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TRANSPORTATION MODELING IN SUPPORTING SUSTAINABLE TRANSPORTATION SYSTEMS AND LOW EMISSION ZONE PLANNING DEVELOPMENT IN INDONESIAN TOURISM DESTINATIONS

Efendhi Prih Raharjo[1]*, Annisa Mahadita Candrarahayu[1], Febrianto Fatah Yogatama[1], I Kadek Surya Putra Adidana[2]
[1]Politeknik Transportasi Darat Indonesia-STTD, Jln Raya Setu No. 89, Cibuntu, Cibitung, Kabupaten Bekasi, Jawa Barat 17520, Indonesia
[2]Politeknik Transportasi Darat Bali, Jl. Batuyang No.109X, Batubulan Kangin, Sukawati, Gianyar, Bali 80582, Indonesia
*efendhisttd@gmail.com

ABSTRACT

Sustainable areas are currently needed in the development of tourism destinations. A sustainable transportation system and the urgency of environmental sustainability are one of the main supporting aspects in achieving regional sustainability. This research aims to produce transportation modeling in support of sustainable transportation systems and the development of Low Emission Zone planning in tourism destinations. The method used in this study is a quantitative method developed through transportation modeling using the Vissim and Visum programs. The analysis was carried out on roads in the Ubud Bali Tourism Area. The results of transportation modeling show that sustainable transportation system planning can reduce the impact of tourism on the transportation sector and the environment by increasing the level of service to A and resulting in reduced air pollution as a result of implementing the Low Emission Zone area.

Keywords**:** low emission zones; sustainable transportation systems; tourism destinations; transportation modeling

INTRODUCTION

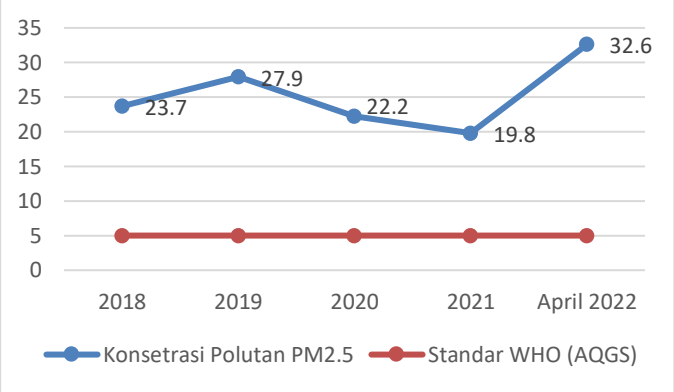
The Ubud tourism area is one of the favorite local and foreign tourist destinations that provides various types of natural, cultural arts and culinary tourism. The arrival rate of tourists, especially foreign tourists who came to Bali, increased dramatically by 10,816.67% in February 2022 to January 2022 after the central and regional governments began to apply normal regulations for the use of transportation to Bali Island (Bali Province Central Statistics Agency 2022). This certainly has an impact on visits to priority tourist areas such as the Ubud Bali Tourism Area. However, the potential for an increase in the number of visits to the Ubud tourist area has other impacts such as transportation and environmental problems that can arise if prevention and handling efforts are not taken. tourism areas that do not consider transportation systems such as congestion due to the use of private vehicles can have a sustainable impact such as environmental pollution and visitor satisfaction (Emmanuel, Frimpong, and Tetteh 2021).

The Ubud tourism area has transportation problems such as congestion caused by the high number of private vehicle users and a parking system that uses the shoulder of the road. Research conducted (Tama, Putri, and Madani 2021) on the Ubud Monkey Forest tourist area shows that the level of congestion occurs during rush hours with a degree of saturation at a value of more than 0.7 and the service value for section C is based on PP No. 32 of 2011 concerning Management and Engineering, Impact Analysis, and Traffic Demand Management. This was caused by the use of private vehicles which increased annually by 10% from 2017 to 2020, and the ratio between motor vehicle ownership and population in Gianyar Regency was 91% in 2020 (BPS Province of Bali 2021). It is projected that in 2045 the ratio between motorized vehicle ownership and the population will reach 138% if certain actions are not taken against the problem of vehicle ownership. Higher vehicle occupancy rates will become a serious problem where if road capacity does not experience significant changes there will be congestion

on the majority of main road sections, especially in tourism areas (Muneera and Krishnamurthy 2020).

The high number of motorized vehicles in an area will have an impact on the level of air pollution (Habib et al. 2021). The level of air pollution will have an impact on air quality which affects the health of the public and tourists visiting tourist areas (Münzel, Sørensen, and Daiber 2021). The 2015 Environmental Status Report issued by the Provincial Government of Bali shows that Gianyar Regency has a PM10 pollutant value of 243.35 µg/m3 which is higher than the PM10 threshold set at 150 µg/m3 (Bali Provincial Government 2015). The results of monitoring the air quality index (IQI) from 2017 to 2022 show fluctuations in the value of the PM2.5 pollutant in the Ubud area. PM2.5 is a pollutant that is less than 2.5 mm in size which can interfere with human respiratory function if inhaled in high concentrations (Rita et al. 2016). Research conducted by Arwini (2020) shows that the majority of air pollution in Bali Province comes from motor vehicle exhaust emissions.

The threshold value for PM2.5 concentration has a different standard where according to the BMKG the safe threshold is 65µg/m3 while WHO through the Air Quality Guidelines 2021 (IQGS) provides a threshold of 5µg/m3 (WHO 2021). WHO sets a new standard for the air quality index because it sees the potential for significant environmental updates during a pandemic and provides encouragement for the use of environmentally friendly renewable resources (WHO 2021). Fluctuations in air quality as indicated by the air quality index in the Ubud area occur as a result of the community activity restriction rules (PPKM) being implemented and as community activities increase, pollutant concentrations have increased as shown in the figure below.



Sumber : www.IQair.com

Figure 1. Air Quality Index for the Ubud Area Based on PM2.5 Pollutants

Spatial planning and planning of the transportation system are one of the variables that strengthen the Ubud tourist area to become a sustainable area (Tama et al. 2021). Research conducted by Wang et al. (2021) show that switching from emitting vehicles to zero-emission vehicles such as electric vehicles can cause the same level of congestion if it is not supported by a good regional system and regional traffic management. Improvements to urban spatial planning and transportation systems can be carried out using a zero-emission area planning approach such as Low Emission Zones or transit-based regional planning supported by sustainable public transportation (Intitute for Transport and Development Policy 2021). Areas based on Low Emission Zones (LEZ) can significantly reduce the amount of pollution by limiting the types of vehicles that enter where only vehicles that have low emissions such as electric vehicles, bicycles and also provide more access for pedestrians (Johnson 2021).

A sustainable transportation system by giving priority to access to public transport and pedestrian and cycling facilities is one of the supporters of a sustainable area, especially in areas with high demand such as tourism areas (Singh, Gurtu, and Singh 2021). The Ubud tourism area can become a more friendly and attractive area for visitors because it can support a good tourist experience if planning for the area is free of traffic jams, pollution, and friendly to priority modes. Planning for a Low Emission Zone area and a Sustainable Transportation System can be a step in achieving a sustainable area in the Ubud tourism area. This is also supported by the Bali Provincial government's policy with Bali Governor Regulation Number 48 of 2019 which supports limiting the number of motorized vehicles with missions and accelerating the development of electric motorized vehicle infrastructure as a step to reduce pollution in the Province of Bali. Transportation modeling as a medium that can represent the existing conditions of transportation both in terms of sections, intersections, and overall network performance can be used in evaluating transportation problems in the Ubud tourism area. Advanced modeling, such as providing treatment for existing conditions, can provide alternative problem solving that is relevant to the wishes of the planner (Fabianova et al. 2020).

The arrangement of the area through the arrangement of transportation conditions in the Ubud Tourism area needs to be modeled in order to provide an overview of changes in the condition of the Ubud Tourism area. Changes to transportation conditions through certain treatments must be evaluated according to the right methods and models in order to get results that match the actual conditions (Heyken Soares et al. 2021). The purpose of this research is to produce transportation modeling in support of sustainable transportation systems and the development of Low Emission Zone planning for tourism destinations. And with the hope that this research can provide benefits to the Government as a policy maker in overcoming environmental problems, especially related to air quality which is getting worse every year, one of the steps that can be taken is through transportation modeling.

METHOD

The research conducted is research that focuses on the disciplines of transportation and the environment by examining the systematic linkages to the variables associated with planning a sustainable Ubud tourism area. The method used in this research is descriptive quantitative. The quantitative method is a method that uses systematic analysis through numerical indicators that can produce systematic and factual data analysis (Syahrum and Salim 2017). According to Zellatifanny & Mudjiyanto (2018) defines quantitative descriptive research as research that analyzes data in numerical or numerical form for certain phenomena which are then systematically explained through certain concepts and indicators.

The data collection technique in this study was to conduct a primary data survey of the existing condition of the Ubud tourist area over a period of one week (May 9 – May 15) to obtain data on weekdays and holidays. Primary data collection was carried out such as a 16-hour traffic counting survey to find out the number of vehicles classified on sections, a 16-hour CTMC survey to determine intersection performance, land use surveys, transportation facility surveys, license plate surveys to obtain travel destination matrix, pedestrian surveys, and parking surveys. Daily air quality index data for the Ubud area were obtained through the IQ AIR real-time application. Secondary data was collected in order to obtain data related to the description of the Ubud tourist area through a literature review (literature review).

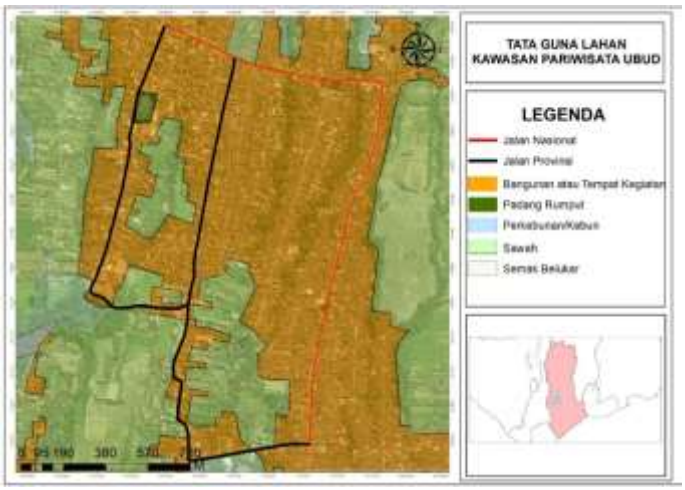
The analysis is carried out in three stages, namely analysis of existing conditions, forecasting for the next 5 years, and analysis of the implementation of the Sustainable Transportation System and Low Emission Zone. Analysis of the performance of the road network was carried

out in accordance with the 1997 MKJI guidelines and the Regulation of the Minister of Transportation of the Republic of Indonesia Number 96 of 2015 concerning Guidelines for the Implementation of Traffic Management and Engineering Activities. Analysis at each stage will produce network performance data that is modeled through the Vissim 22 and Visum 21 applications and also a comparison of the air quality index obtained through the IQ AIR application.

RESULTS

The Existing Condition of the Ubud Tourism Area

The scope of the Ubud tourist area is Ubud Pallace, Monkey Forest, and Ubud Art Market as well as several shops supporting tourism, shown in the image below:



Gambar 1. Peta Tata Guna Lahan

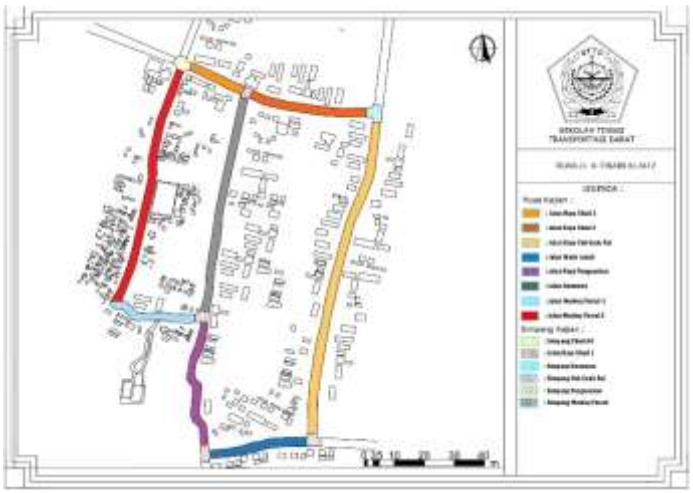


Figure 3. Study Road Section in the Ubud Tourism Area

After conducting an assessment at the tourist sites of Ubud, the researchers then conducted a survey in the form of traffic counting and classified turning movement counting. Then the following data will be obtained:

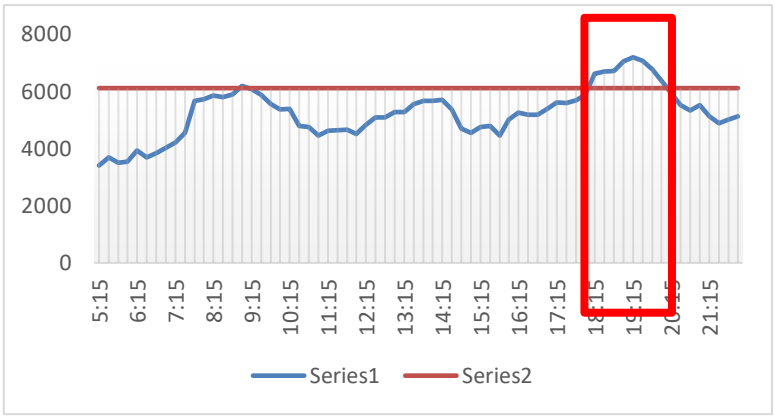


Figure 4. Traffic Volume Fluctuations

Figure 4 shows that peak hour volume occurs from 18.00 to 20.15. This is because at that time it is time to go home from work and tourists who come to see performances at the Ubud Pallace tourist location, and visit shopping and culinary centers. From these results, the modeling analysis used uses peak hours, namely 18.00 to 20.15. With details of traffic volume for each road section:

Tabel 1.
Analisis Kinerja Ruas V/C Ratio

No	Street Name	Capacity	Volume	V/C Ratio
1	Jl. Raya Ubud 1	2264.46	1951.8	0.86
2	Jl. Raya Ubud 2	2859.03	1915.6	0.67
3	Jl. Hanuman	2083.3	1871.7	0.90
4	Jl. MonkeyForest 1	2083.3	1726.2	0.83
5	Jl. MonkeyForest 2	2083.3	1726.2	0.83
6	Jl. Cokorda Gede Rai	2562.44	1435.0	0.56
7	Jl. Made Bees	2229.32	1605.1	0.72
8	Jl. Raya Pengosekan	2229.32	1805.7	0.81

Table 1 it can be seen that the V/C ratio for each road segment studied has a fairly high V/C ratio with the highest on Jalan Hanoman of 0.90 and the lowest on Jalan Cokorda Gede Rai of 0.56. Problems related to this congestion arise due to a need that cannot be accommodated by the existing road capacity and the emergence of several side barriers, both from illegal parking and street vendors which reduce the required road capacity. In addition to the problem of congestion and high side barriers in the form of illegal parking and street swords in the Ubud tourism area, there are other problems that have yet to be addressed, namely the lack of pedestrian facilities. Provision of pedestrian facilities is not only for convenience but also related to the safety of road users. This can be seen in Figure 5

Figure 5. Problems in the Ubud Tourism Area

The Air Quality Index parameter according to IQ Air is based on PM2.5, PM10, and CO pollutants so that the higher the index value, the more pollutants in the area's air. According to Arwini (2020) states that the majority of air pollution in Bali Province is caused by vehicle exhaust emissions. The following is the relationship between air quality and vehicles divided into days at Ubud tourist sites:

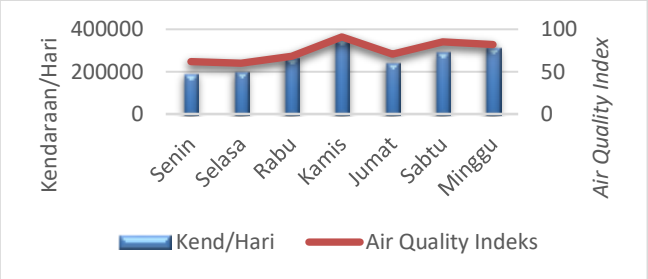


Figure 6. Relationship between Traffic Volume and Air Quality Index

Figure 6 shows that fluctuations in traffic volume are directly proportional to fluctuations in the air quality index. It can be seen that the higher the daily vehicle volume, the higher the air quality index value, which means that there is more pollution in the air. Based on the correlation test, it is known that there is a relationship between vehicles and air quality of 95.3% and then the regression equation Y = 23.24 + 0.000192 is obtained. X. Modeling analysis in this study uses the Vissim and Visum applications. The Vissim application is used to carry out micro analysis so that it is able to show actual traffic conditions, while Visum is used to obtain trip assignment data by dividing the study area based on land use. After validating with the Chi-Square method, we get the existing condition of road performance in the Ubud tourism area, as follows:

Table 2.
Existing Road Performance

No.	Parameter	Road Network Performance	*LOS*
1	Average Delay (seconds)	78.64	
2	Average Speed (km/h)	30.31	E
3	Travel Length (veh-km)	24.682	
4	Travel time (end-hours	697.54	

In the loading shows the density of the road segment from the V/C ratio, it is found that the sections with the largest loading are on the Monkey Forest 1, Jalan Hanoman, Monkey Forest 2, and Jalan Raya Ubud 1 sections. In actual conditions, the Monkey Forest area around these sections become a favorite tourist destination, especially the Performance Temple which is a favorite destination for tourists.

Table 3.
Travel Expenses in the Ubud Tourism Area

No	Street Name	V/C *Ratio*	
		Model	Survei
1	Jl. Raya Ubud 1	0.82	0.86
2	Jl. Raya Ubud 2	0.71	0.67
3	Jl. Hanoman	0.83	0.90
4	Jl. Monkey Forest 1	1.09	0.83
5	Jl. Monkey Forest 2	0.73	0.83
6	Jl. Cokorda Gede Rai	0.60	0.56
7	Jl. Made Lebah	0.69	0.72
8	Jl. Raya Pengosekan	0.92	0.81

Figure 7. Visualization of Loading Results

Do-Nothing Analysis for the Next 5 Years

Do-nothing analysis for the next 5 years without carrying out any transportation planning in improving transportation problems in the Ubud tourism area. With an average vehicle growth rate of 5.5% in Gianyar Regency, the results are:

Table 4.
Road Network Performance for the Next 5 Years (Do-Nothing)

No.	Parameter	Road Network Performance 2025	LOS
1	Average Delay (seconds)	251.648	F
2	Average Speed (km/h)	15.21	
3	Travel Length (veh-km)	81.4506	
4	Travel time (end-hours	2790.16	

Table 5.
Travel Expense for the Next 5 Years (Do-Something)

No	Street Name	V/C *Ratio* (Model)
1	Jl. Raya Ubud 1	1.80
2	Jl. Raya Ubud 2	0.93
3	Jl. Hanoman	1.28
4	Jl. Monkey Forest 1	1.58
5	Jl. Monkey Forest 2	0.85
6	Jl. Cokorda Gede Rai	0.87
7	Jl. Made Lebah	0.90
8	Jl. Raya Pengosekan	1.20

Figure 8. Visualization of Travel Expenses for the Next 5 Years (Do-Nothing)

From the results of the road network performance modeled in Vissim, it shows a decrease in LOS or Level Of Service to F. This means that the road network performance is experiencing

high problems. The results of Visum modeling show that network performance is getting worse as seen from the value of the V/C ratio which has increased from 2022 This will have an impact on locations with the highest attraction such as the Monkey Forest area and Ubud Art Market. As seen from Figure 12, Jalan Raya Ubud 1, Hanuman, Monkey Forest 1 and Monkey Forest 2 are overloaded with red color. Forecasting the impact of air pollution is done by calculating the assumed correlation value of the number of vehicles and air quality in the base year (2022). So that with the increasing number of vehicles, the air quality will decrease or the IQ Air air quality index will experience an increase in value. The graph of changes in air quality index values can be seen in the following figure:

Figure 9. Graph of Comparison of Air Quality Index for 2022 and 2027 (Do-Nothing)

Do-Something Analysis for the Next 5 Years

Do-something analysis uses a sustainable transportation system. Planning for a sustainable transportation system in tourism areas is based on the level of demand so that it can create an area that provides a comfortable atmosphere for tourists (Virkar & Mallya, 2018). There are 2 (two) strategies to be able to realize a sustainable transportation system in the tourist area of Ubud, namely Planning for Regional Integration and Planning for Low Emission Zones.

Regional Integration Planning

The concept of regional integration is an important one in planning a sustainable transportation system in the tourism area (Tama et al., 2021). Based on the results of a pedestrian survey, it shows that the width of the existing sidewalk does not meet the aspects of comfort and protection. The aspect of protection according to ITDP (2021) refers to the area's ability to provide comfort and convenience to pedestrians as well as the convenience of road users to change places. The following is an integration plan for the Ubud tourist area. Planning for pedestrian facilities is carried out using the ITDP guidelines (2021) where in planning pedestrian facilities, the urgency and characteristics of the area must be considered. The tourism area of Ubud tends to be cultural areas and has a high density, so pedestrian facilities are planned to be wide. According to PM 96 of 2015, the width of the sidewalk for commercial areas or areas with large generation has a minimum width of 1.5 – 4 meters.

Figure 10. Wide and Inclusive Pedestrian Facilities

Furthermore, pedestrian facilities use shading facilities in the form of trees and according to Virkar & Mallya (2018) wayfinding facilities will make it easier for tourists and have a high level of satisfaction in accessing the area.

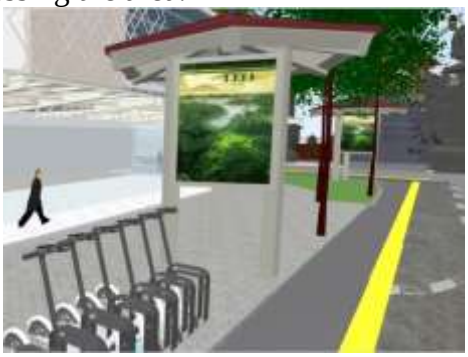


Figure 11. Shading and Wayfinding Facilities

In addition, the planning for bus stops or bus stops is based on the ITDP Indonesia guidelines (2019) where bus stops must be within a radius of 400 meters or a standard walking distance. Stopping facilities must be protected and can provide the aesthetics of the building.

Figure 12. Planning for Stop and Bike Share Facilities

Low Emission Zone Planning

Planning for low emission zone areas is used by providing restrictions on vehicles passing in the area. In non-priority areas, emitting vehicles can enter as usual. In planning the Low Emission Zone area. On-street parking is not permitted along the area and the use of off-street parking is an important location for dropping off passengers. The strategy for determining the time for implementation of the low emission zone is carried out during peak hours, namely at 18.00 - 20.00 so that modeling can be done using data on existing conditions or on a base year. Low Emission Zone area can be seen in the following figure:

Figure 13. Low Emission Zone Area Plan

By applying these two strategies to the Ubud tourism area, an analysis will then be carried out to determine the performance of the road network and air quality in the Ubud tourism area:

Table 6.
Road Network Performance in 2027 (Do-Something)

No	Street Name	V/C Ratio	LOS
1	Jl. Raya Ubud 1	0.09481	A
2	Jl. Raya Ubud 2	0.0737	
3	Jl. Hanoman	0.098825	
4	Jl. Monkey Forest 1	0.091146	
5	Jl. Monkey Forest 2	0.091146	
6	Jl. Cokorda Gede Rai	0.0616	
7	Jl. Made Lebah	0.0792	
8	Jl. Raya Pengosekan	0.0891	

Figure 14. Visualization of Travel Expenses in 2027 (Do-Something)

DISCUSSION

The results of the existing analysis show that in 2022 the performance of the road network in the Ubud tourism area is included in the level of service E with an average V/C ratio of 0.77, which means that the total volume of vehicles approaches the existing road capacity, and there is a level of quality. bad air with an average value of 74. In the do-nothing analysis, it can be seen that there is a very significant decrease with an increase in the number of vehicles on average each year by 5.5% and without special handling of this problem resulting in a level of service F with an average V/C ratio of 1, 18 which means that the total volume of vehicles has exceeded the existing capacity and the deteriorating level of air quality has reached an average of 90.

So as to prevent bad things in the future, it is handled with a do-something analysis through the implementation of a sustainable transport system. The implementation of a sustainable transportation system uses 2 (two) strategies, namely the creation of integrated areas and low emission zone planning. From this application, it was able to improve the performance of the road network to a level of service A, the average V/C ratio was 0.05 and the air quality improved to 29.

Table 7. Comparison of Indicators

Tahun	*Average*		
	Level of Service	V/C *Ratio*	*Air Indeks Quality*
2022	E	0.77	74
2027 (*Do-Nothing*)	F	1.18	90
2027 (*Do-Something*)	A	0.05	29

CONCLUSION

Based on the results of the study, it was concluded that transportation modeling using the vissim and visa applications can be used to determine future movements. This modeling is very useful in transportation planning, especially in commercial areas such as the Ubud tourism area. The increase in the number of tourists every year after the pandemic and the increase in the number of vehicles in the Ubud Tourism Area will have an adverse impact not only on the transportation sector in the form of congestion but also on the environmental sector which continues to experience a decline in the existing air quality. So of course the implementation of a sustainable transportation system by developing a low emission zone and the creation of an integrated area is able to reduce the number of motorized vehicles, traffic jams and improve air quality in the Ubud Tourism Area. This can be seen from the increase in the level of service from F to A and the improvement in the air quality index from 90 to 29. If in the future this can be implemented and developed, it is not impossible that the problem of congestion and air quality in tourism areas can be resolved.

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