = 6,480 x 12 = 77,760 Mileage/ year
3. Microbus price calculation. From the survey results, the following data are shown:
   a. The year of vehicle production is 2000
   b. The condition of the vehicle when purchased is a used vehicle
   c. The year of vehicle purchase was in 2005
   d. The price of the vehicle at the time of purchase was Rp. 85.000.000,-
   e. The interest rate used is 16.78% (based on the microbased base rate of PT. Bank Sinarmas Tbk, April 2018)
   f. The economic value of the vehicle is assumed to be 30 years

Thus, the value of vehicle depreciation for 2017 is:

$$= \frac{12}{30}(85.000.000 - (20\% x 85.000.000))$$

= Rp. 27.200.000,-

Therefore, book value in 2017 was

BV = 85.000.000 – 27.200.000 = Rp. 57.800.000,-

while the book value on 2000 was:

$BV = I - (\frac{t}{N}(I - S))$

$= 85.000.000 - (\frac{5}{30}(85.000.000 - 17.000.000))$

= Rp.96.333.333,33,-

4. Costs per microbus per km

The items calculated are direct and indirect costs. Direct costs are costs directly related to the production of services produced and the indirect cost component incurred by the operator is a route permit, while the other indirect component costs are not carried out by the operator. Here are the results of calculations for direct and indirect costs, as seen at Table II.

Table II. Recapitulation of Direct and Indirect Cost per Microbus-Km

Direct Cost	
Cost of depreciation	Rp. 118,93/microbus-Km
Capital Interest	Rp. 87,31/microbus-Km
Sallary and wage Microbus crew (driver and conductor)	Rp. 259,26/microbus-Km
Fuel oil	Rp. 694,44/microbus-Km
Tires	Rp. 21,09/microbus-Km
Small service	Rp. 80,38microbus-Km
Large Service	Rp. 11,97/microbus-Km
Overhaul	Rp. 111,50/microbus-Km
Oil addition	Rp. 6,68/microbus-Km
Parts and body	Rp. 61,94/microbus-Km
Wash the bus	Rp. 0/microbus-Km
Terminal retribution	Rp. 23,15/microbus-Km
Vehicle tax	Rp. 8,36/microbus-Km
KIR	Rp. 2,06/microbus-Km
Insurance Vehicle	Rp. 30,97/microbus-Km
SUM	Rp. 1.518,04/microbus-Km
Indirect Cost	
Route permission	Rp. 0,64/microbus-Km

5. Cost of per passenger-Km

Cost of principal = 1.518,04 + 0,64

= Rp. 1.518,68/ microbus-Km

Thus, the basic cost per passenger-Km is:

Base cost per passenger-Km $= \frac{1.518,68}{14}$

= Rp. 108,48/psg-Km

4.2. Analysis of Transportation Rates for Route Code 1 and Route Code 16

Use Basic Tariff = 1.518,68/(70% x 14)

= Rp. 154,97/passenger-Km

BEP rate = 154,97 x 9 Km

= Rp. 1.394,71/ passenger

Tariff = 1.394,71+ 10% BEP Rates

= Rp. 1.534,18/ passenger

Based on the survey results, it reveals that there are 5 fleets serving routes 1 and 16, so from the results of the tariff analysis for each vehicle the VOC is obtained and the average tariff is as follows:

a) Average Vehicle Operating Costs

Average VOC

$= \frac{1.394,71+1.638,25+1.557,07+1.702,62+1.847,99}{5}$

= Rp. 1.628,13/Passenger

b) Average operating rates

Average Tariff

$= \frac{1.534,18+1.802,08+1.712,78+1.872,88+2.032,79}{5}$

= Rp. 1.790,94/passenger

The recapitulation of the tariff calculation is based on the VOC analysis and the difference between the official rates is presented in Figure 4.

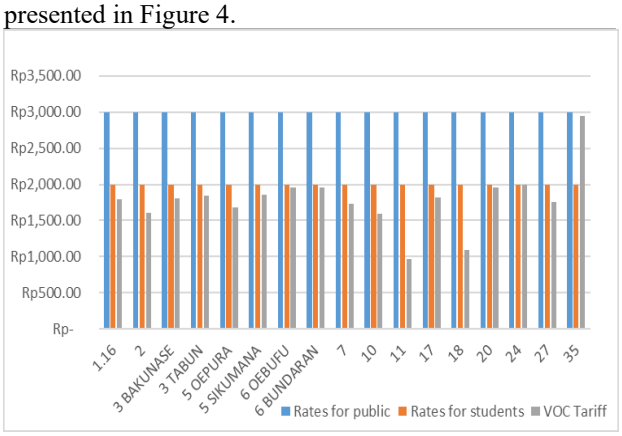


Fig. 4. The recapitulation of the tariff calculation is based on the VOC analysis and the difference between the official rates

4.3. Results of GIS-based Spatial Data Compilation (Geographic Information System)

After data collection, SIG data is based on spatial data collection. The compilation of GIS-based spatial data was carried out to delineate maps of public transport routes in the city of Kupang and the need to compile public transport data information displayed in WebGIS. The shapefile format map used is a vector data map, consisting of the Kupang city's road network (line), and public facility points that are passed through (points) to assist in drawing maps. The depiction of a map of the shapefile format of public transport routes, each route is marked with a different color and its attributes are

arranged according to the existing road attribute data, namely road name data, road function and road length from the data collection results, also added operational time data, the color of public transport and photos of public transport for each route. After drawing a map of the shapefile format (.shp) and compiling map attributes for each public transport route, the map will be exported to the web-map using the qgis2web plugin. When exported selected the base map view is OSM (Open Street Map).

The Web-Map Display of Public Transportation Routes in Kupang City presented in figure 5.

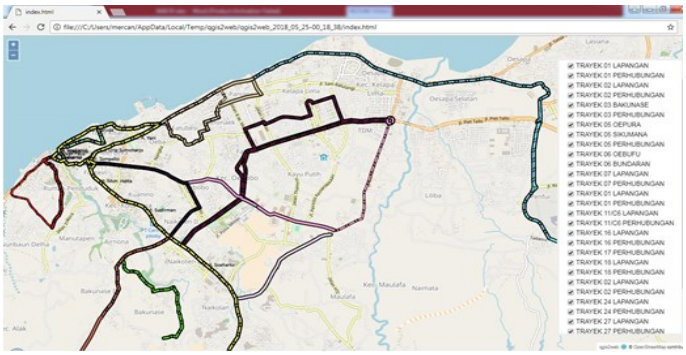


Fig. 5. Web-map display of public transportation routes in Kupang City

4.4. Website Creation

After finishing the map, it will then be displayed on a website. The making of this website uses the sublime text 3.0 application where this application can support the six components of website creation namely HTML5, CSS3, bootstrap, jquery, javascript and PHP. HTML5 serves as the main framework for storing content from websites. CSS3, bootstrap and jquery serve to make the appearance of the website more interesting. While javascript and PHP are programming languages used to manage data from a website

The next step is to determine the domain name and hosting so that the online website can be accessed easily. Domain and hosting are obtained by paying on available platforms. After that the website display that has been created using the sublime text 3.0 application can be uploaded to the internet with the help of FileZilla in order it can be accessed by everyone. The web address that can be accessed is angkutanumumkotakupang.com.

The entire process of preparing the public transportation information system is presented in Figure 6.

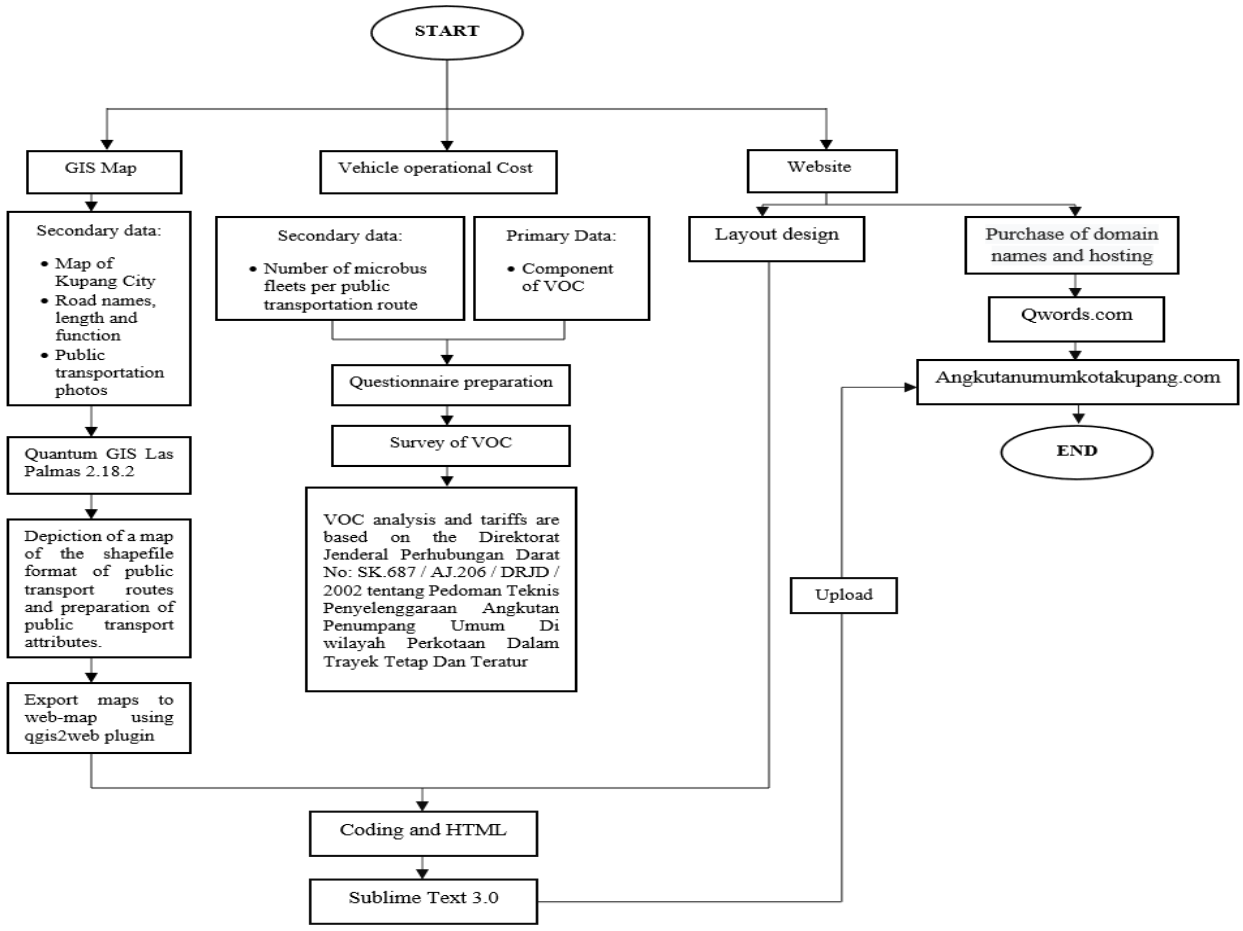


Fig. 6. Flowchart for the preparation of the geographic information system in Kupang City public transport

Following are the display of information on the web:

4.4.1. Display Home on the Web

This is the main page on WEB GIS Kupang Public Transport. This page aims to display the introduction of the Web itself. The display home can be seen in Figure 7.

Fig. 7. Display home on the web

4.4.2. Display of Abstract Pages

It displays abstracts which aims to describe the background of making this website. The display of abstract pages can be seen in Figure 8.

Fig. 8. Display of abstract pages

4.4.3 Map Display Page

A map of Kupang City along with the public transport route layer is displayed. The map displays page as can be seen in Figure 9.

Fig. 9. Map display page

4.4.4. Display of Route Description Pages

On these pages, lane routes will be displayed by each good route officially issued by the Transportation Agency and routes that experience irregularities in the field. The display of route description pages can be seen in Figure 10.

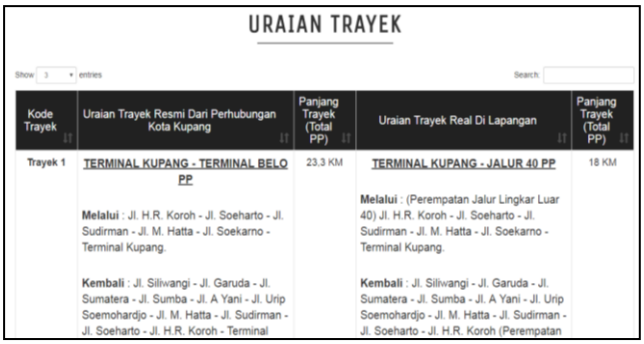


Fig. 10. Display of route description pages

4.4.5. Fleet Page Views

It will contain information about the fleet that serves each route. The display of fleet page views can be seen in Figure 11.

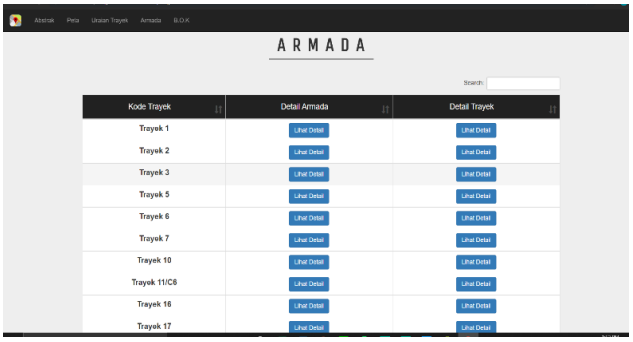
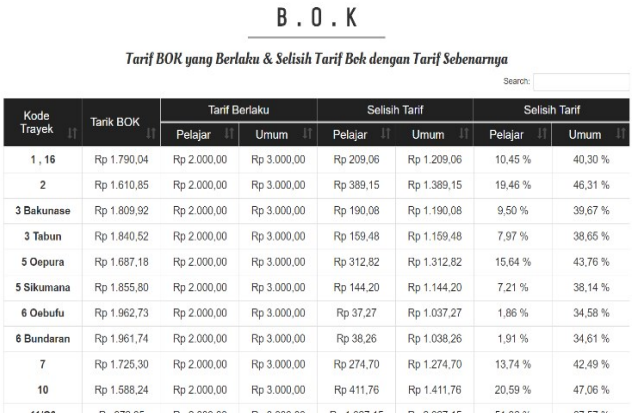


Fig. 11. Fleet page views

4.4.6. VOC Page Views

It contains information about vehicle operating cost rates. The display of VOC page views can be seen in Figure 12.



Kode Trayek	Tarik BOK	Tarif Berlaku		Selisih Tarif		Selisih Tarif	
		Pelajar	Umum	Pelajar	Umum	Pelajar	Umum
1 , 16	Rp 1.790,04	Rp 2.000,00	Rp 3.000,00	Rp 209,06	Rp 1.209,06	10,45 %	40,30 %
2	Rp 1.610,85	Rp 2.000,00	Rp 3.000,00	Rp 389,15	Rp 1.389,15	19,46 %	46,31 %
3 Bakunase	Rp 1.809,92	Rp 2.000,00	Rp 3.000,00	Rp 190,08	Rp 1.190,08	9,50 %	39,67 %
3 Tabun	Rp 1.840,52	Rp 2.000,00	Rp 3.000,00	Rp 159,48	Rp 1.159,48	7,97 %	38,65 %
5 Oepura	Rp 1.687,18	Rp 2.000,00	Rp 3.000,00	Rp 312,82	Rp 1.312,82	15,64 %	43,76 %
5 Sikumana	Rp 1.855,80	Rp 2.000,00	Rp 3.000,00	Rp 144,20	Rp 1.144,20	7,21 %	38,14 %
6 Oebufu	Rp 1.962,73	Rp 2.000,00	Rp 3.000,00	Rp 37,27	Rp 1.037,27	1,86 %	34,58 %
6 Bundaran	Rp 1.961,74	Rp 2.000,00	Rp 3.000,00	Rp 38,26	Rp 1.038,26	1,91 %	34,61 %
7	Rp 1.725,30	Rp 2.000,00	Rp 3.000,00	Rp 274,70	Rp 1.274,70	13,74 %	42,49 %
10	Rp 1.588,24	Rp 2.000,00	Rp 3.000,00	Rp 411,76	Rp 1.411,76	20,59 %	47,06 %

Fig. 12. VOC Page Views

5. CONCLUSION

Based on the results of the analysis that has been done, it is obtained:

1. Average operational costs (VOC) and rates:
   a. The highest operational cost is Rp. 2.677,32,- per passenger, and the highest tariff is Rp. 2,945.05, - per passenger for route 35
   b. The lowest operational cost is Rp. 884.41, - per passenger, and the lowest tariff is Rp. 972.85, - per passenger for route 11 / C6.
   c. The biggest factor that causes the difference in tariffs is the difference in the frequency of the number of rits in a day, the age of the vehicle and the daily fuel use of each microbus from the route.
2. The urban transport route mapping model that has been designed using Quantum GIS Las Palmas 2.18.2 consists of route maps that are equipped with information attributes in the form of road names, road classes, road lengths, operational times, fleet colors and photos of public transportation.
3. The HTML design uses Sublime text 3.0 and the public transport information system that will be displayed on the web is a map of public transportation route information, information and description of public transportation routes, terminal type, number of city transportation fleets and vehicle operating costs (VOC). The web address to access is angkutanumumkotakupang.com.

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