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Initial Study of Arterial Road Traffic and Socio-Economic Characteristics in Malang Regency

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Abstract. Malang Regency is an area with the second busiest road traffic after Surabaya. The purpose of this study is to determine the characteristics of the movement of speed and volume of traffic and performance on arterial roads in Malang Regency. The data collection technique used literature study, conducted a survey at each location point of the research area with the Annual Average Daily Traffic (AADT). The analysis technique used the Highway Capacity Manual Indonesia (MKJI) 2017. The results showed that the level of road service with category B was in Wonosari District with a saturation degree of 0.372, the level of road service category C was in Wagir, Gedangan, Ngajum and Tirtoyudo Districts with saturation degrees between 0.565 - 0.678 and the level of road service category D in Wajak District with degree of saturation 0.798. Meanwhile, 27 roads have a poor service level which is included in the E and F categories with the degree of saturation > 0.850. Recommend policies regarding restrictions on the use of private vehicles and alternative traffic engineering to divert transportation routes to new land uses and to more intensively disseminate information to the public on using public transportation as a means of daily transportation.
Keywords: Annual Average Daily Traffic (AADT), Level of Service (LOS), Highway Capacity Manual Indonesia (MKJI)

1.   Introduction

The Road transportation problem is generally dominated by congestion, noise and air pollution, accidents and delays. This transportation problem has been going on for a long time up to today. However, up to today the quality of transportation problem is getting much worse and the quantity is also getting bigger due to the increasing number of parties associated with the road transportation problems so that it becomes more difficult to overcome [1].

According to [2] geometric planning is road planning in which the actual geometry or dimensions of a road segment and its parts are adjusted to the demands and characteristics of traffic. Traffic volume is the number of vehicles passing the intersection / road segment that will be observed for a certain period of time. The most important data in the evaluation is to know the volume of intersection traffic every hour. When road capacity is improved, while the number of road users continues to increase, the travel time will increase and will cause total congestion. Land use is high intensity and occurs especially during peak hours [3]. Route selection due to land use changes will cause traffic movements to tend to cause differences in travel time from the previous route [4]. As one of the districts having a large population, Malang Regency has a large growth of motorized vehicles as well. Malang Regency, as the second-most

densely populated area of road traffic after Surabaya, has also experienced a high growth trend of motorized vehicles, both two-wheeled and four-wheeled vehicles. That is why now Malang Regency Government continues to strive how to balance the density of land transportation traffic so that it can create the smooth land transportation traffic while still being able to encourage and improve its [5].

Travel patterns tend to change and increase so that it can cut travel activities. This has an impact on traffic congestion happening when the traffic increase exceeds the road capacity limit. It leads to the decrease of vehicle speed. This decrease indicates the decrease in the level of road service (LOS = Level of Service).

The purpose of this study is to determine the characteristics of the movement of speed and traffic volume as well as performance on arterial roads and to provide an initial description of the existing conditions of road traffic flow in Malang Regency.

2.   Review of Related Literature

Republic of Indonesia Government Regulation Number 34 of 2006 and Indonesia Act no 38 The Year 2004 concerning roads, public roads can be classified into the road network system, road function, road status, and road class [6]. Knowledge of road classification becomes important in this study to explain the definition of national roads and their rules. Roads as a part of the national transportation systems have an important role, especially in supporting the economic, social and cultural as well as enviromental sectors. It is hoped that this equal distribution of transportation infrastructure can achieve a balance and equitable development between regions. In addition, the roads existing in Indonesia can form a spatial structure in order to realize the means of national development. The method of calculating the level of traffic services used the calculation formula from MKJI (Highway Capacity Manual Indonesia) which was established in 1997 and revised in 2017 [7].

2.1 Road Capacity

According to MKJI, road capacity is defined as the maximum flow through a point on the road that can be maintained per hour under a certain condition.

To be able to calculate the amount of road capacity, the following calculation formula can be used: (MKJI, 1997 : 5-18) [7]

$$C = Co \times FCw \times FCsp \times FCsf \times FCcs \ldots\ldots\ldots\ldots\ldots (1)$$

Where :
C	= Capacity (pcu/hour)
Co	= Basic capacity (pcu/hour)
FCw	= Road width adjustment factor
FCsp	= Directional separation adjustment factor (only for undivided roads)
FCsf	= Adjustment factor for side and shoulder obstacles / curb
FCcs	= City size adjustment factor

2.1.1 Passenger Car Unit

Each type of vehicle has different movement characteristics. To equalize the units of each vehicle type, a commonly used unit in traffic planning is used which is called a passenger car unit (PCU).

2.1.2 Travel Speed

Travel speed is one of the factors that is quite influential in describing the quality of a road section in accommodating traffic flow. The average speed a vehicle travels through a road segment is the speed of travel. Factors that influence travel speed are traffic volume, vehicle composition and road geometry. Apart from being influenced by the factors already mentioned, each road segment is also influenced by the land use along the road.

2.1.3 Degree of Saturation

The degree of saturation (DS) can be interpreted as the ratio of flow to traffic capacity. The degree of saturation is used as a major factor in determining the level of performance of road segments and segments, the degree of saturation will indicate whether the road segment has a capacity problem or not. The equation in calculating the degree of saturation is as follows:

$$DS = Q / C \dots\dots\dots\dots\dots\dots\dots\dots (2)$$

Where :
DS = degree of saturation (pcu / hour)
Q = traffic flow (pcu / hour)
C = capacity (smp)

2.1.4 Level of Service

Level of Service (LOS) is a parameter that indicates the condition of a road as a whole. The higher the traffic volume on a certain road is, the lower the level of service on the road is. The service level of a road is determined based on quantitative values such as travel speed, degree of saturation, and based on qualitative values such as driver freedom in choosing speed, degree of traffic resistance and level of traffic comfort.

$$LOS = \frac{V}{C} \dots\dots\dots\dots\dots\dots (3)$$

Where :
LOS   : Level of Services
V   : Traffic volume
C   : Traffic capacity

The road service level is determined in an interval scale consisting of 6 levels. These levels are A, B, C, D, E and F, where A is the highest level [8]. The higher the traffic volume on a certain road, the lower the level of service on the road.

2.2 Traffic Management

The definition of traffic management is a process of regulating and using an existing road system with the purpose to reach a specific goal without needing to add or cretae the new infrastructure [9]. Traffic management can handle changes to the geometric layout, creation of road signs and regulatory tools such as signs, road signs for pedestrians, road crossers, and traffic lights for street lighting. The main objective of traffic management is to maximize the use of the system of the roads existing and improve the road safety without damaging environmental quality. Generally a traffic management applied has several characteristics above at once, which can be seen in the picture below.
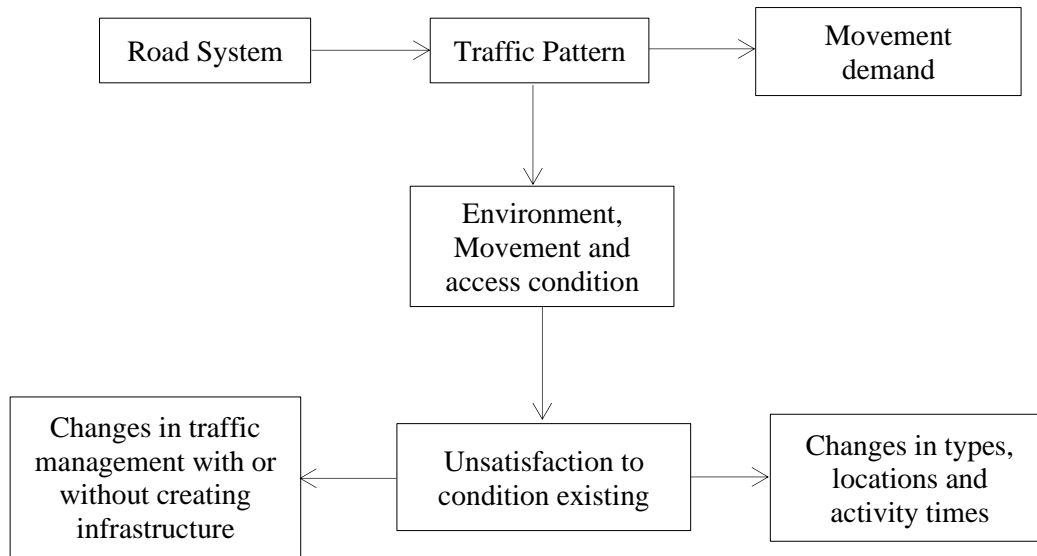
Picture 1. The Role of Traffic Management

3. Research Method

The purpose of this study was to determine the road capacity, the service levels and the movement characteristics of arterial roads in Malang Regency. This research was conducted during the Covid-19 pandemic using a descriptive survey for 33 sub-districts, 12 sub-districts and 378 villages. Geographically Malang Regency is located between 112º 17', 10,90" East Longitude and 112º 57', 00,00" East Longitude and between 7º 44', 55,11" South Latitude and 8º 26', 35,45" South Latitude with an area of 3,530.65 km^2 [10]. This research was carried out on arterial roads in Malang Regency which can be seen on the map below:
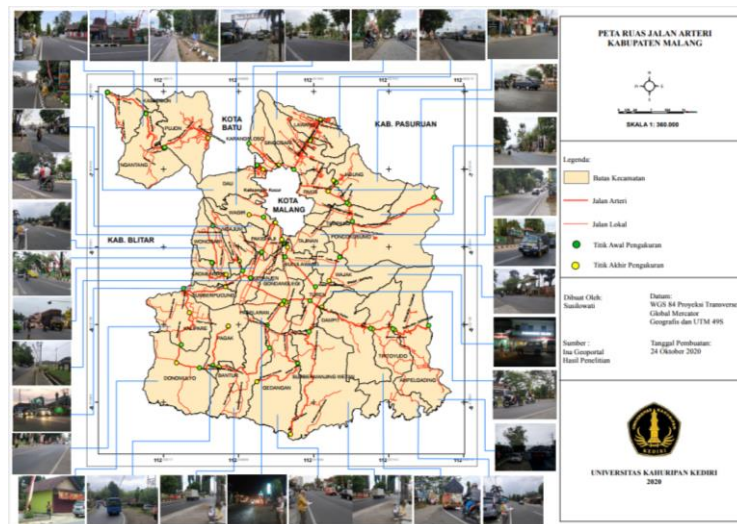
Picture 2. Map of Arterial Roads in Malang Regency

Primary data collection techniques which are traffic volume was obtained through the survey of AADT (annualy average daily traffic) and road geometric data by creating several segments in each road segment that is reviewed based on the geometric characteristics of the road existing. Furthermore, the secondary data was collected from the data of BPS – Statistic Indonesia consisting of population

data and PDRB of Malang Regency. Meanwhile, the road network map was obtained from the Malang Regency Transportation Service. After all the data has been collected, a V/C analysis of the arterial roads in Malang Regency was done. The research method used can be explained in the research flow chart below:

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                    ┌─────────────────┐
                    │   Background    │
                    └────────┬────────┘
                             │
                    ┌────────┴────────────┐
                    │ Problem Identification│
                    └────────┬────────────┘
                             │
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                    │ Statement of Problem │
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┌─────────────────────────┐       ┌──────────────────────────────────────┐
│ Primary Data            │       │ Secondary Data                        │
│ 1. Traffic volume data  │       │ 1. Road network map                   │
│ 2. Geometric Road       │       │ 2. PDRB of Malang regency             │
│                         │       │ 3. Population number of Malang regency│
└────────────┬────────────┘       └─────────────────┬────────────────────┘
             └──────────────┬────────────────────────┘
                 ╱ V/C Analysis of arterial road ╲
                 ╲───────────┬─────────────────────╱
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                    ┌────────┴────────┐
                    │   Conclusion    │
                    └─────────────────┘
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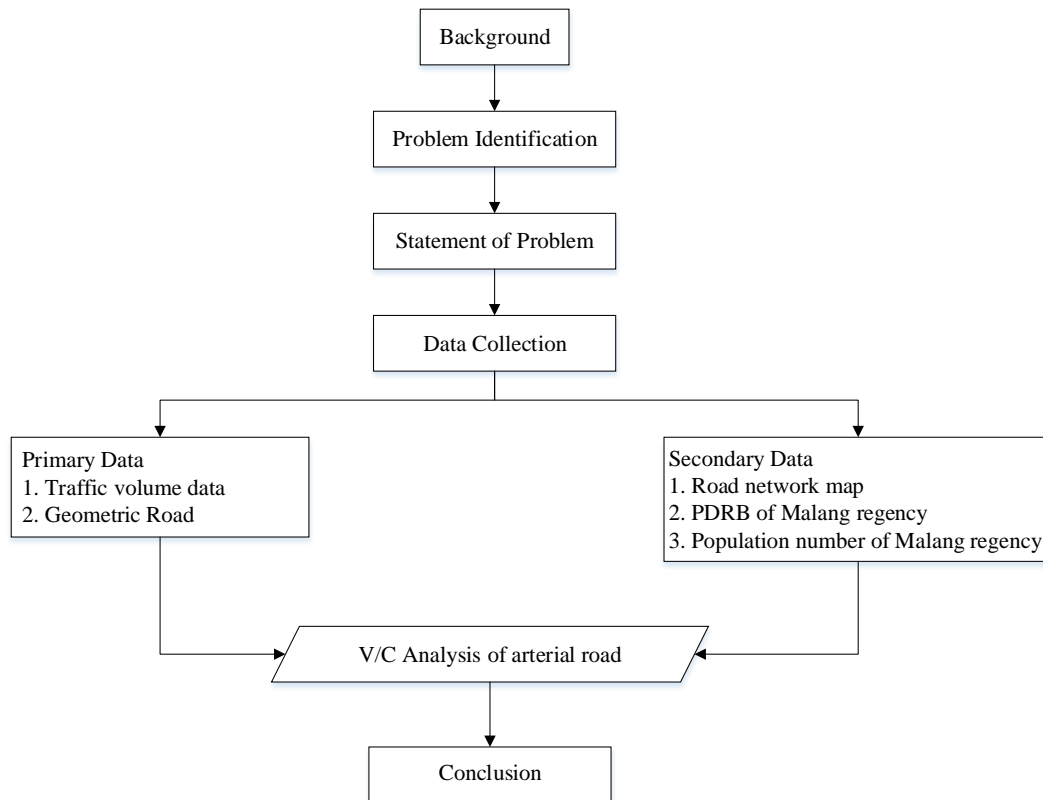
Picture 3. Research Flow Chart

Data analysis technique is that after obtaining data in the form of traffic volume then calculating the road capacity to determine the maximum flow through a point on the road that can be maintained per hour, then calculating the degree of saturation which is useful shows that the road segment has a capacity problem or not. After the value of road capacity and degree of saturation have been obtained, the next step is to calculate the arterial road level of services (LOS) using the V / C formula.

4.   Result and Discussion

The data collection process was carried out by direct survey in the arterial road network with the number of survey points on 33 roads in each District in Malang Regency. The primary data collection consisting of vehicle volume and speed was done at one survey point on each road segment, which represented the data required for each section under review. Meanwhile, road geometric data was got by creating several segments in each road segment reviewed based on the geometric characteristics of the road existing.

4.1 Analysis of Road Traffic Performance

Based on the results of the survey and the analysis table of the flow of Annual Average Daily Traffic (AADT) above, the vehicles with the highest volume passing on arterial roads in Malang Regency is light vehicle types as much as 2350 pcu / hour in the morning, 2180 pcu / hour in the afternoon, 2050 pcu / hour at noon in Singosari District . The second is heavy vehicle type as much as 1891 pcu / hour in the afternoon and light vehicle as much as 1875 pcu / hour in the morning in Lawang District. The third is light vehicle type as much as 1520 pcu / hour in the morning, 1430 pcu / hour in the afternoon

and 1200 pcu / hour in the afternoon in Pakisaji Subdistrict. While the vehicles with the lowest volume were found in Wonosari District with the motorcycle vehicle at 87.5 pcu / hour in the morning and the Tirtoyudo district with the motorcycle vehicle at 97.5 pcu / hour during the day. The average daily traffic volume can be seen in graph 4:
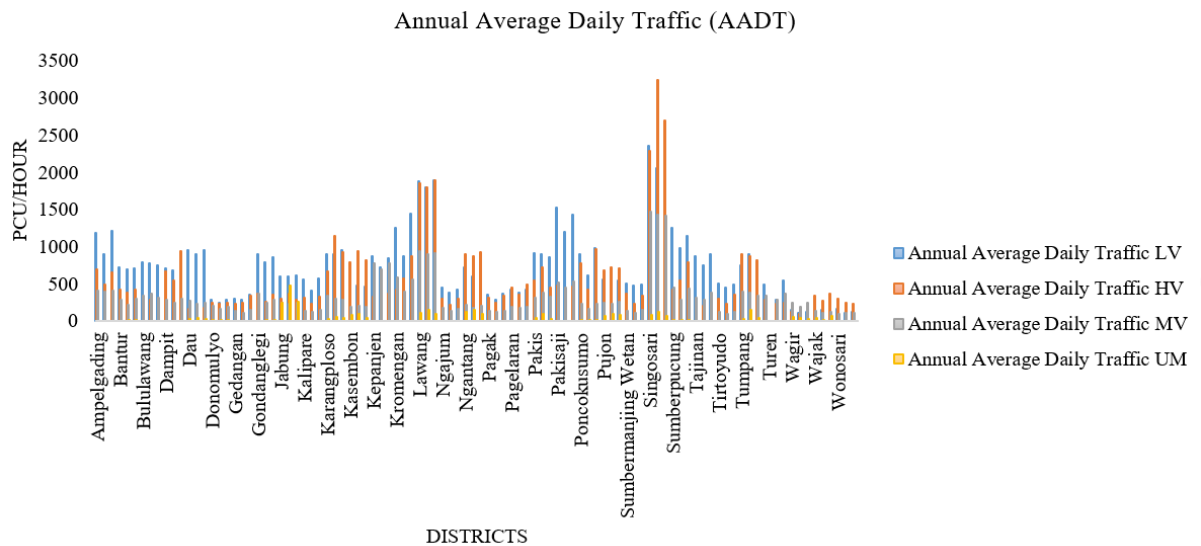
Graph 1. Annual Average Daily Traffic (AADT)

Based on the analysis of Annual Average Daily Traffic (AADT), it was found that Singosari District with the type of light vehicle was 2350 pcu / hour in the morning, 2180 pcu / hour in the afternoon, 2050 pcu / hour at noon, Singosari District is the district with the highest traffic volume This is because Singosari District is the largest industrial and trade center in Malang Regency, so there is a lot of accumulation of vehicles on weekdays which results in congestion on arterial roads.

4.2 Road Capacity
Calculation of road capacity using the following formula:
C = Co x FCw x FCsp x FCsf x FCcs
C = 2900 x 0.87 x 1 x 0.9 x 0.86
  = 1952.80 pcu/hour

So the road capacity in Wonosari District is 1952.80 smp / hour
The results of the calculation of road capacity on each road section at each research location point can be seen in table 1.

4.3 Travel Speed
The average speed that a vehicle travels through a road segment is the speed of travel, speed data is obtained when conducting a survey at each location point using a speed gun measuring instrument. In Wonosari District, the value of travel speed is 30 km / hour. Travel speed survey data can be seen in table 1.

4.4 Degree of Saturation
The degree of saturation is used as a major factor in determining the level of performance of road segments and segments, the degree of saturation will indicate whether the road segment has a capacity problem or not. The value of the degree of saturation can be calculated using the following formula:

DS   = Q / C
DS   = 727.90 / 1952.80
        = 0.3727

So the value of the degree of saturation in Wonosari District is 0.3727. The results of calculating the degree of saturation in other sub-districts can be seen in table 1. In accordance with the above calculations, the results will be obtained as in table 1 below:

Table 1. Traffic Assignment.

| No	Districts	Volume (pcu/hour)	Capacity (pcu/hour)	Q (pcu)	(DS)	Speed (km/hour)
1	Kasembon	4.639	1866.01	2319.50	1.2430	50
2	Ngantang	5.642	1866.01	2820.90	1.5117	50
3	Pujon	4644.65	1692.43	2322.33	1.3722	50
4	Lawang	14196.2	2556.35	7098.10	2.7767	40
5	Singosari	19372.5	1692.43	9686.25	5.7233	40
6	Pakis	5524.5	1145.24	2762.25	2.4119	30
7	Jabung	4435.9	1256.98	2217.95	1.7645	30
8	Tumpang	6324	1256.98	3162.00	2.5156	40
9	Karangploso	6498.6	1945.32	3249.30	1.6703	30
10	Pakisaji	6993.5	2331.39	3496.75	1.4999	40
11	Turen	3039.8	1089.38	1519.90	1.3952	40
12	Gondanglegi	4397.5	1779.22	2198.75	1.2358	40
13	Kepanjen	5615.5	2331.39	2807.75	1.2043	40
14	Kromengan	6962.75	2045.08	3481.38	1.7023	50
15	Sumberpucung	6289.1	2045.08	3144.55	1.5376	50
16	Kalipare	2789.45	1089.38	1394.73	1.2803	40
17	Bantur	4119.55	1256.98	2059.78	1.6387	30
18	SumberManjing Wetan	2791.25	1256.98	1395.63	1.1103	30
19	Dampit	5104.5	1089.38	2552.25	2.3428	30
20	Poncokusumo	5276.05	1256.98	2638.03	2.0987	30
21	Pagelaran	3052.7	1201.11	1526.35	1.2708	30
22	Ampelgading	6323.3	1256.98	3161.65	2.5153	40
23	Tajinan	4201.6	2331.39	2100.80	0.9011	40
24	Dau	4133.85	2331.39	2066.93	0.8866	40
25	Donomulyo	2074.95	1201.11	1037.48	0.8638	40
26	Pagak	2278.25	1201.11	1139.13	0.9484	30
27	Bululawang	4073	2331.39	2036.50	0.8735	40
28	Wajak	2007.6	1256.98	1003.80	0.7986	40
29	Wagir	1420.65	1256.98	710.33	0.5651	25
30	Ngajum	2522.75	1952.80	1261.38	0.6459	30
31	Gedangan	2137.25	1866.01	1068.63	0.5727	40
32	Tirtoyudo	2651.5	1952.80	1325.75	0.6789	30
33	Wonosari	1455.8	1952.80	727.90	0.3727	30

4.5 Level of Services (LOS)

After analyzing the traffic volume in each sub-district in Malang Regency, the next step is doing analysis to determine the level of service. The result of that analysis can be seen in the table 2. below

Table 2. Level of Service (LOS).

No	Districts	Level of Services
1	Kasembon	F
2	Ngantang	F
3	Pujon	F
4	Lawang	F
5	Singosari	F
6	Pakis	F
7	Jabung	F
8	Tumpang	F
9	Karangploso	F
10	Pakisaji	F
11	Turen	F
12	Gondanglegi	F
13	Kepanjen	F
14	Kromengan	F
15	Sumberpucung	F
16	Kalipare	F
17	Bantur	F
18	SumberManjing Wetan	F
19	Dampit	F
20	Poncokusumo	F
21	Pagelaran	F
22	Ampelgading	F
23	Tajinan	E
24	Dau	E
25	Donomulyo	E
26	Pagak	E
27	Bululawang	E
28	Wajak	D
29	Wagir	C
30	Ngajum	C
31	Gedangan	C
32	Tirtoyudo	C
33	Wonosari	B

Based on the analysis of traffic volume calculation, it can be seen that the level of service (LOS) on arterial roads in Malang Regency showed that 22 districts were included in the F category with a percentage of 66.66%, 5 districts were included in category E with a percentage of 15.15%, 1 sub-district was included incategory D with a percentage of 3.03%, 4 districts were included in category C with a percentage of 12.12% and 1 sub-district was included in category B with a percentage 3.03%. Thus, almost 84% of road service levels in Malang Regency tend to cause congestion.

Level of Services (LOS)
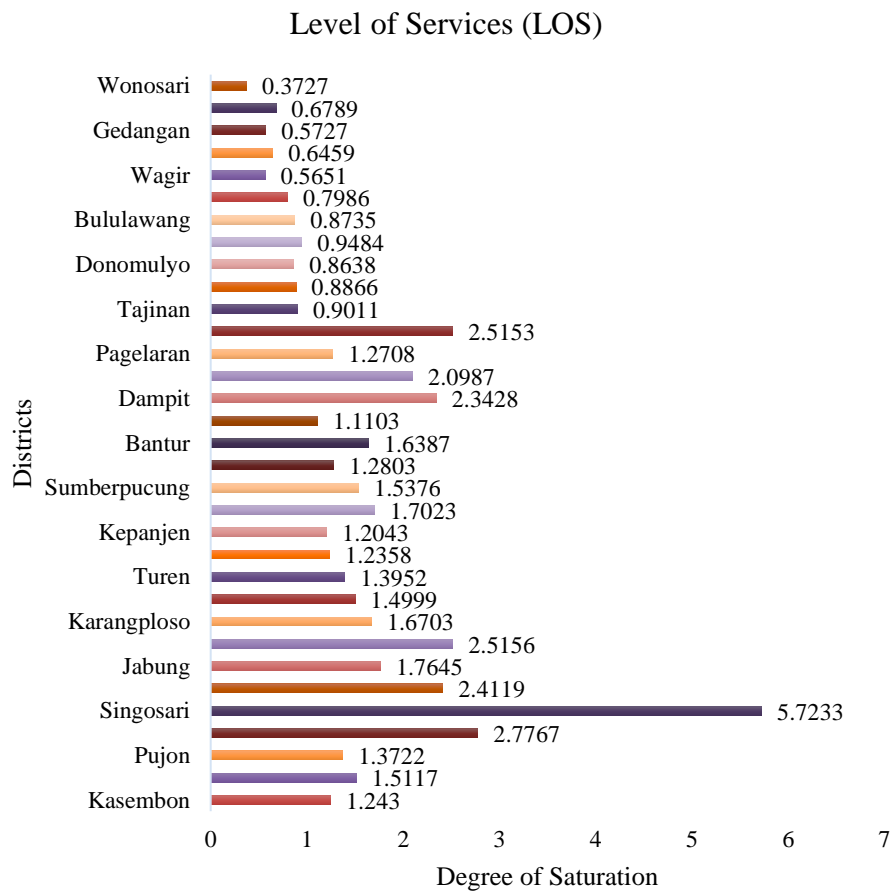
Graph 2. Level of Services (LOS)

The level of road service with category B is in Wonosari District with a saturation degree value of 0.372, the level of road service with category C is in Wagir, Gedangan, Ngajum and Tirtoyudo Districts with a saturation degree value between 0.565 - 0.678 then the road service level with category D is in the District Wajak with a saturation degree value of 0.798. Meanwhile, 27 roads in the District of Malang Regency have a bad road service level which is included in the E and F categories with a degree of saturation > 0.850.

Based on previous research conducted by the Research and Development Agency of East Java Province in 2017, [5] the transportation mode in Malang Regency is dominated by 87% of two-wheeled vehicles and predicts that the performance of the road network in the next 15 years will decrease so that it will experience severe congestion. This is due to the development of online transportation modes, which require improvements to the online transportation service system to reduce the use of private vehicles. From the study conducted by the Research and Development Agency of East Java Province, this research can prove that the performance of the road network in Malang Regency in 2020 has a road service level of 84% in category F or it can be said to be bad.

5.   Conclusion

The level of road service with category B is in Wonosari District with a saturation degree value of 0.372, the level of road service with category C is in Wagir, Gedangan, Ngajum and Tirtoyudo Districts with a saturation degree value between 0.565 - 0.678 then the road service level with category D is in the District Wajak with a saturation degree value of 0.798. Meanwhile, 27 roads in the District of Malang

Regency have a bad road service level which is included in the E and F categories with a degree of saturation > 0.850. The characteristics of traffic movements during the Covid-19 pandemic in 22 Districts were included in category F with the number of traffic flows that were at a rush rate with relatively low speed. This situation resulted in long queues of vehicles. Thus, almost 84% of road service levels in Malang Regency tend to cause congestion. Because of this condition, it is expected that the Public Works Office and Malang Regency Transportation Office have more attention in providing new policies regarding restrictions on types of private vehicles, providing traffic engineering alternatives for diverting transportation routes to new land uses so that congestion can be reduced and get more intensive to provide socialization to the public to get used to using public transportation more as a as means of their daily transportation. This is one of the ways to achieve sustainable and continously transportation planning.

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