E-ISSN 2656-8039
INTERNATIONAL JOURNAL OF ENVIRONMENT, ENGINEERING & EDUCATION
VOL. 4, NO. 1, 2022
www.ijeedu.com

Research Article

The Impact of Land Use Changes on Trip Generation: A Study in the Tallasa City Corridor

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Received: December 12, 2021; **Accepted:** April 25, 2022; **Published:** April 27, 2022

Abstract: The objectives to be achieved in this study are to examine the effect of land-use change on traffic generation in the Tallasa City corridor in Makassar City. The goals to be completed are identifying land use and transportation conditions, calculating traffic flow, analyzing land use development, analyzing movement generation, and analyzing the effect of land-use change on traffic generation on the corridor of Tallasa City. The research method used in this research is descriptive by identifying the land use and transportation conditions of the Tallasa City corridor. Then carried out an analysis of land use development, analysis of generation and attraction, and analysis of the effect of land use on the generation and appeal of the Tallasa City corridor movement in Makassar City. Based on the analysis results, it can be concluded that the condition of average service level of the existing conditions on the Tallasa City corridor is in category A, with the meaning of stable flow, and the driver is free to determine the speed he chooses. The planned land use pattern in the study area is dominated by land use for housing, education, trade, and services. The type of land use influences the effect of land-use change on traffic generation in the Tallasa City corridor. As a result of this land-use change causes a generation that reduces the level of road services in the planning year, which changes to category C with the meaning of steady flow and speed controlled by traffic.

Keywords: Land Use; Transportation Conditions; Road Services; Service Level; Traffic.

1. Introduction

Development generally results in changes in the need for movement. The effect of development on the movement that can be identified the earliest is the magnitude of the generation and pull of the movement [1], [2]. Traffic generation is highly dependent on two aspects, namely the type of land use and the number and intensity of land use activities. As the earliest stage in transportation modeling, the traffic generation and attraction model are a process that translates land use and its intensity into transportation quantities [3].

The emergence of settlements in urban areas and on the city's outskirts will further impact increasing traffic density [4]. One of the causes of traffic problems related to trip generators is that the trips generated by an area are higher than the existing service capacity, and these trips occur at relatively the same time, so traffic jams are difficult to avoid [5].

Urban land-use patterns following the functions and activities of the population can be used to determine the shape, character, or profile of the urban population's journey. The travel profile or character of the population can be used to identify and estimate the need for transportation (transport demand) [6]. Transport demand is the basis (base) used to determine how many transportation facilities (fleets) must be provided in the

This article citation: A. T. Lopa, M. R. Hasrul, J. Yanti, "The Impact of Land Use Changes on Trip Generation: A Study in the Tallasa City Corridor," Int. J. Environ. Eng. Educ., vol. 4, no. 1, pp. 27-35, 2022.
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future and what modes are appropriate for a particular activity that must be held.

Land use is the regulation of land use on vacant land in an area (national, regional, and local) for certain activities. There is usually a direct interaction between the type and intensity of land use and the supply of available transportation facilities. One of the main objectives of planning and land use and transportation system is to ensure an efficient balance between land use activities and transportation capability [7], [8]. One of the variables that can state that the measure of the level of ease of achieving a land use is said to be high or low is the distance between the two land uses (in Km) and the pattern of land use regulation [9], [10].

Land use potential measures the scale of socio-economic activities on a particular land. A distinctive feature of Land Use is its ability or potential to "generate" traffic. Thus, it is only natural to link the Land Use potential of a piece of land, which has certain activities to generate a certain amount of traffic flow per day. To estimate the need for network development and transportation systems, a method is needed to determine how much influence the development (change in movement needs) has on changes in traffic flow movements. Knowing the magnitude of the influence of development on the movement can determine the need for control and regulation to ensure smoothness, safety, and efficiency in the existing network system [11].

A trip is an event, while the act of walking (travel) is a process [12]. Land use is one of the main determinants of movement and activity. This activity is known as the trip generation, which determines the transportation facilities (bus, taxi, city transportation, or private car) needed to make a move. When additional facilities in the system are available, accessibility will automatically increase.

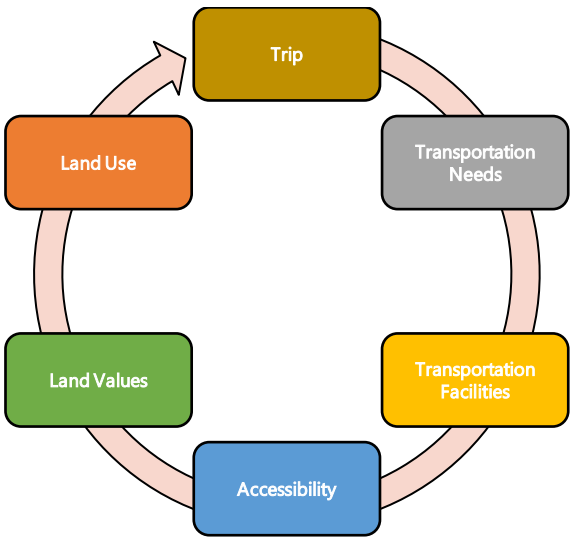

Figure 1. Land Use and Transportation Cycle [13].

Changes in accessibility will determine land values, and these changes will affect land use. If such a change did occur, the trip generation rate would change the entire cycle. It should be noted that this cycle is a simplification of the actual reality, and market forces are not demonstrated. However, this cycle illustrates the fundamental relationship between transportation and land use [13].

The increase in land requirement in each region is the most crucial factor in developing development intended by humans for needs in various fields [14], [15]. So that the need for space becomes a priority to increase development both in the economic sector, government facilities, infrastructure, development for the education sector, and the allocation of other needs in urban areas so that the availability of land is limited. The development of land change causes lands previously intended for agriculture, ponds, and green open spaces to turn into commercial places, trading centers, and social areas. The high demand for land in urban areas causes the narrowness of the available land for green open space.

Changes to the need for traffic movements that reflect the implementation of the Regional Spatial Plan will always result in changes to the movement of traffic flows. Furthermore, these changes must be supported by the transportation network (infrastructure) and the city transportation system, so network development is needed. The more increasing and developing a city, the stronger it will attract movement from other corners or centers of activity. This development will cause a significant change in land use considering the area to be built where previously the land was a swamp and vacant land used for fish cultivation and gardening. Besides that, it can also function as a reduction in pollution and air pollution as space green open.

The formulation of the problem according to the background above is: How is the level of road service in the study area when the condition exists, what is the pattern of land use in the Perintis Road - Sutami Road Corridor in the last five years, how is the impact of land use on traffic generation in the study area.

2. Research Methods

2.1. Location Study

Seeing the very rapid progress of Makassar City invites big investors in the property sector to invest in this city, both in apartment dwellers and independent urban settlements. One of the large national-scale investors who are very interested in making significant investments in this city is the Ciputra Group, and it can be seen from the last five years that where Ciputra Group has consistently carried out development from residential concepts to

independent urban settlements such as Citra Land housing and the Center Point of Indonesia area.

Figure 2. Location Study

In 2019 Ciputra Group expanded its business investment in the Tamalanrea area, namely Land Tallasa City, with an area of ± 700 Ha, which will be flanked by two main roads Jl. Gubernur and Jl. Tol Ir. Sutami with road access that can connect Perinits Road – Sutami Road. The concept of an independent city was developed by Tallasa City in which there are two housing complexes, a commercial area, an international school, a shopping center, a university, and a hospital.

2.2. Data Collection Techniques

The research method is a series or process carried out in this study, including the preparation stage, data collection methods, analysis and discussion methods, conclusions, and suggestions. Primary data collection techniques are divided into 3 (three) ways of collecting data, namely:

a. A preliminary survey is carried out before conducting a field survey to determine the time of the survey, the number of location points to be studied, and the number of surveyors to assist in conducting the survey. In this survey, the observation time is also determined on normal working days, between Monday and Wednesday, with observation hours divided into 3 (three) observation sessions, namely morning, afternoon, and evening rush hours.
b. A geometric data survey of roads can be carried out after conducting a preliminary survey or at the same time as a traffic volume survey. Important information carried out through this survey includes the cross-sectional profile of the road, the width of the road, the width and number of lanes, and the width of the road shoulder or sidewalk. The equipment used to conduct the survey is a meter, digital camera, and stationery.
c. The traffic flow calculation survey counts the number of vehicles passing the Perintis - Sutami Road corridor. Placement points for surveyors who carry out LHR surveys are set at survey point locations along with the study site, which is considered to represent the densest points of traffic volume passing along the road section under review. To simplify calculating traffic volume, the classification of vehicle composition for the calculation of traffic flow is carried out based on the rules listed in the MKJI (Indonesian Road Capacity Manual) [16].

2.3. Data Analysis

In detail, the analysis used in this study is Changes in Land Use; the data used is secondary data from relevant agencies in the form of time series data on land use for the last five years along the Perintis - Sutami Road corridor. Furthermore, an analysis of changes and developments in the activity system in the research area will also be carried out, namely by taking an inventory of land uses that are actively used for an activity.

a. Traffic Volume; in calculating the number of movements, traffic counting data is used, with variables of traffic volume, vehicle composition, and trip generation/attraction that pass and affect the Jalan Perintis – Sutami Road Corridor. The volume of traffic and the composition of vehicles from various types of vehicles that pass through the road are converted into passenger cars, and after a land-use change occurs, the trip rate calculation is used based on the trip rate issued by the ministry of transportation.
b. Traffic Generation; in calculating the number of traffic generation using calculations with the ITE Method, following the development objectives of land change. After that, projections are made for the next five years by considering the percentage of vehicle growth per year.
c. Capacity and Service Level Analysis; the analysis used is to calculate roads' capacity and service level. The data is taken from the results of geometric measurements of the road, which is then entered into the equation according to the form of the Indonesian Road Capacity Manual (MKJI) [16] to get the capacity for the volume of vehicles obtained from traffic counting, which is then calculated on the volume of traffic that passes through the road segment.

2.4. Level of Service

Level of Service (LOS) is a qualitative measure that describes the operational conditions in a traffic flow and the perception of drivers and passengers on these conditions. Each facility can be evaluated based on six levels of service, A to F, where A represents the best-

operating conditions and F for the worst conditions [17]. The characteristics of the assessment of the service level of the primary and sub-urban roads based on the V/C ratio (Traffic Volume/Capacity) [18], [19] are as follows:

Table 1. Level of Service (LOS) based on Volume per Capacity (V/C) Ratio

Description	Ratio (V/C)	Level of Service
Free flow of traffic, unimpeded	0.60	Level A
Traffic flow is good; there may be cases of slowdown	0.70	Level B
Traffic flow is still good and stable, with an acceptable slowdown	0.80	Level C
Starting to feel the disturbance in the flow, the traffic flow is starting to become unstable	0.90	Level D
Service volume is at capacity, and traffic flow is unstable	1.00	Level E
Service volume is more significant than capacity, and traffic flow has been congested	>1.00	Level F

2.5. Road Capacity

Road capacity is the ability of a road segment to accommodate the ideal traffic flow or volume in a particular time unit, expressed in the number of vehicles that pass a specific road section in one hour (vehicles/hour) or by considering the various types of vehicles passing through a road; the unit is used. Passenger car as a vehicle unit in calculating capacity; the capacity uses units of passenger cars per hour.

When the flow of traffic is low, the traffic speed is free; there is no interference from other vehicles, the more vehicles that pass through the road, the speed will decrease until one day the traffic flow/volume can no longer increase; this is where capacity occurs. After that, the current will decrease continuously under forced current conditions until one day, the condition is wholly jammed, the current does not move, and the density is high.

Factors that affect the capacity of city roads are the width of the lane or lane, the presence or absence of a road divider/median, road shoulder/kerb, barriers, and road gradients, in urban areas or outside the city, city size. The formula in urban areas is shown below:

$$\boldsymbol{C = C_o \times F_{CW} \times F_{CSP} \times F_{CSF} \times F_{CCS}} \quad (1)$$

Where:

C = Capacity (PCU/hour)
C_o = Basic capacity (PCU/hour); usually, the number is 2300 PCU/hour
F_{CW} = Road width adjustment factor
F_{CSP} = Directional separation adjustment factor (only for undivided roads)
F_{CSF} = Side and shoulder resistance adjustment factor
F_{CCS} = City size adjustment factor

The primary measures often used in defining traffic flow are flow concentration and velocity. Flow and volume are often considered synonymous, although the term flow is more appropriate to describe traffic flow and contains the number of vehicles in a space measured in a specific time interval. Volume is more often limited to the number of vehicles that pass a point in space during a given time interval. In the Indonesian Road Capacity Manual [16], what is referred to as traffic element/composition are objects or pedestrians part of traffic. At the same time, the vehicle is an element of wheeled traffic.

3. Result and Discussions

Based on the data, analysis and calculations are carried out to obtain the average daily traffic conditions during field observation hours; the average daily traffic for each vehicle direction, both weekdays and holidays, is as follows.

Table 2. Hourly Average Cross-Daily Data Results

Direction**	Vehicles/Hours	PCU*/Hours	Description
Road **A** - Road **B**	778	503	Weekdays
Road **A** - Road **B**	275	188	Holiday
Road **B** - Road **A**	711	478	Weekdays
Road **B** - Road **A**	201	143	Holiday

Perintis Road (A**); Sutami Road (**B**)
*Passenger Car Unit (PCU)

Capacity is defined as the maximum flow through a point on the road that can be maintained per hour under certain conditions, based on geometric road data and other data needed based on the calculation of urban road capacity in chapter 5 of the Indonesian Road Capacity Manual (MKJI) the following results are obtained for both directions. The capacity for the West Ring Road (Tallasa City) section is calculated using the Indonesian Road Capacity Manual. The complete data can be seen in the table below.

Table 3. Road Segment Capacity (PCU/Hours)

Road Segment	C_o	F_{cw}	F_{csp}	F_{csf}	F_{ccs}	C
West Ring Road	9,900	0.96	1.00	1.03	1.00	9,789

Table 4. Performance of Existing Road Sections on Weekdays

Observation Time	V/C Ratio	Level of Service
07.00 - 08.00	0.16	Level A
08.00 - 09.00	0.15	Level A
09.00 - 10.00	0.07	Level A
10.00 - 11.00	0.06	Level A
11.00 - 12.00	0.07	Level A
12.00 - 13.00	0.12	Level A
13.00 - 14.00	0.11	Level A
14.00 - 15.00	0.08	Level A
15.00 - 16.00	0.10	Level A
16.00 - 17.00	0.17	Level A
17.00 - 18.00	0.11	Level A
18.00 - 19.00	0.06	Level A
19.00 - 20.00	0.04	Level A
Average	0.10	Level A

Table 5. Performance of Existing Road Sections on Holiday

Observation Time	V/C Ratio	Level of Service
07.00 - 08.00	0.03	Level A
08.00 - 09.00	0.03	Level A
09.00 - 10.00	0.03	Level A
10.00 - 11.00	0.03	Level A
11.00 - 12.00	0.03	Level A
12.00 - 13.00	0.05	Level A
13.00 - 14.00	0.05	Level A
14.00 - 15.00	0.03	Level A
15.00 - 16.00	0.04	Level A
16.00 - 17.00	0.05	Level A
17.00 - 18.00	0.03	Level A
18.00 - 19.00	0.02	Level A
19.00 - 20.00	0.02	Level A
Average	0.03	Level A

From the data obtained, which has been presented above, the initial condition (existing) of the West Ring Road level of service at peak hours is A with a V/C ratio of 0.16. These data indicate that the performance of this road segment is still very stable, whereas following US-HCM [20], service level A has a description of free-flow conditions with high speed and low traffic volume. The driver can choose the speed obtained without obstacles.

Furthermore, the authors calculated the area of land-use change based on data obtained from time-series aerial photos via Google Earth, where the total area of land that changed in this research area from 2015-to 2019 was 858,785 m2 with the expansion of changes increasing rapidly every year. Year wherein 2019, there was an increase of > 200% from 2018. This shows a high increase in land-use change, resulting in several things, including increased travel production, reduced water catchment areas, and reduced green open areas. If the government's precise handling does not follow this, it will impact both congestion and flood disasters in the area around the research location.

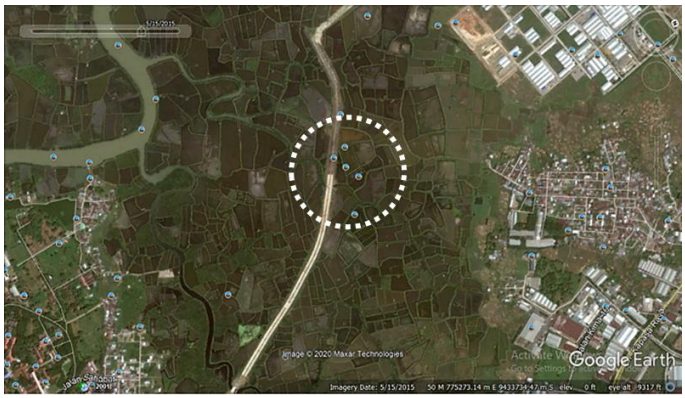

Figure 3. Land Use in 2015

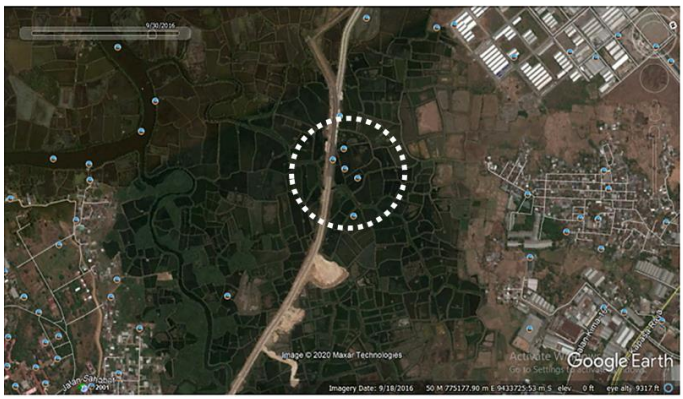

Figure 4. Land Use in 2016

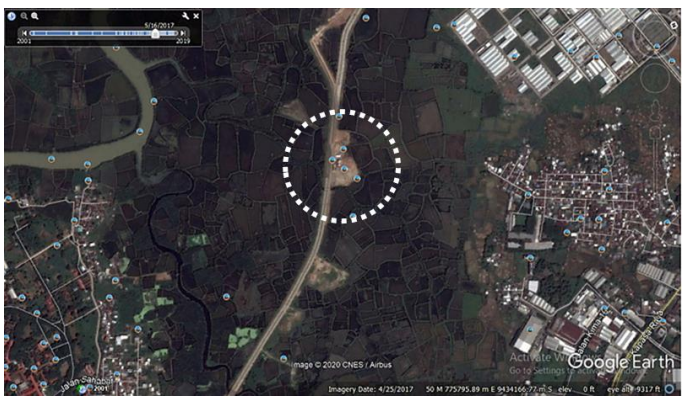

Figure 5. Land Use in 2017

Figure 6. Land Use in 2018

Figure 7. Land Use in 2019

Calculates the traffic generation prediction calculated using the trip rate with the ITE (Institute of Transportation Engineers) method [21], [22]. The building whose generation is calculated is a building that has started its physical work until it has been completed, with the operational plan year being five years from the current year.

Table 6. Area of Land Use Change Between 2015-2019

Years	Area of Changes (m^2)	Percentages (%)
2015	0.00	0.00
2016	53,157	6.00
2017	78,540	9.00
2018	214,840	25.00
2019	512,248	60.00
Total	858,785	100.00

Each building uses different units as determined by ITE; for housing, the units are per unit to be directly used to calculate traffic generation, in contrast to automotive centers and warehouses that use SF or Square Feet units, so they must first be converted from meters. Square feet into square feet, the results obtained are then compared with the total area of land-use change. From the results obtained, it is known that the total trip generation is 2894 trips, and the total land-use change is 858,785 m2, so when compared with the total trip generation, it will get 0.003 trip generation for every 1 m2 land-use change in the study location area.

Table 7. Traffic Generation Calculate

Type of Buildings	Quantity	Units	Travel (Unit)	Number of Trips at Peak Hours
Akasia Cluster Housing	518	Unit	0.99	513
Alamanda Cluster Housing	520	Unit	0.99	515
Citraland Tallasa City Housing	200	Unit	0.99	297
Tallasa City Shophouse	20	Unit	0.63	13
Automotive Center	327	1000 SF	2.26	740
Nature Cluster Warehouse	360	1000 SF	2.27	817
			Total	2894

The effect of land use on traffic performance by predicting generation if the construction has been completed and has been operating is outside of the calculation of the generation of schools, universities, and apartments that will also be built at this location, and the percentage increase in the number of vehicles per year is calculated after five years from now.

It can be seen in the table below that the effect of changes in land use on generation for working days, resulting in changes in the level of road service wherein the initial conditions the average service level shows service level A, but after changes in land use the average service level changes to service level. B, even at peak hours in the morning and evening, the service level shows service level C. The same is also shown for holidays where the average service level changes to service level B where previously service level A was, even during peak hours of noon and hour peak afternoon service level shows a value of C. A complete level of service on weekdays and holidays after a change in land use can be seen in the table below

Table 8. Effect of Traffic Generation

Observation Time	Effect of Traffic Generation on Weekdays				Effect of Traffic Generation on Holiday			
	Traffic Volume (V)	Capacity (C)	V/C Ratio	Level of Service	Traffic Volume (V)	Capacity (C)	V/C Ratio	Level of Service
07.00 - 08.00	4,446	9,789	0.450	Level C	3,207	9,789	0.33	Level C
08.00 - 09.00	4,380	9,789	0.450	Level B	3,158	9,789	0.32	Level B
09.00 - 10.00	3,580	9,789	0.370	Level B	3,172	9,789	0.32	Level B
10.00 - 11.00	3,433	9,789	0.350	Level B	3,182	9,789	0.33	Level B
11.00 - 12.00	3,590	9,789	0.370	Level B	3,236	9,789	0.33	Level B
12.00 - 13.00	4,034	9,789	0.410	Level B	3,387	9,789	0.35	Level C
13.00 - 14.00	4,003	9,789	0.410	Level B	3,377	9,789	0.35	Level C
14.00 - 15.00	3,631	9,789	0.370	Level B	3,170	9,789	0.32	Level B
15.00 - 16.00	3,883	9,789	0.400	Level C	3,256	9,789	0.33	Level C
16.00 - 17.00	4,593	9,789	0.470	Level B	3,385	9,789	0.33	Level B
17.00 - 18.00	3,978	9,789	0.710	Level B	3,223	9,789	0.33	Level B
18.00 - 19.00	3,497	9,789	0.360	Level B	3,116	9,789	0.32	Level B
19.00 - 20.00	3,333	9,789	0.340	Level B	3,057	9,789	0.31	Level B
Average	3,875	9,789	0.400	Level B	3,225	9,789	0.33	Level B

It can be seen in the table above that both weekdays and holidays result in the influence of traffic generation on the level of road service, which reduces the level of road service, especially at peak hours, namely in the morning and evening, which is the peak level of mobility of movement when leaving to start activities. Furthermore, to return home after carrying out activities, the road service level A in the existing condition became service level C after the land-use change and the buildings built were operational.

From the author's observations, this area is a new area that will be of interest to the residents of Makassar because it has a reasonably high accessibility advantage and is supported by a reasonably good road geometry. Hence, there may be many land-use changes in the Tallasa City Road corridor in the future, so the number of trips will increase and reduce road service. The level of road service before the land-use change was at service level A for both weekdays and holidays, with an average value of V/C ratio was 0.10 for weekdays and 0.03 for holidays. Based on observations in the analysis of land use patterns in the last five years based on time series from Google Earth, there is a significant change on the right side of Perintis Road towards Sutami Road, with a total land area that has changed until 2019 is 512,248 m2 of the total land area that will be changed is 700 hectares.

The pattern of change and the amount of movement is a function of the pattern of land-use change on it. Meanwhile, any land-use change will undoubtedly require an increase provided by the area's transportation system [6]. Paquette et al. also stated that land use of a plot of land with certain activities would generate a certain amount of traffic flow per day [23]. Existing land use in the study area is the dominant factor that impacts the occurrence of generation and travel in the future. This follows the theory put forward by Black [6] that the pattern of movement (generation and pull) and the choice of mode of movement is a function of the pattern of movement. Land-use change on it. Meanwhile, any change in land use will certainly require improvements provided by the transportation system concerned.

Transportation and land use are so closely related that they are usually considered to form a single land use transport system. Transportation needs must be adequately met for land use to be adequately realized, and a traffic jam system will certainly hinder land-use activities [24], [25]. On the other hand, transportation that does not serve a land use will be wasted, not utilized. The movement of people and goods in a city, called traffic flow, is a combined consequence of land activity (demand) and the ability of the transportation system to cope with traffic flow problems (supply). There is usually a direct interaction between the type and intensity of land use and the supply of available transportation facilities. One of the main objectives of planning and land use and transportation system is to ensure an efficient balance between land use activities and transport capability [26], [27].

The elements contained in the transportation system also contribute, such as the attributes of the transportation system that describe how the level of service provided by the transportation system is in the form of service conditions, including travel time, transportation costs, service, comfort, safety, reliability, and fleet availability according to the desired time [28].

The mutually beneficial relationship between transportation and land use results in an urban area's

movement and traffic flow patterns. The accessibility of a place has an enormous impact on land value, and the location of a place within the transportation network determines its level of accessibility [29]. Thus, in the long term, the transportation system, and the flow of traffic in it, will form a pattern of land use. The relationship between land use and transportation shows that many variables affect the relationship between land use and transportation [30]. Some of the most critical variables are sources of finance, industrial activity, fuel costs, supply and demand, business structure, job opportunities, and population growth. The interaction between land use and transportation is very dynamic and complex. This interaction involves various aspects of activities as well as various interests. Changes in land use will always affect the development of transportation and vice versa. In this regard, Black [6] stated that the pattern of change, the magnitude of movement, and the choice of the mode of movement are a function of the pattern of land-use change. Meanwhile, any land-use change will certainly require improvements provided by the area's transportation system [31].

4. Conclusion

Based on the results of the analysis, it was found that the effect of changes in land use on the level of service in the Tallasa City section, where the change in land use will cause a total of 2894 trips at peak hours, thus changing the level of service which was initially at the average service level A to become service level B with a v/c ratio of 0.40 for weekdays and 0.33 for holidays, and for weekdays there is a service level C in the morning 07.00-08.00 and in the afternoon 16.00-17.00, for holidays there is a service level C during the day 12.00-13.00, 13.00-14.00 and in the afternoon 16.00-17.00.

Acknowledgments

Thanks to Universitas Negeri Makassar for the administrative support and research facilities provided.

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