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# The scenario of reducing congestion and resolving parking issues in Makassar City, Indonesia

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ABSTRACT

This study aims to analyze congestion and parking points to construct a behavioral model of congestion, parking, and traffic performance, as well as develop scenarios for projecting the congestion reduction in Makassar City, Indonesia. Three stages were conducted in the study, namely the use of surveys for collecting data on the parking and congestion levels, and the public's perceptions in developing a behavioral model towards the relationship between parking and congestion. Furthermore, a resolving scenario and projection model for reducing the level of congestion in 2020 to 2050 were compiled. In the first phase, a survey of 67 roads consisting of 78 segments in Makassar was employed to measure the parking and congestion levels. The variables observed were the number of congestion points, vehicle volume, city road capacity, degree of saturation, speed, travel time, and delay. Furthermore, the second stage surveyed the community's perception of the relationship between congestion and parking by distributing questionnaires to 250 respondents. These respondents were selected by incidental sampling in 8 points representing the subdistricts in Makassar. The last stage involved focused group discussions with city managers to formulate resolving scenarios. Base on the scenarios, the projection of the congestion reduction was estimated. The results indicated that the severe congestion incidents, which reduce the travel services in the city, occurred due to crossroads, T junctions, U-turns, parking, and complex occasions. Also, the behavioral model indicated the assessment level and showed that resolving parking issues tend to have more impact in reducing congestion. Therefore, focus group discussions recommend short, medium, and long-term solutions. In addition, projections over 30 years suggest remarkable improvement when resolving parking issues and traffic management are considered in congestion reduction strategies.

## 1. Introduction

Congestion is a major transportation problem in big cities, including in Indonesia (Farda & Balijepalli, 2018), where there are high vehicle densities on roads and highways. For example, no current information has been obtained on the right solution for overcoming traffic congestion in the capital city of Jakarta (Alhadar, 2011, Sugiarto et al., 2020). This problem occurs when the increase in road capacity is disproportional to the number of vehicle growth, resulting in longer travel time (Banister, 2005). Subsequently, this situation causes huge costs and inconvenience for many businesses and enterprises, especially those requiring a high level of transportation activity per unit of production, and reduces investment in transportation infrastructure (O'Mahony and Finlay, 2004). This results in a negative impact, which has large individual, economic, environmental, and social costs (Curtis, 2012; Matan et al., 2012; Mizutani et al., 2011). Congestion causes a large loss of vehicle operating costs and time due to weaving at intersections (Said, 2011). Although countless expenditures and efforts have been exhausted to address traffic congestion problems, especially in big cities within Indonesia, little progress has been reported. Despite the advancement of technology or provision of infrastructure, congestion develops consistently with the city and population (Newman & Kenworthy, 1996).

Makassar is one of the major cities in Indonesia, located in South Sulawesi with an area of 175,77 km$^2$ and a population density of 8,701 people/km$^2$. This city has several main roads, including 13 segments prone to traffic congestions, with a total length of 40 km. Congestion is a result of various factors, including the growth vehicle numbers parked on the road, narrowing of roads in transitional sections, median openings of indiscipline road users, alongside limited traffic signs, control officers, and weak law enforcement. Therefore, attention should be focused on its local root cause to resolve this problem. A previous survey indicated the main causes of congestion in Makassar were the median

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openings and parking of vehicles on the road, hence lane engineering and parking management are both required to resolve this problem. Several studies on resolving congestion focused on car-free day, odd–-even plate measures (Li & Guo 2016, Farda & Balijepalli, 2018), congestion charging (Andersson and Nässén, 2016, Sugiarto et al., 2020, Tang, 2021), mathematical modeling (Thiagarajan et al., 2017), information systems using programming algorithms (Tan et al., 2013), and ad-hoc wireless networks (Rajesh & Gnanasekar, 2015).

## 2. The overview of congestion

Urban transportation is an important element in economic activity and urban development, as well as the main supporting sector for community mobility and freight transportation. Moreover, the number of motorized vehicles has increased due to population growth in urban areas resulting from relatively high rapid urbanization. Also, the mass transportation system in most developing countries has failed to be the main mode of conveyance because it lacks safety and convenience. Therefore, the citizens prefer private cars because it facilitates personal mobility, alongside providing a sensation of security and higher status. The sprawling urban growth with a poor public transport network has supported the trend of motorization among urban residents in these countries (Bull, 2003), and influence buffer zones around cities. According to Adisasmita (2011), the number of motorized vehicles in Indonesia increases by 10% yearly, while the construction of new roads is sluggish, with only 0.05%, leading to a serious negative impact on traffic congestion.

In Indonesia, congestion is mainly due to the intensive use and widespread ownership of automobiles in recent decades. This problem usually arises in cities with a population of more than 2 million people, and until 1996, several cities, such as Jakarta, Surabaya, Medan, Bandung, Yogyakarta, Semarang, and Makassar, were free of this issue. Also, the use of private vehicles has increased with the deterioration in the quality of life, especially in urban centers, due to congestion and delays on several roads, as well as sound and air environmental pollution (Zhong et al., 2017). The growth rate of vehicles is disproportionate with transportation facilities and infrastructure, where the current road construction programs in urban areas are very expensive and accessibility and mobility are disturbed.

Congestion on the urban road networks has increased substantially since the 1980 s. Furthermore, some special circumstances, including road capacity reduction at a certain point or segment, increased the vehicle numbers required for a certain volume of people or goods, heavy traffic, traffic incidents, roadworks, and weather events, cause or worsen congestion. Rainfall also reduces the capacity and speed of traffic operations, resulting in greater congestion and lost productivity of the road network.

The root causes of congestion include industrialization, urbanization, and inefficient land use patterns. Industrialization and unplanned urbanization developed a large number of serious problems, including the increase of traffic density, and congestion, as well as pollution and scarcity of urban land (Uzun, 2010). Consequently, traffic congestion has become a major problem due to the increasing concentration of population and activity in cities, especially in this car age (Zhang & Li, 2010). This problem occurs due to (1) the use of private vehicles, (2) inadequate road capacity, (3) human attitudes, behavior, and habits, as well as (4) infrastructure development factors. Roy et al., (2020) argued that the emergence of transportation network companies has worsened congestion in big cities such as San Fransisco, America.

The existence of parking issues in big cities including maneuvers, shortstop for dropping the passengers and parking on road edges. This causes a vehicle speed to diminish, increasing road congestion. Parking is an element of transportation infrastructure inseparable from the transportation network system, thus, its arrangements may affect the performance of a road network. Previous studies have taken into account the reduction in road width due to on-street parking and its effect on road capacity reduction. However, all these studies have not explicitly considered the effect of parking as a cause of congestion. The solution to overcome congestion needs to involve public perception because public behavior influences this problem. Therefore, the study aims to analyze the hotspot congestion and parking points, develop a parking point relationship model with congestion, and develop resolving the parking scenarios as well as project traffic reduction in Makassar City.

## 3. Methods

This study was conducted in three stages using surveys for parking and congestion levels as well as public perceptions in building a model of the relationship between parking and congestion. Besides, a settlement scenario and a projection model for reducing the level of congestion between 2020 and 2050 were compiled. In the first phase, a survey was conducted for 7 days on 67 city roads consisting of 78 segments in Makassar to measure the level of parking and congestion. The variables observed were the number of congestion points, vehicle volume, road capacity, degree of saturation, speed, travel time, and delay.

### 3.1. *Traffic flow (volume)*

Traffic flow is the number of traffic element movements that pass the unrestricted upstream point, stated in units of vehicles/hour or pcu/hour. The composition of the traffic movements passing through the intersection is divided into four parts, known as a) Light vehicles with four wheels and two axles within 2–3 m, including passenger vehicles, microbuses, pickups, and small trucks, b) Heavy vehicles with more than four wheels and axles and spacing of 3–4 m, including buses, two-axle, and three-axle trucks, c) Motorcycle which is a two-or three-wheeled motor vehicle, such as a motorized pedicab and bikes, and d) Unmotorized vehicles which are the two or three-wheeled, such as tricycles, bicycles, wheelchairs, and pedestrians. In addition, traffic flow (Q) for each movement (turn left, straight, and right-turn) was converted from hourly vehicles to units of passenger cars (pcu) per hour. Table 1 shows the conversion process using equivalent passenger cars for each type of vehicle.

### 3.2. *Capacity*

The total highway capacity of all intersection arms is the multiplication of the basic capacity (Co) obtained from ideal conditions and the correction factors (F). These factors consist of road width capacity, splitting, and the side obstacle consequence, which takes into account the effect of actual conditions on capacity, expressed by the below formula:

$$C = Co \times CFw \times CFsp \times CFso \times FCcs \tag{1}$$

Where:
C = city road capacity
Co = basic capacity
CFw = correction factor of road width capacity
CFsp = correction factor of road splitting (two ways flow)
CFso = correction factor effect of side obstacles
CFcs = correction factor of city size

**Table 1**
Urban highway passenger car unit.

| Class | Passenger Car Unit |
|---|---|
| Light Vehicles | 1.00 |
| Heavy Vehicles | 1.30 |
| Motorcycle | 0.50 |
| Unmotorized | 1.00 |

### 3.3. Degree of saturation

Degree of saturation (DS) is defined as the level of density that occurs due to the movement of vehicles passing the intersection, expressed by the formula:

$$DS = Qfl/C \tag{2}$$

Where:
DS = Degree of saturation
Qfl = Total flow (pcu/hour)
C = Capaicty (pcu/hour)

The degree of saturation or volume capacity ratio is the major indicator of traffic performance, where an inverse relationship is seen between the two factors.

### 3.4. Speed

Speed is expressed as the rate of movement of a vehicle calculated in terms of time unit distance (km/hour) (Hobbs, 1979), as formulated:

$$V = s/t \tag{3}$$

Where:
V = Speed (m/sec)
s = Distance (m)
t = Time (sec)

However, in the Manual of Indonesia Road Capacity, there are known free-flow and operational speeds.

Free-flow speed

The free-flow velocity is calculated based on the following equation:

$$FV = (FV0 + FVW) \times FFVCS \times FFVSF \tag{4}$$

Where:
FV : Light vehicle free-flow speed for real conditions.
FVW: Speed adjustment for road width (km/h)
FV0: Basic free-flow speed for light vehicles (w)
FFVCS: Speed correction for city size
FFVSF: Adjustment factors for side and shoulder-width barriers

Operational speed was calculated based on the survey.

### 3.5. Travel time

Travel time is the total time required to pass a certain length of the road, including stop-times and delays at intersections. The travel time for each link is calculated as the length of the link divided by the average instantaneous velocity at the upstream and downstream links, with the following formulation:

$$T = 2L/(Vs + Vf) \tag{7}$$

Where:
T = travel time
L = Segment length (km)
Vs = Speed at starting segment
Vf = Speed at terminal segment

### 3.6. Delays

Delays at intersections occur due to two reasons, including a) Traffic Delays (TD) due to interactions with other movements in the intersection and b) Geometric Delays (GD) due to slowing and acceleration of disturbed and undisturbed vehicles.

Geometric delay (DG) can be calculated by

$$\text{If } DS < 1.0 : DG = (1 - DS) \times (PT \times 6 + (1 - PT) \times 3) + (DS \times 4) \tag{8}$$

If $DS \geq 1.0$ : DG = 4 with: DS : Degree of saturation
PT: Turn flow ratio to total flow.
6: Normal geometric delays for vehicles turn undisturbed (sec/pcu)
4: Normal geometric delays for vehicles turn disturbed (sec/pcu)

Therefore, the Intersection Delay (D) is the sum of the delays caused by traffic geometrically or empirically:

$$D = DT + DG \tag{9}$$

### 3.7. Level of service

The Indonesian Road Capacity Manual states that one measure of traffic performance is the Level of Service (LOS). This is a qualitative measure that reflects drivers' perception of the quality of the vehicle. Moreover, this is related to a quantitative approach measure, which is generally expressed in terms of capacity (C), degree of saturation (DS), average speed, travel time, delay (D), queue probability (QP), queue length, and stop vehicle ratio.

The number of motor vehicles in Makassar grew from 1,425,150 to 1,563,608 between 2016 and 2018, or 3–7% annually and to 1,632,837 at the end of 2019. Also, up until 2019, the tendency of road length growth was<1% with a value of 1,593.46 km in 2016, which reached 1,604.26 km by the end of the year.

The second stage was to survey the community's perception of the relationship between congestion and parking. This was conducted using a questionnaire survey method which captured user perceptions on the relationship between these factors. In this study, the population of Makassar City which was based on the number of drivers, in the form of a peak hour prediction was identified as two-wheeled and four-wheeled daily drivers. The number of samples included 250 respondents based on the Slovin formula and the incidental sampling in 8 points representing the subdistrict in Makassar.

The construction of the behavioral model involved the measurement of some variables, indicators, and items of indicators. Subsequently, the data was obtained from the respondents' perceptions and the responses of each question were subjected to options from 1 = Strongly Disagree to 5 = Strongly Agree. Table 2 shows the latent variables, indicators, and indicator items from each latent variable. Also, qualification level was determined by the below ranges:

Very low = 1.00 – 1.80
Low = 1.81 – 2.60
Medium = 2.61 – 3.40
High = 3.41 – 4.20
Very high = 4.21 – 5.00

The conceptual framework of this study is based on the theoretical foundation of various references and is supported by previous studies, such as parking management best practices, management policy in reducing traffic congestion and environmental pollution, car-free day, and odd–even plate (Farda & Balijepalli, 2018). Besides, the public's attitudes to evaluate urban congestion charging policy (Sugiarto et al., 2020), the effectiveness of an Opportunistic Traffic Management System for Vehicular Networks (Leontiadis et al., 2011), coping with congestion, understanding the gap between policy assumptions and behavior (Salomon & Mokhtarian, 1997), as well as Alleviating Urban Traffic Congestion (Arnott *et al.,* 2005) support this work. Fig. 1 shows the conceptual framework of the study based on the description above. In addition, congestion handling must start from empirical study and public perception on this problem, where community consent was obtained through filling out questionnaires describing the need for changes in the regularity of urban transportation management. This review can strengthen and facilitate the government in offering policies to gradually reduce the potential for parking and traffic jam points on all roads. Fig. 1 depicts the stages of policy implementation formulated through the research results dissemination and the form of regulations to improve traffic performance.

Based on the analysis results, the third phase was conducted through

**Table 2**
Indicators and indicator items.

| Latent Variable and Indicators | Item of Indicators |
|---|---|
| Congestion X1 | |
| Congestion X1.1 | Vehicle volume X1.1.1<br>Type and composition of vehicles X1.1.2<br>Road conditions X1.1.3<br>Road narrowing X.1.1.4<br>Damaged road surface X.1.1.5<br>Availability of signs X.1.1.6<br>The accuracy of signs position X.1.1.7<br>Sign quality X.1.1.8<br>Signs fulfilment X.1.1.9<br>Driver awareness X.1.1.10<br>Driver compliance X.1.1.11<br>Driver discipline X.1.1.12<br>Driver character X.1.1.13<br>Vehicle parking X.1.1.14<br>Illegal parking X.1.1.15<br>Temporary parking X.1.1.16<br>Shuttle parking X.1.1.17 |
| Congestion Point X1.2 | Congestion point X1.2.1<br>Congestion at the intersection X1. 2.12<br>T junction intersection X1. 2.3<br>4-way intersection X1.2.4<br>5-way intersection X1.2.5<br>Congestion at the median opening X1. 2.6<br>Median opening position X1. 2.7<br>Median openings distance X1.2.8<br>Parking at public centers X1.2.9<br>Parking at the trade centers X1.2.10<br>Parking at offices X1.2.11<br>Parking on the street X1.2.12 |
| The period of congestion X1.3 | The period of congestion X1.3.1; traffic peak period/rush hour X1.3.2; Time of non-traffic peak period/ non-rush hour X1.3.3; |
| The duration of congestion X1.4 | Duration of congestion X1.4.1; Duration of congestion during the rush hour X1.4.2; Duration of congestion in the non-rush hour X1.4.3; |
| Parking X2 | |
| Parking situation X2.1 | Non-fixed parking X2.1.1; Fixed parking X2.1.2; Illegal parking X2.1.3; Shuttle parking X2.1.4 |
| Parking position on the street X2.2 | Parking on the street X2.2.1; Parking on the street without ‘no-parking’ sign X2.2.2; Parking on the street with ‘no-parking’ sign X2.2.3 |
| Parking position at agency office and school X2.3 | Parking at offices/agencies X2.3.1; Availability of parking to pick-up students X2.3.2; Availability of parking for employees, teachers and students’ parents X2.3.3; Availability of parking for office/ agency/ school guests X2.3.4 |
| Parking Position at the location of the Trade centre X2.4 | Availability of parking for hotel/ restaurant employees X2.4.1;<br>Availability of parking for hotel/ restaurant customers X2.4.2;<br>Availability of parking for street food vendors X2.4.3;<br>Availability of parking for mall officers X2.4.4;<br>Availability of parking for mall visitors X2.4.5;<br>Availability of parking at trade centre/ malls X2.4.6; |
| Traffic Modification Y1 | |
| Closure of U-turn Y1.1 | Temporary closure Y1.1.1; Permanent closure Y1.1.2 |
| Traffic Modification Y1.2 | Unidirectional temporary path Y1.2.1; Unidirectional permanent path Y1.2.2; Addition of roads Y1.2.3; Detour Y1.2.4 |
| Road rules Y1.3 | Odd-even rule Y1.3.1; Discipline of traffic controllers Y1.3.2; |
| Parking management Y2 | |
| Time restrictions Y2.1 | Rush-hour parking ban Y2.1.1; Short-term parking Y2.1.2; |
| Provision of parking lot Y2.2 | Provision of parking by the government Y2.2.1; Provision of parking by the private sector Y2.2.2; Provision of parking by the community Y2.2.2 |
| The angle changes of parking Y2.3 | 45-degrees parking Y2.3.1; Parallel parking Y2.3.2; |

**Table 2** (*continued*)

| Latent Variable and Indicators | Item of Indicators |
|---|---|
| Community discipline Y2.4 | Discipline of the community as the users Y2.4.1; Parking attendant discipline Y2.4.2; Law enforcement Y2.4.3 |
| Traffic performance Z | |
| Speed Z.1 | Speed Z.1.1; Traveling time Z.1.2 |
| Road service Z.2 | Operational cost efficiency Z.2.1; Degree of saturation Z.2.2; Community satisfaction Z.2.3 |

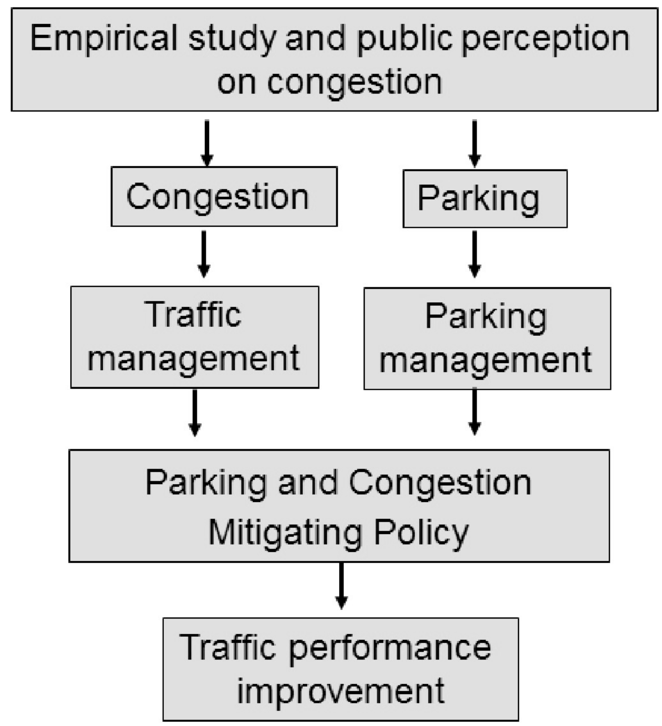


**Fig. 1.** The conceptual framework of this study of reducing congestion and resolving parking issues in Makassar City Indonesia.

focused group discussions, which involved the compilation of a problem-solving scenario by local governments. This discussion focused on strategy outlines and details the scenario of congestion reduction, which was planned on 78 segments within 30 years.

This study applied Structural Equation Modeling analysis tools (SEM), which combined two statistical methods, including factor analysis and simultaneous equation modeling. The conceptual model for the proposed framework was created and analyzed by using the Smart PLS software (Ringle et al., 2015). Meanwhile, the value of RMSEA, chi-square, significance, d_ULS, d_G, NFI, SRMR, and AGFI was analyzed to evaluate the validity of the formative indicator model. The model’s predictive relevance ($Q^2$) were evaluated to assess the predictive capacity of the model and calculated based on the following formula:

$$Q^2 = 1 - - \left(1 - - R1^2\right)\left(1 - - R2^2\right) \tag{10}$$

The projection model was conducted by applying regression through estimating variables, such as road capacity, DS, and speed based on DS. Also, the value of each variable was calculated using a yearly 3.76% assumption of vehicle growth. The value of the resolving parking and traffic management constant was obtained from handling congestion in six stages, each conducted for 5 years. This value was estimated with the assumption of success in resolving parking issues and traffic management occurred maximally so that road capacity (C) recovers as if the obstacles were absent (see formula 1).

## 4. Results

### 4.1. Identification of traffic points and congestion levels in Makassar city

The recapitulation of traffic congestion points on 67 roads showed there were 390 congestion points, where 54, 179, 36, and 78 were due to crossroad, T junction, U-turn, parking, and cross as well as parking complex, respectively (Table 3).

The existence of a lot of traffic congestion in the city of Makassar results in low travel services as seen from the number of segments that exceeded the road capacity. A total of 65 of 78 segments (83.3%) superseded the road capacity and led to the high saturation level of average 2, and then to a worse situation level. Therefore, the average speed in all segments was below 26 km/h (Table 4).

### 4.2. The behavioral model between congestion, parking and the solutions

Description of Respondents' Answers

The description of the respondents' answers for each indicator in the questionnaire was analyzed descriptively. Table 5 shows an overview of these answers for all variables and indicators that had good results within the very high and high categories. Also, all indicators of parking and traffic performance were considered very high, while others varied on very high and high categories (Table 5).

#### 4.2.1. The model validity and goodness of fit

The validity of the formative indicator model used the significance criteria of each indicator external weight, where significance was attained when the *t*-test statistical value was $T < 1.96$ or T greater than 1.96. Besides, the path diagram used in this study was observed, and all the latent variables using this model were classified as formative, meaning the validity criteria of significance were used.

Moreover, the results of the Fit Model Test using several criteria indicate that the overall model was fit and acceptable. Also, the Adjusted Goodness of Fit Index (AGFI) value had an output of 0.905, indicating this model has a better fit, where greater than 0.90 is seen as a good value (Hair et al., 2010). The Standardized Root Means Residual (SRMR) value also showed an acceptable fit, where lower values represent the better fit and vice versa. Also, the rule of thumb occurs when an SMSR value greater than 1 indicates a problem with model fit, where 0 is seen as a good value (Hair et al., 2010). The Normed Fit Index (NFI) had an output value of 0.958, where 1 is seen as a good value. In addition, the RMSEA (Root Mean Square Error of Approximation) value shows the results of the analysis fell into a mediocre fit (Table 6).

#### 4.2.2. Congestion

The congestion possibility is constructed by the indicators of congestion causes, points, period, and duration, where the outer loading of all X1 indicators was greater than 0.50. Table 7 shows the study instrument fulfilled the convergent validity requirements. Therefore, this instrument consisting of indicators and indicator items in the questionnaire could be applied to analyze the congestion possibility. The number shown outside the loading value indicates how far the indicator reflected each latent variable. All congested indicators show significant results of $P < 0.001$, indicating this problem was formed by the causative factor, the presence of congestion points, its period, and duration.

The outer loading of all congestion-forming indicators with all variables was greater than 0.50, hence, the study instrument met the convergent validity requirements. Therefore, this instrument consisting of indicators and indicator items in the questionnaire could be used to measure potential congestion. Table 8 shows a high discriminant value between the indicators of congestion causes, points, and traffic, and congestion, where these three indicators had a very strong influence.

**Table 3**
Recapitulation of Congestion Points Identification.

| No | Roadway segment name | CR | TJ | UT | Complex | Parking | Total CP |
|---|---|---|---|---|---|---|---|
| 1 | Perintis Kemerdekaan | 2 | – | – | 9 | 1 | 12 |
| 2 | Urip Sumoharjo | – | – | 5 | 3 | | 8 |
| 3 | Gunung Bawakaraeng | – | 3 | – | – | | 3 |
| 4 | Kartini | – | 1 | – | – | | 1 |
| 6 | Botolempangang | 2 | – | – | – | | 2 |
| 7 | Karunrung | 1 | 2 | – | – | – | 3 |
| 8 | Arief Rate | – | 1 | – | 1 | | 2 |
| 9 | Sultan Hasanuddin | 2 | – | – | – | | 2 |
| 10 | Pattimura | – | 1 | – | – | | 1 |
| 11 | Slamet Riyadi | – | 1 | – | – | | 1 |
| 12 | Riburane | – | – | 1 | 1 | | 2 |
| 13 | Ahmad Yani | – | 1 | – | – | | 1 |
| 14 | Bulusaraung | – | 1 | – | – | | 1 |
| 15 | Mesjid Raya | – | 2 | – | – | | 2 |
| 16 | Sudirman | 1 | – | – | – | | 1 |
| 17 | Sam Ratulangi | 1 | 1 | – | – | | 2 |
| 18 | Landak Lama | 1 | – | – | – | 1 | 2 |
| 19 | Mappaoddang | 1 | 1 | – | – | 1 | 3 |
| 20 | Cendrawasih | 2 | 2 | – | – | 2 | 6 |
| 21 | Balaikota | | 2 | | | | 2 |
| 22 | Taman Makam Pahlawan | 1 | 1 | – | – | 3 | 5 |
| 23 | Abdesir | 3 | 3 | – | – | 3 | 9 |
| 24 | Adhyaksa Baru | 1 | 1 | – | – | | 2 |
| 25 | Boulevard | | | 1 | 4 | | 5 |
| 26 | Pengayoman | 1 | 4 | 4 | 3 | | 12 |
| 27 | Leimena | – | 5 | – | – | | 5 |
| 28 | Antang Raya | | 4 | | | 2 | 6 |
| 29 | Todopuli Raya | 3 | 3 | | | 4 | 10 |
| 30 | Talasalapang | 1 | 3 | | | 1 | 5 |
| 31 | Syech Yusuf | 1 | 3 | | | 3 | 7 |
| 32 | Malengkeri | 1 | 5 | | | | 6 |
| 33 | Bajiminasa | 1 | 1 | | | | 2 |
| 34 | Kasuari | 2 | 1 | | | 1 | 4 |
| 35 | Lanto | 1 | 4 | | | | 5 |
| 36 | Bulukunyi | 2 | 1 | | | | 3 |
| 37 | Latimojong | 1 | 1 | 1 | 5 | | 8 |
| 38 | Saddang | 4 | 4 | | | | 8 |
| 39 | Saddang Baru | 1 | 6 | | | | 7 |
| 40 | Kumala | – | 6 | – | – | 2 | 8 |
| 41 | Batua Raya | 1 | 1 | | | | 2 |
| 42 | Monginsidi | 2 | 3 | – | – | | 5 |
| 43 | Pelita Raya | 3 | 7 | | | 7 | 17 |
| 44 | Landak baru | | 9 | | | | 9 |
| 45 | Tentara Pelajar | 1 | 1 | – | 5 | 2 | 9 |
| 46 | Kalimantan | 4 | 5 | | | 4 | 13 |
| 47 | Butung | – | 5 | | | 13 | 18 |
| 48 | Banda | – | 4 | | | | 4 |
| 49 | Cokroaminoto | | 1 | | 3 | | 4 |
| 50 | Wahidin | 2 | 7 | | | | 9 |
| 51 | Cakalang | | 9 | | | 7 | 16 |
| 52 | Sangir | | 4 | | | 10 | 14 |
| 53 | Pasar Cidu | | 4 | | | 7 | 11 |
| 54 | Pecinnang | | 4 | | | | 4 |
| 55 | Lamadukkeleng | | – | – | – | 1 | 1 |
| 56 | Haji Bau | 1 | 1 | – | – | 1 | 3 |
| 57 | Penghibur | – | 1 | – | – | | 1 |
| 61 | Nusantara | – | 1 | – | – | | 1 |
| 63 | Pettarani | – | 14 | | 8 | | 22 |
| 64 | Veteran Utara | 2 | 3 | 6 | | | 11 |
| 65 | Veteran Selatan | | 7 | 7 | | 1 | 15 |
| 66 | Sultan Alauddin | 1 | 4 | 3 | 1 | | 9 |
| 67 | Hertasning | | 9 | 8 | | 1 | 18 |
| Total of Congestion Point | | 54 | 179 | 36 | 43 | 78 | 390 |

#### 4.2.3. Parking

Table 9 shows all external parking indicators had a value greater than 0.50. Therefore, the four indicators could be used in further analysis, where the research instrument used to explore the urban community perceptions data was able to meet convergent validity

**Table 4**
Vehicle volume, street capacity, DS, speed, travel time, delay and service grade in Makassar city.

| No | Name | Volume | Capacity | DS | Speed | | Travel time | Delay | LoS |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Free | Opera-tional | | | |
| 1 | Perintis Kemerdekaan | 8,230 | 5,880 | 1.56 | 57.20 | 25.67 | 1,716 | 18.10 | F |
| 2 | Urip Sumiharjo | 8,833 | 4,704 | 2.09 | 51.41 | 30.00 | 583 | 23.87 | F |
| 3 | Bawakaraeng | 4,987 | 3,065 | 1.95 | 54.72 | 29.04 | 87 | 22.24 | F |
| 4 | Sudirman | 7,281 | 7,371 | 1.17 | 51.41 | 20.74 | 297 | 12.59 | F |
| 5 | Ratulangi | 7,647 | 7,371 | 1.21 | 51.41 | 21.44 | 255 | 13.10 | F |
| 6 | Landak | 6,278 | 2,296 | 3.34 | 30.34 | 37.17 | 39 | 39.31 | F |
| 7 | Cendrawasih | 6,751 | 4,914 | 1.57 | 44.52 | 25.74 | 511 | 17.46 | F |
| 8 | Haji Bau | 3,818 | 7,211 | 0.61 | 49.98 | 23.82 | 98 | 5.75 | B |
| 9 | Kakatua | 4,169 | 3,363 | 1.53 | 49.82 | 25.38 | 34 | 17.02 | F |
| 10 | Karunrung | 5,429 | 3,292 | 2.08 | 56.40 | 29.93 | 47 | 23.75 | F |
| 11 | Sutan Haslanuddin | 7,949 | 5,880 | 1.48 | 46.06 | 24.86 | 178 | 16.40 | F |
| 12 | Ahmad Yani | 2,993 | 7,211 | 0.51 | 61.10 | 25.01 | 111 | 4.43 | A |
| 13 | Sulawesi | 2,116 | 7,211 | 0.34 | 48.96 | 26.65 | 167 | 2.34 | A |
| 14 | Veteran Utara | 4,895 | 4,277 | 1.35 | 57.23 | 23.44 | 315 | 14.87 | F |
| 15 | Veteran Selatan | 4,870 | 3,659 | 1.56 | 57.23 | 25.64 | 305 | 17.34 | F |
| 16 | Nusantara | 5,065 | 4,979 | 1.14 | 49.29 | 20.13 | 347 | 12.19 | F |
| 17 | Yos Sudarso | 5,065 | 3,141 | 1.65 | 45.57 | 26.50 | 92 | 18.45 | F |
| 18 | Hertasning | 4,522 | 3,363 | 2.62 | 49.29 | 33.40 | 402 | 30.47 | F |
| 19 | Arief Rate | 7,927 | 3,350 | 1.79 | 51.41 | 27.73 | 51 | 20.19 | F |
| 20 | Andalas | 7,351 | 3,536 | 1.72 | 49.29 | 27.16 | 129 | 19.37 | F |
| 21 | Bulusaraung | 4,648 | 4,865 | 0.94 | 50.47 | 18.27 | 133 | 9.77 | E |
| 22 | Mesjid Raya | 4,473 | 5,845 | 0.86 | 50.47 | 20.15 | 211 | 8.81 | D |
| 23 | Pettarani | 8,781 | 4,704 | 2.19 | 53.00 | 30.69 | 586 | 25.11 | F |
| 24 | Kartini | 3,282 | 2,480 | 1.58 | 49.59 | 25.84 | 51 | 17.59 | F |
| 25 | J Botolempangan | 1,329 | 2,480 | 0.63 | 58.14 | 23.58 | 134 | 5.99 | C |
| 26 | Kajoalalido | 1,685 | 2,480 | 0.79 | 58.14 | 21.38 | 59 | 7.95 | D |
| 27 | Mappaodang | 2,176 | 1,457 | 1.72 | 49.82 | 27.15 | 244 | 19.36 | F |
| 28 | Rajawali | 1,979 | 1,457 | 1.56 | 49.82 | 25.66 | 120 | 17.36 | F |
| 29 | Penghibur | 2,865 | 2,480 | 1.32 | 45.60 | 22.99 | 247 | 14.43 | F |
| 30 | Riburane | 2,121 | 1,457 | 1.64 | 45.60 | 26.45 | 33 | 18.38 | F |
| 31 | Slamet Riadi | 4,253 | 2,480 | 1.88 | 45.60 | 28.45 | 32 | 21.29 | F |
| 32 | Balaikota | 1,601 | 2,480 | 0.79 | 45.60 | 21.46 | 65 | 7.89 | D |
| 33 | Yoseph Latumahina | 2,120 | 2,480 | 0.65 | 45.60 | 23.43 | 67 | 6.15 | C |
| 34 | Pattimura | 1,848 | 1,457 | 1.39 | 45.60 | 28.23 | 45 | 20.96 | F |
| 35 | Monginsidi | 7,229 | 7,211 | 1.19 | 54.06 | 21.14 | 174 | 12.88 | F |
| 36 | Malengkeri | 3,052 | 2,397 | 3.56 | 54.06 | 38.18 | 150 | 41.96 | F |
| 37 | Peccinang | 7,401 | 2,321 | 3.33 | 54.06 | 37.13 | 45 | 39.20 | F |
| 38 | Pengayoman | 4,473 | 3,849 | 1.31 | 47.17 | 22.86 | 306 | 14.31 | F |
| 39 | Pasar Cidu | 3,900 | 3,135 | 1.48 | 44.52 | 24.91 | 52 | 16.46 | F |
| 40 | Pelita | 4,029 | 3,666 | 1.27 | 54.06 | 22.25 | 153 | 13.77 | F |
| 41 | Sangir | 4,387 | 1,397 | 3.62 | 54.06 | 38.47 | 42 | 42.75 | F |
| 42 | Saddang | 5,130 | 3,292 | 1.92 | 47.17 | 28.78 | 135 | 21.83 | F |
| 43 | Saddang Baru | 2,403 | 5,880 | 0.50 | 54.06 | 25.09 | 165 | 4.33 | A |
| 44 | Sutami | 7,662 | 20,900 | 0.42 | 91.94 | 55.47 | 736 | 11.59 | A |
| 45 | Syech Yusuf | 3,045 | 2,397 | 1.40 | 49.82 | 23.96 | 216 | 15.40 | F |
| 46 | Tallasalapang | 2,758 | 2,397 | 1.33 | 44.52 | 23.16 | 213 | 14.59 | F |
| 47 | Toddopuli Raya | 3,648 | 2,639 | 1.73 | 47.17 | 27.28 | 154 | 19.53 | F |
| 48 | Taman Makam Pahlawan | 3,729 | 2,900 | 1.41 | 49.82 | 24.08 | 98 | 15.53 | F |
| 49 | Tentara Pelajar | 7,783 | 3,135 | 2.71 | 47.17 | 33.88 | 98 | 31.49 | F |
| 50 | Abdullah Dg. Sirua | 5,017 | 1,397 | 3.98 | 47.17 | 40.04 | 360 | 47.14 | F |
| 51 | Adhyaksa Baru | 4,587 | 1,397 | 3.66 | 51.94 | 38.66 | 58 | 43.26 | F |
| 52 | Antang Raya | 5,781 | 2,321 | 2.71 | 44.52 | 33.91 | 506 | 31.57 | F |
| 53 | Abdul Kadir | 3,633 | 1,397 | 3.00 | 44.52 | 35.48 | 200 | 35.15 | F |
| 54 | Anggrek | 4,326 | 1,397 | 3.32 | 51.94 | 37.05 | 51 | 39.01 | F |
| 55 | Bajiminasa | 2,884 | 4,914 | 0.69 | 54.06 | 22.81 | 77 | 6.75 | B |
| 56 | Bulukunyi | 3,529 | 3,350 | 1.23 | 54.06 | 21.73 | 38 | 13.33 | F |
| 57 | Batua Raya | 3,847 | 2,321 | 1.78 | 54.06 | 27.67 | 174 | 20.11 | F |
| 58 | Boulevard | 7,368 | 3,849 | 2.53 | 54.06 | 32.83 | 132 | 29.27 | F |
| 59 | Bandang | 4,595 | 3,849 | 1.51 | 54.06 | 25.13 | 138 | 16.72 | F |
| 60 | Butung | 4,458 | 1,397 | 3.62 | 49.82 | 38.47 | 42 | 42.75 | F |
| 61 | Banda | 3,859 | 1,397 | 3.29 | 49.82 | 36.92 | 46 | 38.69 | F |
| 62 | Cakalang | 5,053 | 3,187 | 1.86 | 47.17 | 28.31 | 57 | 21.08 | F |
| 63 | Leimena | 5,919 | 2,321 | 3.24 | 54.06 | 36.69 | 114 | 38.11 | F |
| 64 | Wahidin | 4,632 | 7,211 | 0.73 | 49.82 | 22.38 | 304 | 7.13 | D |
| 65 | Diponegoro | 3,051 | 2,296 | 1.45 | 54.06 | 24.60 | 87 | 16.10 | F |
| 66 | Cokrominoto | 4,025 | 3,363 | 2.56 | 49.82 | 33.06 | 57 | 29.74 | F |
| 67 | Pasewang | 4,887 | 3,292 | 1.76 | 54.06 | 27.50 | 103 | 19.85 | F |
| 68 | Kalimantan | 2,083 | 1,397 | 1.74 | 54.06 | 27.35 | 63 | 19.65 | F |
| 69 | Kasuari | 4,587 | 3,292 | 1.55 | 49.82 | 25.62 | 41 | 17.32 | F |
| 70 | Landak Baru | 5,461 | 3,292 | 2.07 | 47.17 | 29.90 | 161 | 23.69 | F |
| 71 | Latimojong | 4,326 | 3,659 | 1.27 | 51.94 | 22.27 | 267 | 13.78 | F |
| 72 | Kumala | 4,912 | 3,493 | 1.85 | 51.94 | 28.23 | 173 | 20.96 | F |
| 73 | Andi Djemma | 5,461 | 3,292 | 2.07 | 47.17 | 21.46 | 65 | 7.89 | F |

(*continued on next page*)

**Table 4** (*continued*)

| No | Name | Volume | Capacity | DS | Speed | | Travel time | Delay | LoS |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Free | Opera-tional | | | |
| 74 | Latimojong | 4,326 | 3,659 | 1.27 | 51.94 | 23.43 | 67 | 6.15 | F |
| 75 | Kumala | 4,912 | 3,493 | 1.85 | 45.60 | 28.23 | 45 | 20.96 | F |
| 76 | Somba Opu | 2521 | 1244 | 2.28 | 46.74 | 31.29 | 100 | 26.22 | F |
| 77 | Sultan Alauddin | 5424 | 2295 | 2.77 | 46.74 | 34.21 | 383 | 32.23 | F |
| 78 | Lamadukelleng | 4065 | 1244 | 3.07 | 46.74 | 35.81 | 80 | 35.94 | F |

**Table 5**
General Description of Respondents' Answers towards all Research Variables and Indicators.

| Variable | Indicators | Average of respondents' answers towards indicators | Category |
|---|---|---|---|
| Congestion | X1.1 | 4.52 | very high |
| | X1.2 | 4.81 | very high |
| | X1.3 | 4.11 | high |
| | X1.4 | 4.25 | very high |
| Parking | X2.1 | 4.67 | very high |
| | X2.2 | 4.80 | very high |
| | X2.3 | 4.65 | very high |
| | X2.4 | 4.85 | very high |
| Traffic management | Y1.1 | 3.90 | high |
| | Y1.2 | 4.15 | high |
| | Y1.3 | 4.06 | high |
| Parking management | Y1.4 | 4.14 | high |
| | Y2.1 | 4.24 | very high |
| | Y2.2 | 4.20 | high |
| | Y2.3 | 4.19 | high |
| Traffic performance | Z1.1 | 4.34 | very high |
| | Z1.2 | 4.28 | very high |

**Table 6**
Goodness of Fit Index.

| Criteria | Value | Cut off-value | acceptable fit |
|---|---|---|---|
| RMSEA | 0.013 | ≤ 0.08 | mediocre fit |
| Chi Square | 7.9 | ≤ 32.67 | acceptable fit |
| significance | p greater than 0.05 | p ≥ 0.05 | acceptable fit |
| d_ULS | 0.601 | ≥ 0.05 | acceptable fit |
| d_G | 0.654 | ≥ 0.05 | acceptable fit |
| NFI | 0.958 | ≥ 0.90 | acceptable fit |
| SRMR | 0.063 | ≤ 0.08 | acceptable fit |
| AGFI | 0.905 | ≥ 0.90 | acceptable fit |

**Table 7**
Value of convergent validity (outer loading) and the significance of congestion indicators.

| Indicator | Outer Loading | Standard Deviation (SD) | T Statistics (\|O/STERR\|) | P value |
|---|---|---|---|---|
| X1.1 | 0.914 | 0.014 | 66.58 | 0.000 |
| X1.2 | 0.949 | 0.010 | 92 | 0.000 |
| X1.3 | 0.925 | 0.011 | 81.67 | 0.000 |
| X1.4 | 0.908 | 0.018 | 49.9 | 0.000 |

requirements. The level of significance for all the parking indicators showed significant results of $P < 0.001$, indicating parking was formed by factors such as parking situation, the presence of parking points, its duration, and period.

The outer loading of all parking establishment indicators and variables was greater than 0.50, meaning the instrument used met the convergent validity requirements. Therefore, the study instrument consisting of indicators and indicator items in the questionnaire could be used to measure parking potential. Table 10 shows the high discriminant value between the parking position indicator (X2.2) and period (X2.4) with the parking variable indicating a very strong influence from the two indicators.

### 4.2.4. *Traffic management*

All of Y external indicators were rated more than 0.50 hence, these five indicators could be set in the next analysis. The study instrument used to explore traffic management data was able to meet the convergent validity requirements, where the level of significance for all indicators that established parking results was $P < 0.001$, indicating that Traffic management was formed by U-turning closure factor (Y1.1), lane engineering (Y1.2), and road rules (Y1.3) (Table 11).

The traffic management indicators had an outer loading value of<0.50, while the others were greater than 0.50. Y1.1 did not meet the requirements for congestion validity, parking, and traffic performance. Also, the Y1.3 indicator did not qualify for traffic performance validity while Y1.2 and Y1.3 had a high discriminant value against Traffic management. This shows the two indicators have a strong influence on traffic management as seen in Table 12.

### 4.2.5. *Parking management*

Table 13 shows all parking management external indicators were rated more than 0.50, meaning these five indicators can be arranged for the later analysis. Therefore, the study instrument used to analyze parking management data was able to fulfill the convergent validity requirements. The significance level of all established parking indicators was assumed to show significant results of $P < 0.001$, indicating that parking management was formed by time limitation factor (Y2.1), parking space provision (Y2.2), angles changes (Y2.3), and discipline community (Y2.4).

In Table 14, the outer loading of all parking indicators and variables was more than 0.50, meaning the study instrument used met the convergent validity requirements. Therefore, the instrument consisting of indicators and indicator items in the questionnaire could be used to measure parking management. The high discriminant value between the time limitation indicator (Y2.1), parking space provision (Y2.2), and angle changes (Y2.3), on traffic management indicates a very strong influence of those three indicators.

### 4.2.6. *Traffic performance*

Table 15 shows all external indicators of parking management were rated more than 0.50, meaning both indicators can be confirmed in the later analysis. Therefore, the research instrument used to explore

**Table 8**
Discriminant validity (cross loading) and reliability (composite reliability) of congestion.

| Indicator | Congestion | Parking | Traffic management | Parking management | Traffic performance | CR |
|---|---|---|---|---|---|---|
| X1.1 | 0.913 | 0.891 | 0.649 | 0.750 | 0.567 | 0.959 |
| X1.2 | 0.949 | 0.882 | 0.656 | 0.737 | 0.590 | |
| X1.3 | 0.925 | 0.868 | 0.680 | 0.779 | 0.566 | |
| X1.4 | 0.908 | 0.852 | 0.557 | 0.660 | 0.632 | |

**Table 9**
Value of convergent validity (outer loading) of parking indicator.

| Indicator | Outer Loading | Standard Deviation (SD) | T Statistics (\|O/STERR\|) | P value |
|---|---|---|---|---|
| X2.1 | 0.953 | 0.010 | 95.9 | 0.000 |
| X2.2 | 0.959 | 0.006 | 155.8 | 0.000 |
| X2.3 | 0.934 | 0.022 | 42.7 | 0.000 |
| X2.4 | 0.959 | 0.008 | 124.43 | 0.000 |

**Table 15**
Convergent validity (outer loading) of traffic performance indicator.

| Indicator | Outer Loading | Standard Deviation (SD) | T Statistics (\|O/STERR\|) | P value |
|---|---|---|---|---|
| Z1 | 0.957 | 0.006 | 161.48 | 0.000 |
| Z2 | 0.921 | 0.0018 | 49.8 | 0.000 |

**Table 10**
Discriminant validity (cross loading) and reliability (composite reliability) of parking.

| Indicator | Congestion | Parking | Traffic management | Parking management | Traffic performance | CR |
|---|---|---|---|---|---|---|
| X2.1 | 0.908 | 0.953 | 0.632 | 0.752 | 0.693 | 0.94 |
| X2.2 | 0.920 | 0.959 | 0.674 | 0.801 | 0.712 | |
| X2.3 | 0.867 | 0.934 | 0.685 | 0.790 | 0.669 | |
| X2.4 | 0.902 | 0.959 | 0.713 | 0.839 | 0.730 | |

**Table 11**
Convergent validity (outer loading) of Traffic management indicator.

| Indicator | Outer Loading | Standard Deviation (SD) | T Statistics (\|O/STERR\|) | P value |
|---|---|---|---|---|
| Y1.1 | 0.682 | 0.081 | 8.38 | 0.000 |
| Y1.2 | 0.949 | 0.009 | 104.8 | 0.000 |
| Y1.3 | 0.915 | 0.0016 | 56.2 | 0.000 |

**Table 12**
Discriminant validity (cross loading) and reliability (composite reliability) for Traffic management.

| Indicator | Congestion | Parking | Traffic management | Parking management | Traffic Performance | CR |
|---|---|---|---|---|---|---|
| Y1.1 | 0.388 | 0.382 | 0.682 | 0.520 | 0.262 | 0.891 |
| Y1.2 | 0.690 | 0.720 | 0.949 | 0.913 | 0.520 | |
| Y1.3 | 0.640 | 0.662 | 0.915 | 0.848 | 0.470 | |

**Table 13**
Convergent validity (outer loading) of parking management indicator.

| Indicator | Outer Loading | Standard Deviation (SD) | T Statistics (\|O/STERR\|) | P value |
|---|---|---|---|---|
| Y2.1 | 0.951 | 0.019 | 73.75 | 0.000 |
| Y2.2 | 0.963 | 0.007 | 134.25 | 0.000 |
| Y2.3 | 0.969 | 0.007 | 148.8 | 0.000 |
| Y2.4 | 0.950 | 0.008 | 122.6 | 0.000 |

**Table 14**
Discriminant validity (cross loading) and reliability (composite reliability) of parking management.

| Indicator | Congestion | Parking | Traffic management | Parking management | Traffic Performance | CR |
|---|---|---|---|---|---|---|
| Y2.1 | 0.707 | 0.751 | 0.876 | 0.951 | 0.540 | 0.98 |
| Y2.2 | 0.762 | 0.797 | 0.884 | 0.963 | 0.571 | |
| Y2.3 | 0.751 | 0.795 | 0.898 | 0.969 | 0.582 | |
| Y2.4 | 0.812 | 0.858 | 0.851 | 0.950 | 0.686 | |

**Table 16**
Discriminant validity (cross loading) and reliability (composite reliability) of traffic performance.

| Indicator | Congestion | Parking | Traffic management | Parking management | Traffic Performance | CR |
|---|---|---|---|---|---|---|
| Z1 | 0.696 | 0.789 | 0.532 | 0.653 | 0.957 | 0.937 |
| Z2 | 0.469 | 0.567 | 0.405 | 0.500 | 0.921 | |

**Table 17**
R-square variables for the latent variable of the structural model.

| Latent variable | R-square |
|---|---|
| Traffic Management | 0.509 |
| Parking Management | 0.701 |
| Traffic Performance | 0.580 |

**Table 18**
. The significance relationship between variables.

| Variables | Original Sample (O) | Sample Mean (M) | Standard Deviation (STDEV) | T Statistics (\|O/ STDEV\|) | P Values |
|---|---|---|---|---|---|
| Congestion → Traffic Performance | −0.558 | 0.144 | 3.883 | 0.000 | −0.558 |
| Congestion → Parking Management | 0.017 | 0.166 | 0.102 | 0.919 | 0.017 |
| Congestion → Traffic management | 0.162 | 0.204 | 0.794 | 0.427 | 0.162 |
| Parking → Traffic Performance | 1.223 | 0.161 | 7.591 | 0.000 | 1.223 |
| Parking → Parking Management | 0.821 | 0.150 | 5.493 | 0.000 | 0.821 |
| Parking → Traffic management | 0.559 | 0.182 | 3.074 | 0.002 | 0.559 |
| Parking Management → Traffic Performance | 0.139 | 0.123 | 1.129 | 0.259 | 0.139 |
| Traffic management → Traffic Performance | −0.106 | 0.097 | 1.084 | 0.279 | −0.106 |

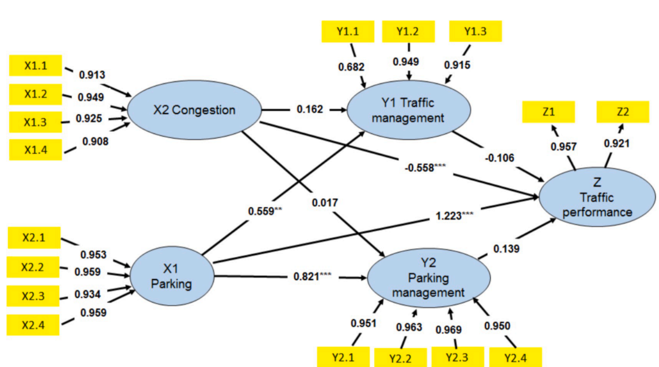


**Fig. 2.** The behavioral model to show the relationship among the parking, parking management, and traffic performance variables to resolve the parking issues in Makassar City Indonesia.

parking management data was able to fulfill the convergent validity requirements. Based on the consideration of the outer loading high-level values, these two indicators reflect a satisfying traffic performance. In addition, the CR (critical ratio) value of this analysis model was 0.890 meaning the value was higher than 0.70, thus, speed (Z1) and road service (Z2) could be used to reflect the traffic performance variables (Table 16).

After obtaining a valid and reliable measurement model for latent variables, the results were used in the analysis of structural or internal models. The evaluation of the inner goodness of fit model for each endogenous latent variable was determined based on the R-square value or the coefficient of determination. Also, the suitability goodness of the structural model as a whole was measured by the predictive relevance of $Q^2$, where this model was declared suitable if $Q^2$ greater than 0.50. The R-square value of parking and traffic management, as well as traffic performance, was 0.701, 0.509, and 0.580, respectively (Table 17).

Based on the R-square value of the two endogenous latent variables presented in Table 17, traffic and parking management could determine the predictive relevance $Q^2$ value using the following formula:

$Q^2 = 1 - (1–0.509)\ (1–0.701) = 0.8532$

This value indicates that about 85.32% of the latent endogenous diversity variables in the structural model could be explained by a model formed from exogenous variables with the potential for congestion and parking. Meanwhile, the remaining 9% is explained by other variables besides the model and error. This structural model was concluded to be suitable because the Q2 value of the predictive relevance was more than 0.50.

Based on the test results in Table 18, parking management had a positive relationship to parking, traffic performance, and management. The behavioral model showed this factor acted as a moderator for

**Table 19**
Resolving of parking issues based on the public focus group discussion with several stakeholders.

| Parking location (percentage of the points) | Solution | | |
|---|---|---|---|
| | Short-term | Mid-term | Long-term |
| Business center (34.5%) | Performing odd and even shift systems, increasing parking rates, providing employee buses, prohibiting private vehicles for staff, improving parking spaces in the hallway of shops other than on the road, improving the quality of public transportation. | Increasing the number of public transportations<br>Setting up part of a special parking building | Relocation of the market area<br>Setting up special parking spaces for business facilities |
| Public facility (65.5%) | Performin odd and even shift system<br>Arranging guest vehicles and preventing them from careless parking<br>Increasing parking charge<br>Improving the quality of public transportation | Providing school buses<br>Building a bus stop or corridor for the school children who were waiting for their pick-up on the sidewalk | Setting up special parking spaces for public facilities |

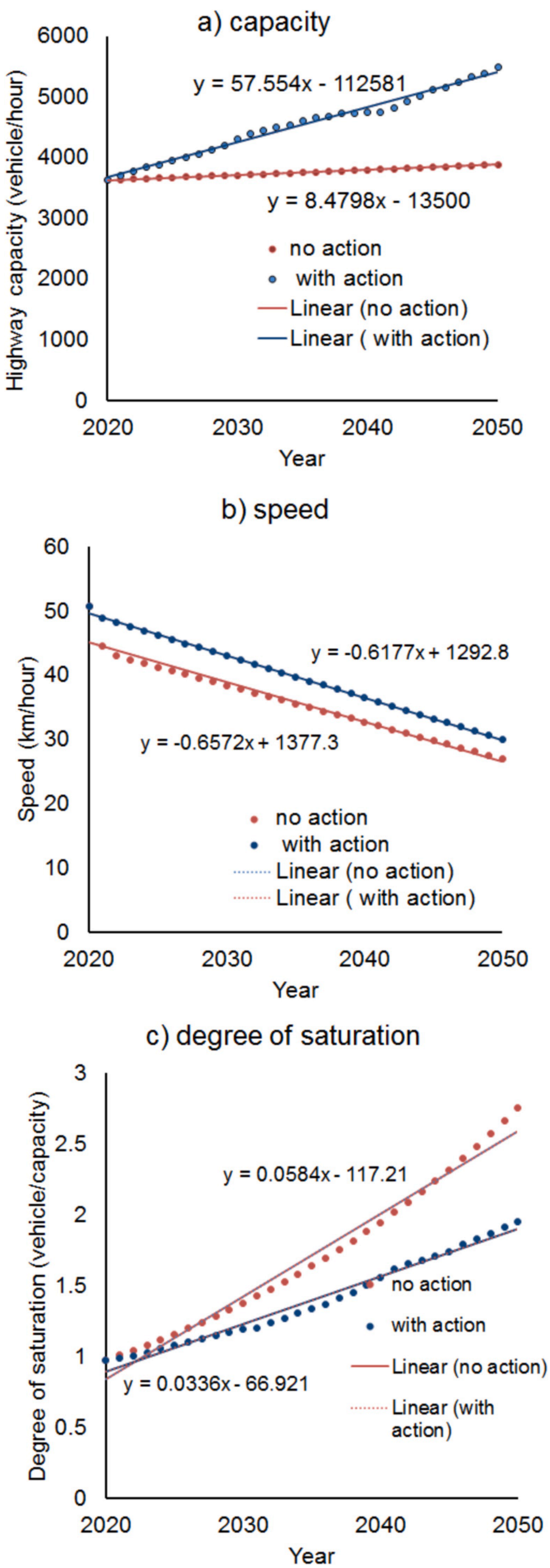


**Fig. 3.** Projection of reducing congestion and resolving parking issues scenarios in Makassar City Indonesia on (a) traffic capacity, (b) speed, (c) degree of saturation based on action compared to no action (control) of resolving solution based on the public focus group discussion.

congestion and parking, where the path with the highest loading factor was parking, parking management, and traffic performance (Fig. 2).

### 4.3. *Resolving parking issue scenario and congestion reduction project*

#### 4.3.1. *Resolving parking issue scenario*

The results of the focus group discussions indicate the need for a short, medium, and long-term solution. These short-term solutions for congestion in business centers include performing odd and even plate shift systems, providing employee buses, prohibiting private staff vehicles, and improving parking spaces in the shop hallway. Meanwhile, medium and long terms solutions include the construction of a special parking building or market relocation. Also, short-term solutions for public facilities include managing guest vehicles, providing buses, constructing bus stops and special parking spaces (Table 19).

#### 4.3.2. *The estimation of congestion reduction*

The results of resolving parking analysis indicate the improvement of the service level. Furthermore, with the scenario of reducing congestion and resolving parking issues, the average capacity and saturation increased by 1.387% and 2.35%, respectively while the speed decreased by 1.73%. Without any action to cope with those problems, the average and saturation was estimated to increase by 3.53%, while the capacity and speed decreased by 0.226% and 2.06% s respectively. Fig. 3a shows the former scenario produced an equation of $y = 57.55x - 112581$, while the latter was $y = 8.48x - 13500$. Meanwhile, Fig. 3b shows the speed of vehicles with the scenario was projected higher than that of no action, where the equation of the former was $y = -0.62x + 1292.8$ and the latter was $y = -0.68x + 1377.3$. The degree of saturation of vehicles with treatment was projected lower than that of no action. Fig. 3c shows the equation of the former was $y = 0.0336x - 66.92$, while the latter was $y = 0.058x - 117.21$.

## 5. Discussion

This study shows that the high level of congestion in Makassar is due to the reduced road capacity, increased traffic density, and flow disturbances caused by on-street parking and parking maneuvers. Improper parking and maneuvers can cause severe delays, especially on busy roads, resulting in a stop-start situation in traffic flow (Yousif and Purnawan, 1999). Temporary bottlenecks are often started by on-street parking maneuvers, which lead to additional delays endured by other drivers. Furthermore, the occurrence of this situation near a signalized intersection drastically reduces its service level (Cao et al., 2016).

The relationship model between parking, congestion, resolving the parking, and traffic management show a public preference for parking arrangements because its resolution is believed to improve traffic services. Therefore, the resolving parking scenario was the focus of the medium and long terms period strategy in this study. Also, short-term efforts, such as regulating parking and vehicle number plates as well as increasing parking fees, are expected to reduce congestion. This study's scenario is consistent with that of Putra et al. (2018) and Tumanduk et al. (2019) studies, which demonstrated increasing parking fees may reduce the use of private cars and enhance public transportation. Parking relocation was another attempt used to free up the road from on-street parking, hence increasing traffic services. Although several studies show the development of parking buildings is feasible for long-term investment (Thamrin & Wiyati 2014, Nurman et al., 2021), this strategy is considered tough, especially if the construction is conducted by freeing up existing buildings.

Moreover, when the electronic road pricing and parking strategy were implemented at high rates, road users in Jakarta switched to using public transportation. Due to the increase in parking rates, 19% and 50%, of the respondents change to use the minibus public transportation mode and the online-based public transportation (online taxis), respectively while 30% remain to use private vehicles. The other study also reported that the increase of parking rate to 25.000 IDR influenced 56% and 73% of the respondents to switch modes of transportation from private vehicles to online taxis, and other public transportations (i.e. minibus), respectively. Furthermore, increasing the parking rate reduces the number of parking vehicles while increasing the possibility of more frequent parking changes, thereby increasing road services (Glazer & Niskanen, 1992). Base on the results, there is a need for public transportation quality improvement because the existing public transportation is considered to lack safety, comfort, and security (Daraba et al., 2018).

The odd–even plate parking arrangement was another recommended system for vehicles circulating on the road, though it has never been studied as a solution in the case of parking. Moreover, the study conducted to evaluate the application of this system in Jakarta showed changes in the road service levels. The implementation of this policy on the street caused the average vehicle speed to increase from 28 km/h to 36.5 km/h and 38 km/h. Also, the traffic volume reduced by 9% and 12% for even and odd plate prohibitions, respectively (Mutharuddin & Herawati, 2013). The success of handling the congestion with the odd–even system was also taken into account though, a different opinion was conveyed by Farda & Balijepalli (2018). This system is very effective at the beginning of its implementation but the performance gradually diminishes as drivers start to adapt by buying a second vehicle or even using fake number plates. However, this system may address this problem through tighter inspection mechanisms in parking to avoid fraud caused by fake plate numbers.

## 6. Conclusions

The study indicated that the severe congestion incidents in Makassar due to crossroads, T junctions, U-turns, parking, and complex occasions resulted in travel service reductions. Moreover, the behavioral model results indicated the assessment level for resolving parking issues had more impact in reducing congestion. Therefore, focus group discussions recommend short, medium- and long-term solutions, where over 30-year projections suggest a remarkable improvement in congestion. However, this study has limitations in terms of mathematical modeling on congestion and parking using data from information systems. In addition, future studies must develop computer simulations using programming algorithms so the results obtained can accommodate more variables and data.

## CRediT authorship contribution statement

**Lambang Basri Said:** Conceptualization, Data curation, Investigation, Methodology, Software, Supervision, Writing - original draft. **Ilham Syafey:** Data curation, Software, Validation, Visualization, Writing - review & editing.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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