Traffic Volume Patterns in Urban Areas (Case Study: Sungguminasa City Border Road - Takalar Regency Border Road Km 0-3.41)

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ABSTRACT

Pallangga District is the district with the second largest population in Gowa Regency, with a population of 133,027 people or 16.84 percent of the total population in Gowa Regency (Gowa Regency Central Statistics Agency, 2023). The rapid development of housing and commerce has made Pallangga District the most populous area apart from the district capital, namely Sungguminasa. This has also led to changes in land use and an increase in traffic volume, causing congestion. The development of housing and commerce has generated travel generation and attraction around the Sungguminasa City Border Road - Takalar Regency Border Road, but this has not been followed by an increase in transportation facilities and infrastructure, especially road capacity. This shows that land use planning and transportation planning have a relationship that mutually influences each other. This research aims to determine the traffic volume on Jalan Batas Kota Sungguminasa-Batas Kota Takalar Km 0-3.41. The research method used is quantitative analysis by conducting traffic volume surveys and using the 2023 Indonesian Road Capacity Guidelines (PKJI, 2023) as a reference. The results of the research show that road capacity and traffic volume influence the occurrence of traffic jams on the Sungguminasa City-Batas City Border Road, Takalar Regency.

Keywords: traffic; volume; road; capacity; Takalar Regency.

INTRODUCTION

The current development and growth of society and its environment has led to an increase in the number of vehicles on urban roads. This causes the level of movement and traffic density to increase, so that the need for transportation also increases. This increase in traffic volume can cause traffic jams which can affect the safety and delays of road users. Therefore, it is necessary to analyze the pattern of increasing traffic volume on urban roads to determine the factors that influence the increase in traffic volume and make predictions about the pattern of increasing traffic volume in the future.

Traffic is an important aspect of modern urban life. Traffic volumes and levels of traffic density, often measured by the volume-to-capacity ratio (V/C ratio), have a major impact on mobility, transport efficiency and the quality of the urban environment. Therefore, correlation analysis between traffic volume and V/C ratio becomes very relevant in efforts to understand and manage urban traffic better.

The current traffic conditions in Indonesia can be described as an ever-growing challenge. In various big cities such as Jakarta, Surabaya and Bandung, traffic congestion is a critical problem. Factors such as high traffic volumes, lack of adequate road infrastructure, and lack of efficient public transportation contribute to the resulting congestion. High levels of air pollution in several big cities are also a negative impact of traffic congestion, which can endanger public health.

The same thing also happened in Makassar City. Traffic conditions in Makassar City, which is the capital of South Sulawesi Province, are a combination of high mobility and several challenges that are often faced in rapidly developing cities. With the population continuing to grow and the number of motorized vehicles increasing, traffic jams are a common problem, especially during rush hours. The main roads in the city are often congested with vehicles, and the chances of getting stuck in a

traffic jam are high. Despite efforts by local governments to improve road infrastructure and reduce congestion, challenges associated with economic growth and urbanization remain. In this context, investment in a more efficient public transportation system and sustainable mobility alternatives is also an important part of the long-term solution to overcome traffic problems in Makassar City.

Gowa Regency is one of the buffer areas of Makassar City. The strategic location of the Gowa Regency area and the decreasing number of vacant land areas in Makassar City have resulted in the rapid development of housing, industry and commerce in Gowa Regency. This development has had a positive impact in several ways, one of which is an increase in the economy in Gowa Regency. However, it cannot be denied that this also has a negative impact in several aspects, one of which is the increase in the number of vehicles which then results in traffic jams.

Gowa Regency is located in the southern area of South Sulawesi Province which directly borders 7 districts/cities. Makassar City and Maros Regency are districts/cities that border Gowa Regency to the North, Sinjai, Bulukumba and Bantaeng Regency border to the East, Takalar and Jeneponto Regency border to the South, while Makassar and Takalar City border to the West (Central Agency Gowa Regency Statistics, 2022).

The population of Gowa Regency in 2021 is 773,315 people. Gowa Regency is the district with the third largest population in South Sulawesi Province, with an average growth rate of 1.56 percent per year (Gowa Regency Central Statistics Agency, 2022). The increase in population in Gowa Regency is influenced by the location of Gowa Regency which borders directly on Makassar City, so that many Makassar residents or people who work in Makassar choose to live in Gowa Regency. It is also recorded that Gowa Regency has 19 companies/industries (medium and large) with a workforce of 1,663 people. Meanwhile, for Micro and Small Industries, there were 12,056 units recorded with a total of 28,000 workers.

Pallangga District is the district with the second largest population in Gowa Regency, with a population of 133,027 people or 16.84 percent of the total population in Gowa Regency (Gowa Regency Central Statistics Agency, 2023). The rapid development of housing and commerce has made Pallangga District the most populous area apart from the district capital, namely Sungguminasa. This has also led to changes in land use and an increase in traffic volume, causing congestion. The development of housing and commerce has generated travel generation and attraction around the Sungguminasa City Border Road - Takalar Regency Border Road, but this has not been followed by an increase in transportation facilities and infrastructure, especially road capacity. This shows that land use planning and transportation planning have a relationship that mutually influences each other.

The problem of congestion that occurs on the Sungguminasa City Border Road - Takalar Regency Border Road will cause losses for the community and road users, including: air pollution, loss of time, loss of energy/fatigue/stress, loss of fuel and delays in the distribution of goods. Congestion can also cause air pollution caused by burning vehicle fuel. The Gowa Regency Environmental Service for the last 2 (two) years has issued the Gowa Regency Air Quality Index. According to (Wikipedia Indonesia, 2023) the Air Quality Index (IKU) is a measure used to assess air pollution. Increasing air pollution will increase the IKU value, where the IKU for Gowa Regency in 2021 is 85.58, while in 2022 it is 86.80. This shows an increase in the KPI value which can be interpreted as an increase in air pollution. This increase in KPI can be influenced by several things, one of which is the influence of motor vehicle exhaust emissions.

The Sungguminasa City Border Road - Takalar Regency Border Road section is a National Road which functions as the main route for AKAP transport and distribution of goods, to and from Takalar, Jeneponto, Bantaeng and Bulukumba Regencies. The Sungguminasa City Border Road - Takalar Regency Border Road is a four-lane, two-lane undivided road without a median with a road width of 12 meters and a shoulder width of 1.1 meters. The Sungguminasa City Border Road - Takalar Regency Border Road is a Class I road, namely an arterial and collector road that can be passed by motorized vehicles with a width not exceeding 2,500 millimeters, a length not exceeding 18,000 millimeters, a maximum size of 4,200 millimeters and the heaviest axle load being 10 tons. .

Departing from the current problem of traffic jams, the aim of this research is to determine the traffic volume on the Sungguminasa City Border Road - Takalar City Limit Road Km 0-3.41.

Road Network

According to Law Number 2 of 2022, roads are land transportation infrastructure which includes all parts of the road, including connecting buildings, complementary buildings and equipment intended for public traffic, which are at ground level, above ground level, below ground level. and/or water, as well as above the water surface, except rail roads, truck roads and cable roads. Meanwhile, the road network system is a single road segment that connects and binds activity centers/growth centers, and transportation nodes with areas under the influence of its services in a hierarchical relationship. In (MKJI; Directorate General of Highways, 1997) 6 (six) types of traffic facilities are described, namely signalized intersections, unsignalized intersections, interwoven sections, urban roads, freeways and out-of-town roads. Urban roads have the characteristics of developing permanently and continuously along all or almost half of the road, at least on one side of the road, whether in the form of land development or not. Based on the description above, the Sungguminasa City Border Road - Takalar Regency Border Road according to its function is a Collector Road and is an urban road, with a four-lane two-way undivided road type/without median (4/2 UD).

Traffic Volume

Traffic volume is the number of motorized vehicles passing a point on the road expressed in passenger car units per hour (pcu/hour) which is then multiplied by the passenger car equivalent (emp) (MKJI; Directorate General of Highways, 1997).

Table 1. Passenger Car Equivalence for Undivided Urban Roads

Undivided Road Type	Total two-way traffic flow (vehicles/hour)	HV	Emp	
			MC	
			WC traffic lane width(m)	
			$\leqq 6$	> 6
Two lane undivided (2/2 UD)	0	1,3	0,5	0,40
	$\geqq 1800$	1,2	0,34	0,25
Four lane undivided (4/2 UD)	0	1,3	0,40	
	$\geqq 3700$	1,2	0,25	

Source: (PKJI, 2023)

Motor vehicle traffic volume is a term used to describe the intensity or number of vehicles passing on a highway within a certain period of time. This traffic volume is usually measured in units of vehicles per hour or vehicles per day (Syaiful S et.al, 2023). In many large cities, especially in developing countries such as Indonesia, the volume of motor vehicle traffic continues to increase from year to year along with the increasing population, urbanization, and economic growth that encourages private vehicle ownership (Syaiful S et.al, 2023).

The high growth in traffic volume has a significant impact on various aspects of life, including travel time, air pollution, and energy consumption. One of the biggest problems faced due to high traffic volume is congestion. In big cities such as Jakarta, Surabaya, and Medan, traffic congestion is often a daily problem that disrupts people's activities. Congestion occurs when the number of vehicles passing on a road exceeds the capacity of the road, causing vehicle movement to slow down or even stop completely (Syaiful S et.al, 2022).

The high volume of traffic also contributes to increased air pollution. Motorized vehicles, especially those using fossil fuels, emit exhaust emissions containing carbon dioxide (CO_2), nitrogen oxides (NOx), and other particles that are harmful to human health and the environment. In addition, congestion that slows down vehicle speed also worsens fuel consumption, resulting in higher emissions. Air pollution due to high traffic volumes is often one of the main causes of declining air quality in urban areas, which has a negative impact on the health of residents (Syaiful S et.al, 2022).

In addition to environmental impacts, high traffic volumes also have an impact on the efficiency of time and productivity of the community. Time spent in traffic jams can cause decreased productivity,

both in economic and daily contexts. For workers, congestion can affect the time of arrival at work, reduce quality of life, and increase stress. For entrepreneurs and companies, delays in the delivery of goods due to congestion can also increase operational costs and reduce the efficiency of the supply chain (Syaiful S, Fadly A, 2020; Syaiful S et.al, 2021).

Several factors that influence the increase in traffic volume include the growth in the number of vehicles, limited road infrastructure, and the lack of efficient public transportation. People tend to choose to use private vehicles, both cars and motorbikes, because of the comfort and flexibility they offer. However, this actually worsens the traffic situation, especially in urban areas that are already (Syaiful S, Hariyadi D, 2019). Efforts to overcome the high volume of traffic and the resulting congestion include various strategies, both in terms of government policy and community participation. The construction of new road infrastructure such as toll roads, flyovers, and underpasses is one solution that is often implemented to reduce the traffic load on main roads. However, this solution only has a short-term impact if it is not accompanied by efforts to reduce the use of private vehicles (Syaiful S, Rusfana H, 2022; Syaiful S et.al, 2024).

RESEARCH METHODS
Research sites

The researcher chose the location of Jalan Batas Kota Sungguminasa-Batas Takalar Regency because it is one of the roads in Gowa Regency which has a fairly high level of traffic density, especially during rush hours, so the researcher wants to find a way out of this so that traffic can be created smoothly. smooth and comfortable. The research location is along the Sungguminasa City Border Road - Takalar Regency Border Road, 3.41 km long, located at coordinates -5.214420, 119.450699 to -5.239336, 119.432547.

Figure 1. Research Location

Research methods

This study uses a quantitative approach. Quantitative research method is a method that aims to create a picture or description of a situation objectively using numbers, starting from data collection, interpretation of the data and the results (Arikunto, 2002). It is hoped that the use of this research method can provide readers with an overview of the conditions that occur in the field.

Data retrieval

The data needed and collected in this research is traffic volume data obtained directly in the field. The researcher conducted a survey at KM 1.74 and the survey was carried out by 3 (three) surveyors

with 2 (two) shifts per day (07.00-15.00 and 15.00-22.00 WITA) for each direction of vehicle movement, for a total of 12 (twelve) people.
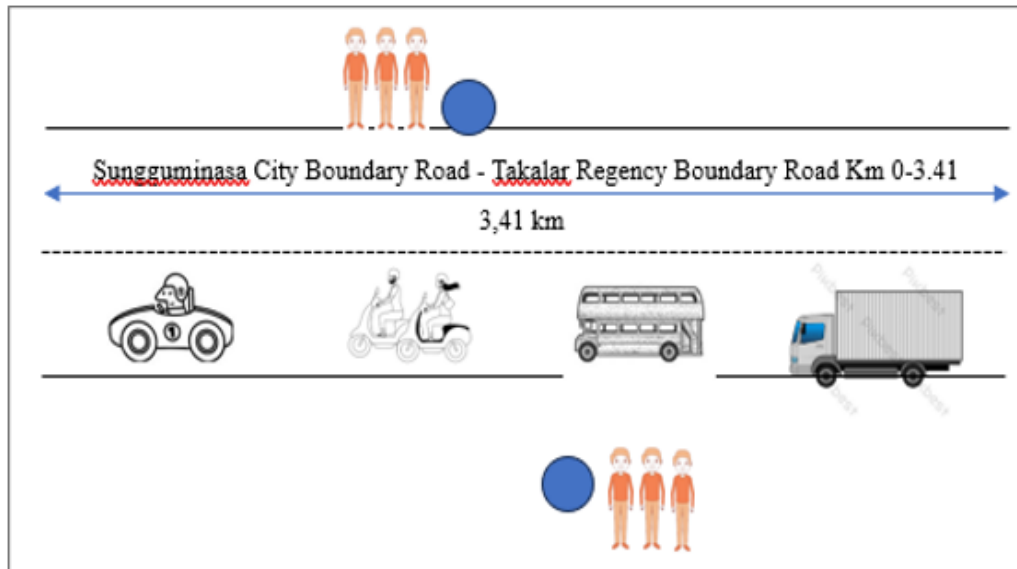

Figure 2. Surveyor Position

Data collection using the traffic volume survey method was carried out manually at 07.00-22.00 WITA for 7 (seven) days, to obtain Average Daily Traffic (LHR). This survey was carried out by counting all vehicles passing through the Sungguminasa City Limits-Takalar District Road section, except for special vehicles, for example: rollers, graders, military convoy vehicles, steel tanks, etc. The grouping of vehicle types surveyed is in accordance with (PKJI, 2023) as in the following table:

Table 2. Vehicle Classification Based on PKJI

Road type	Total two-way traffic flow (vehicles/hour)	HV	EMP MC	
			WC traffic lane width(m)	
			$\leqq 6$	$\geqq 6$
Four lane undivided (4/2 UD)	0	1,3	0,40	
	$\geqq 3.700$	1,2	0,25	

Source: (PKJI, 2023)

Where:

MC (motor cycle) = two- or three-wheeled motorized vehicles, including motorbikes, bentors, and so on

Heavy vehicles (HV) = motorized vehicles with more than four wheels, including buses, 2-axle trucks, 3-axle trucks, and so on.

Existing Data

Gowa Regency has a road length of 2,761 km in 2021. This road length consists of 23 km of State Roads, 272 km of Provincial Roads, and 2,467 km of Regency Roads. The length of this road is not directly proportional to the number of vehicles in Gowa Regency. The number of vehicles continues to increase, while the length of roads in Gowa Regency remains the same. According to (BPS South Sulawesi, 2023) the number of motorized vehicles in Gowa Regency in the last three years has increased, as can be seen in the following table:

Table 3. Number of Motorized Vehicles in Gowa Regency

Years	Number of Vehicles				Total
	Passenger Car	Bus	Truck	Motorcycle	
2020	22.448	207	11.220	260.970	294.845
2021	23.531	205	11.769	269.963	305.468
2022	25.525	209	12.613	284.931	323.278

Source: (BPS South Sulawesi, 2023)
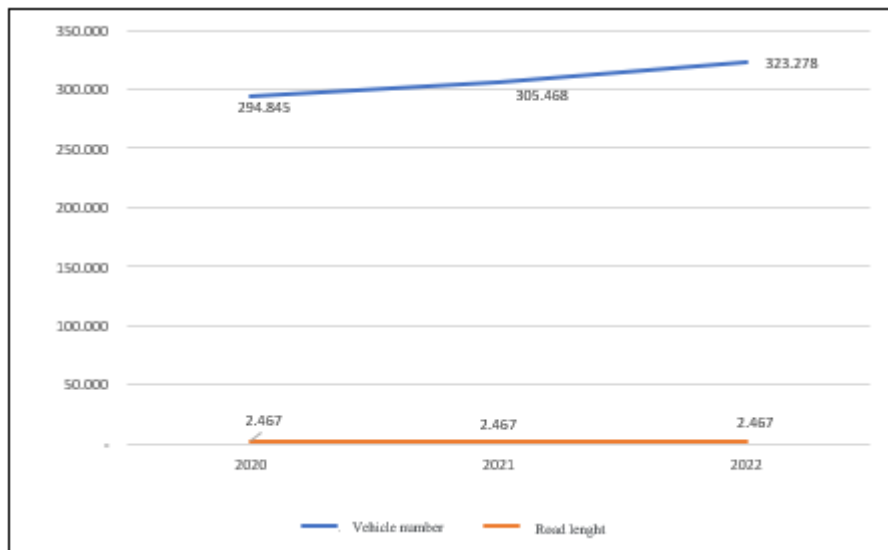
Figure 3. Comparison of Number of Vehicles and Road Length

RESEARCH AND DISCUSSIONS

Based on the results of the vehicle volume survey which was carried out for 7 (seven) days from 07.00-22.00 WITA, the traffic volume per day was obtained.

Table 4. Peak Number of Vehicles (vehicles/hour)

| Observation Day	Directions Takalar - Sungguminasa		Directions from Sungguminasa to Takalar	
	Observation Hours	Number of vehicles (vehicles/hour)	Observation Hours	Number of vehicles/hour)
Monday	07.00-08.00	11.424	17.00-18.00	5.623
Tuesday	07.00-08.00	10.675	17.00-18.00	6.951
Wednesday	07.00-08.00	10.441	18.00-19.00	5.354
Thursday	07.00-08.00	10.557	17.00-18.00	5.616
Friday	07.00-08.00	10.141	18.00-19.00	5.456
Saturday	07.00-08.00	7.779	17.00-18.00	5.392
Sunday	16.00-17.00	4.727	20.00-21.00	4.298

Source: Survey Results
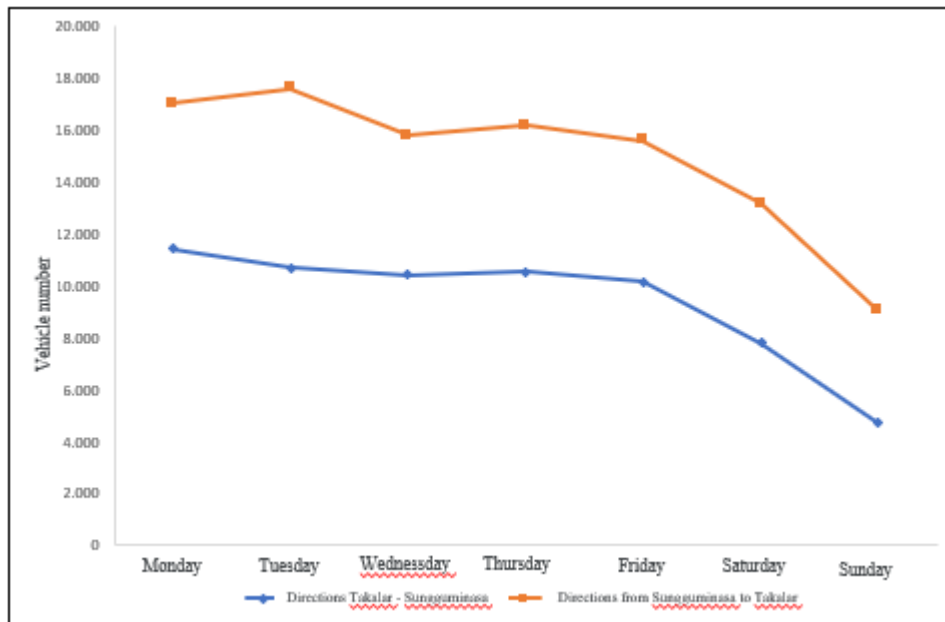
Figure 4. Graph of Number of Vehicles

In calculating the number of vehicles, vehicle counts are carried out during the survey using traffic counters at predetermined points and pouring them into a survey formula sheet with data presented every 15 (fifteen) minutes.

From the survey conducted, the highest number of vehicles on the road from Takalar-Sungguminasa occurred on Monday at 07.00-08.00 WITA, this is because Monday is the first day at the beginning of the week where activities, both work and school, start on Monday, and The number of vehicles will decrease significantly starting from 10.00 WITA.

Meanwhile, on the Sungguminasa-Takalar road section, the highest number of vehicles occurs on Tuesdays at 17.00-18.00 WITA. Where most people carry out their activities in Sungguminasa and Makassar City. So in the afternoon until evening, the Sungguminasa-Takalar road is always congested with vehicles. From the results of the survey, it can be seen that the number of vehicles passing through the Sungguminasa-Takalar road section during peak hours is not as large as in the opposite direction, this is because on the Sungguminasa-Takalar road section the number of vehicles is relatively constant at over 4,000 vehicles, which happens starting from 17.00-21.00 WITA.

From the results of multiplying by emp per vehicle type as in the data above, the overall traffic volume can be known, namely by using the formula:

$Q = Q_{LV} + Q_{HV} + Q_{MC}$

Where:
Q_{LV} = Number of light vehicles (pcu/hour)
Q_{HV} = Number of heavy vehicles (pcu/hour)
Q_{MC} = Number of motorbikes (pcu/hour)

From the results of these calculations, the traffic volume pattern at peak hours in units of pcu/hour is obtained as shown in the following table and figure:

Table 5. Traffic Volume Pattern at Peak Hours Per Day (pcu/hour)

| Observation Day	Directions Takalar - Sungguminasa		Directions from Sungguminasa to Takalar	
	Observation Hours	Number of vehicles (vehicles/hour)	Observation Hours	Observation Hours
Monday	07.00-08.00	5.844	18.00-19.00	3.175
Tuesday	07.00-08.00	5.295	17.00-18.00	3.555
Wednesday	07.00-08.00	5.172	18.00-19.00	3.108
Thursday	07.00-08.00	5.234	18.00-19.00	3.216
Friday	07.00-08.00	5.037	18.00-19.00	3.020
Saturday	07.00-08.00	4.366	17.00-18.00	2.964
Sunday	16.00-17.00	2.827	20.00-21.00	2.770

Source: Survey Results
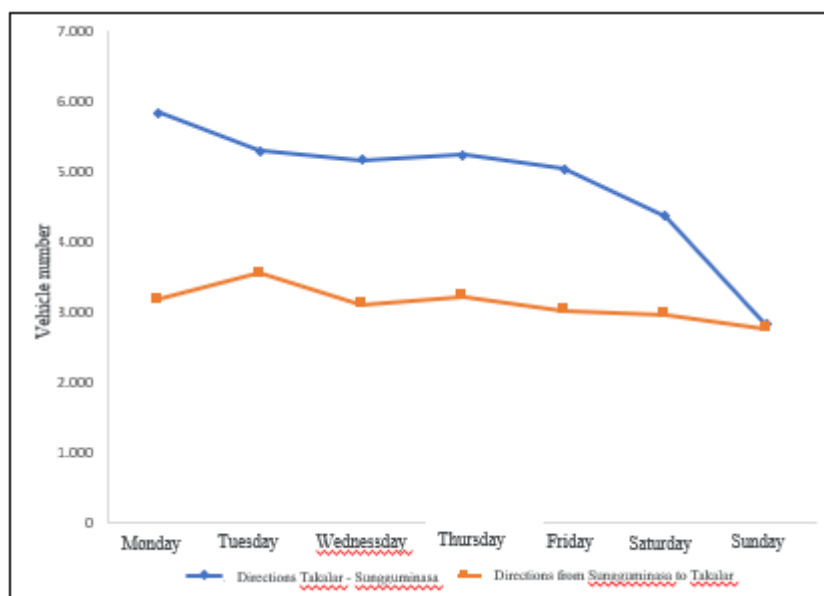
Figure 5. Traffic Volume Pattern at Peak Hours Per Day (pcu/hour)

From the results of the Road Geometric survey, data was obtained on the existing section of the Sungguminasa City-Takalar Regency Boundary Road along with side obstacles that affect road capacity. The existing conditions observed are:

Along the Sungguminasa City Boundary Road - Takalar Regency there is a continuous and local traffic flow. The continuous flow is vehicles from and going to Takalar Regency, Malakaji District,

Jeneponto Regency, Bulukumba Regency and Selayar Island. Meanwhile, local traffic is vehicles entering and exiting along the Sungguminasa City-Takalar Regency Boundary Road.

The highest traffic volume on the Takalar-Sungguminasa road section has a constant pattern where the highest traffic volume occurs in the morning at 07.00-08.00 WITA, except on Sundays. This is influenced by the people who mostly carry out activities in Sungguminasa and Makassar City, including working, going to school and distributing goods. The type of vehicle that dominates traffic volume at peak hours is two-wheeled vehicles (motorbikes) with more than 80% of the total traffic volume passing from Takalar to Sungguminasa.

The highest traffic volume on the Sungguminasa-Takalar road section has a slightly changing pattern where the highest traffic volume occurs in the afternoon and sometimes at night between 17.00-19.00 WITA, except on Sundays. This is influenced by people who travel back to their homes. Even though the traffic volume in the direction of Takalar-Sungguminasa is not as high as in the morning, the traffic volume pattern in the direction of Sungguminasa-Takalar tends to be the same and lasts for approximately 4 (four) hours. The type of vehicle that dominates traffic volume at peak hours is two-wheeled vehicles (motorbikes) with more than 65% of the total traffic volume passing from Sungguminasa to Takalar.
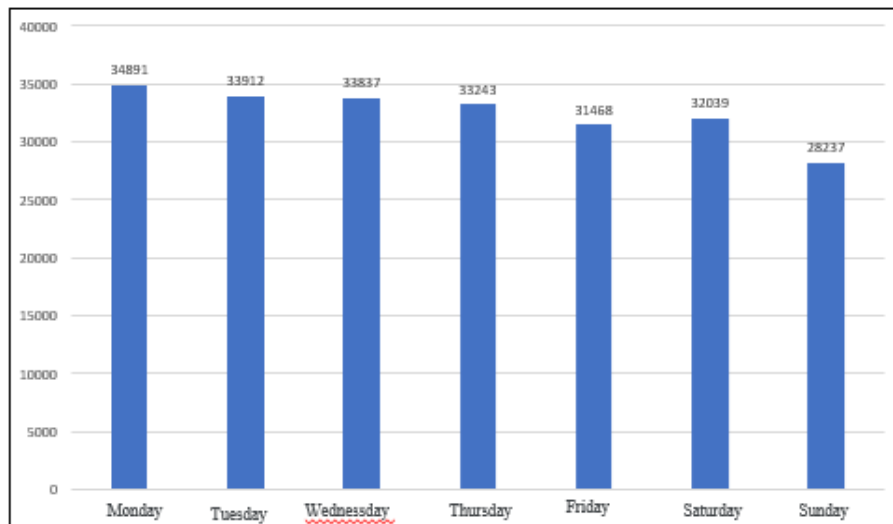

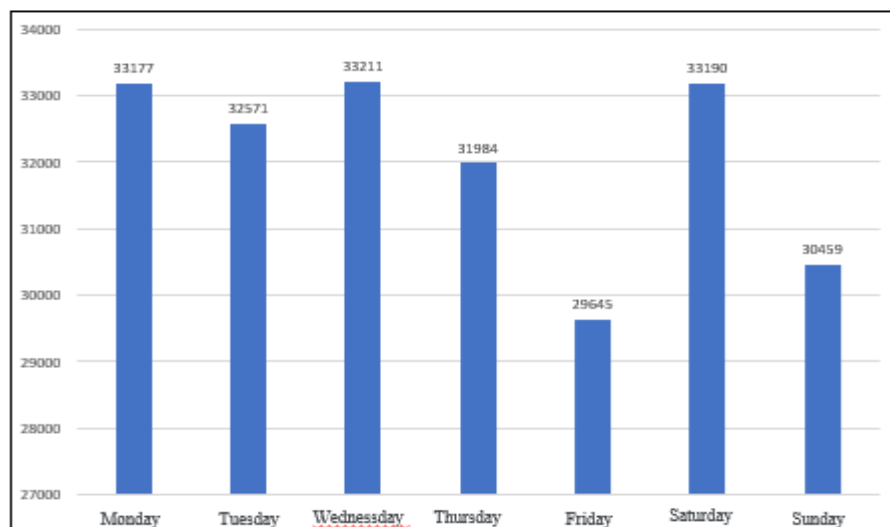**Figure 6.** Daily traffic volume in the Takalar-Sungguminasa direction (smp/hour)

Figure 7. Traffic volume per day in the Sungguminasa-Takalar direction (pcu/hour)

CONCLUSIONS

Based on the analysis and discussion described previously, it can be concluded that the traffic volume pattern on the Sungguminasa City-Takalar Regency Border Road Km 0-3.41 is different between traffic from Takalar to Sungguminasa in the opposite direction. This difference is due to different travel patterns, the pattern of leaving for routine activities (for example: work, school, etc.), namely going to Sungguminasa or Makassar City which is done in the morning so that the highest traffic volume occurs at 07.00-08.00 WITA. Meanwhile, the pattern of movement returning home from activities is towards Pallangga, Barombong, Bajeng and Takalar Regency, which occurs in the afternoon until evening. The highest traffic volume towards Takalar is not as big as the highest traffic volume towards Sungguminasa, this is because the traffic volume towards Takalar is relatively the same in size during the 4 hours starting from 17.00-21.00 WITA. This is caused by several things, including: different home times, me and there are also those who make other trips after office hours (for example stopping at a shopping center, etc.).

REFERENCES

Arikunto, S. (2002). Metodologi Penelitian Suatu Pendekatan Proposal. 2017.

Badan Pusat Statistik Kabupaten Gowa. (2022). *Kabupaten Gowa Dalam Angka Tahun 2022* (2022 ed.). Badan Pusat Statistik Kabupaten Gowa. https://gowakab.bps.go.id/publication

Badan Pusat Statistik Kabupaten Gowa. (2023). *Kabupaten Gowa Dalam Angka 2023*. Badan Pusat Statistik Kabupaten Gowa.

BPS Sulsel. (2023). Provinsi Sulawesi Selatan Dalam Angka 2022. In *Badan Pusat Statistik Sulawesi Selatan*.

MKJI;Direktorat Jenderal Bina Marga. (1997). MKJI 1997. In *departemen pekerjaan umum, "Manual Kapasitas Jalan Indonesia."*

PKJI, D. J. B. M. (2023). Pedoman Kapasitas Jalan Indonesia. In *Kementerian PUPR* (Vol. 2, Nomor 21).

Wikipedia Indonesia. (2023). *No Title*. https://id.wikipedia.org/wiki/Indeks_kualitas_udara#:~:text= Semakin tinggi nilai AQI%2C, semakin tinggi pula risiko kesehatan.

Syaiful, S., Yulianto, M., Murtejo, T., & Rulhendri, R. (2023). Analysis of the Function and Convenience of Pedestrian Public Transport Support the City of Bogor. ASTONJADRO, 12(3), 646–657. https://doi.org/10.32832/astonjadro.v12i3.4341

Syaiful, S., Pratikso, P., & Wiwoho Mudjanarko, S. (2023). Literature Study of the Sustainability Model of Transportation Facilities and Infrastructure in the Management of Public Transportation with the Concept of Inter-Regional Cooperation (Case in the City and District of Bogor). ASTONJADRO, 12(2), 613–634. https://doi.org/10.32832/astonjadro.v12i2.14114

Syaiful, S., Prayudyanto, M. N., Rulhendri, R., Lestari, P. A., Nabila, A. N., Damiana, S. L., & Haldiana, H. (2022). Vehicle Traffic Volume Analysis Due to Sound Generated in front of the RS. Hermina Bogor. ASTONJADRO, 11(2), 475–489. https://doi.org/10.32832/astonjadro.v11i2.7136

Syaiful, S., Siregar, H., Rustiadi, E., & Hariyadi, E. S. (2022). Performance of Three Arms Signalized Intersection at Salabenda in Bogor Regency. ASTONJADRO, 11(1), 13–29. https://doi.org/10.32832/astonjadro.v11i1.4955

Syaiful, S., & Fadly, A. (2020). Analysis of the Effectiveness of Bus Services Outside of Campus IPB Dramaga Bogor. ASTONJADRO, 9(2), 173–186. https://doi.org/10.32832/astonjadro.v9i2.3597

S Syaiful, H Siregar, E Rustiadi, ES Hariyadi. (2021). Traffic Improvement Strategy in Transportation System Using AHP Method. ARPN Journal of Engineering and Applied Sciences 16 (22), 2431-2439.

S Syaiful, D Hariyadi. (2019). Case Study on Sustainable T-Jungtion Cibinong City Mall (CCM) in

Bogor Indonesia, ARPN Journal of Engineering and Applied Sciences 14 (17), 2960-2971.

S Syaiful, H Rusfana. (2022). Rigid Pavement Planning in Traffic: Case Study in Ciherang Road and Pemuda Road, Bogor Regency, Indonesia. Journal of Applied Engineering Science, 1-13.

S Syaiful, P Pratikso, SW Mudjanarko, D Diansyah. (2024). The Effect of Traffic Volume on the Noise Caused by Motorized Vehicles in front of Karya Bhakti Pratiwi Dramaga Hospital, Bogor. ARPN Journal of Engineering and Applied Sciences 19 (1), 16-32.