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Traffic Movement Modeling Using PTV Visum Software

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Abstract

The number of vehicles grows every year, so transportation planning must be well designed, and the four-step transportation model is one way to support it. This study aimed to model the 2018 trip distribution, forecast trips for 2019–2025, and model traffic assignment on the national road network of West Java Province using PTV Visum software. The study used secondary data comprising an origin-destination matrix, road geometry and traffic flow data, socioeconomic data, and trip production and attraction data for 27 regency/city zones. Trip production and attraction models were developed by linear regression on population ($R^2 = 0.7945$ and 0.7954). Trip distribution was analysed using a doubly constrained gravity model (DCGR) with a Tanner impedance function, and traffic assignment was analysed using the equilibrium assignment method. The model produced a 2018 trip distribution of 3,808,395,180 persons/day, which increases to 11,466,572,132 persons/day in 2025. Validation of the assigned traffic in the screenline area covering Karawang, Purwakarta, and West Bandung Regencies yielded an R value of 0.8569 ($p < 0.05$), indicating that the traffic assignment produced by PTV Visum is valid.

Keywords : *Trip Distribution, Trip Assignment, Gravity Model, Traffic Movement, PTV Visum*

INTRODUCTION

Traffic movement patterns arise from the process of fulfilling needs. Every land use or activity system has particular types of activities that generate trips and attract trips in the course of meeting those needs [1]. Transportation modelling helps planners understand how the system works and predict changes in traffic flow resulting from changes in land use and transportation infrastructure [2].

Transportation problems arise because the number of vehicles continues to grow

every year. Addressing them requires transportation planning that is sound and well designed. A widely used approach is the four-step transportation model, which consists of trip generation, trip distribution, modal split, and trip assignment [2,3]. This approach remains the basis of strategic transport planning in Indonesia, for example in the demand and capacity analysis of the Jabodetabek public transport network [4] and in forecasting intercity travel demand on the Java corridor [5].

Several previous studies have applied software-based transportation modelling. Suthanaya and Maulidawati modelled travel patterns in Denpasar City using PTV Visum and obtained a model similarity of R = 0.4090 [6]. Novačko et al., in their study *Estimation of Origin-Destination Trip Matrices for Small Cities*, produced a model with R = 0.709 [7]. Duraku et al., in *Building and Calibration Transport Demand Model in Anamorava Region*, achieved a similarity of 0.9912 between the model and real conditions, demonstrating a valid model [8]. In Indonesia, PTV Visum has been used to estimate road network loading in Sungguminasa [9], evaluate the level of service of the road network in Balikpapan [10], model freight vehicle routes in Dumai [11], and analyse the distribution and assignment of water-truck trips in Kupang [12,13]. Internationally, it has been used to calibrate and validate a regional public transport demand model in Lithuania [14] and to compare static equilibrium and dynamic assignment for a hospital area in Jeddah [15].

These studies were generally conducted at the city or regional scale. The present study applies a similar approach at the provincial scale, covering the national road network and 27 regency/city zones of West Java Province. The software used is PTV Visum, a GIS-based package for traffic analysis, forecasting, and data management that consistently models the interaction between road users and the traffic network [16]. The objectives of this study were to model the 2018 trip distribution, forecast trips for 2019–2025, and model traffic assignment on the national road network of West Java Province using PTV Visum.

METHOD

This quantitative study is based on transportation modelling and uses secondary data. It covers two modelling stages, trip distribution and trip assignment, both carried out in PTV Visum. The research workflow is presented as a flowchart in Figure 1.

Study Area

The study area is West Java Province, which consists of 18 regencies and 9 cities [17] (Figure 2). Each regency/city was treated as one zone, giving 27 zones in the model.



Figure 1 Research Flowchart

Source: Analysis Results, 2021



Figure 2 Map of West Java Province

Source: BPS-Statistics of West Java Province, 2018

Data

This study used four types of secondary data. (1) *Origin-destination (OD) matrix data*, describing passenger trips between zones in West Java, obtained from the Research and Development Agency of the Ministry of Transportation (Balitbang Kemenhub). (2) *Road geometry and traffic flow data*, covering annual average daily traffic (AADT), road capacity, *International Roughness Index* (IRI), speed, and road geometry, obtained from the Directorate General of Highways (Bina Marga), Ministry of Public Works and Housing. (3) *Socioeconomic data* for each regency and city, including population, vehicle ownership, area, and other supporting data. (4) *Trip production and attraction data*, giving the number of people travelling from and to each zone, obtained from the National Transportation Database System of the Ministry of Transportation and presented in Table 1.

Table 1 Trip Production and Attraction in West Java Province, 2018 (persons/year)

Regency/City	Production	Attraction	Regency/City	Production	Attraction
Bandung Regency	123,209,711	123,662,741	Subang Regency	30,979,561	30,944,518
West Bandung Regency	79,533,121	78,956,889	Sukabumi Regency	48,853,639	48,589,979
Bekasi Regency	594,825,601	594,005,315	Sumedang Regency	22,294,867	22,705,039
Bogor Regency	468,958,339	473,439,630	Tasikmalaya Regency	35,094,391	34,604,425
Ciamis Regency	63,970,495	63,372,856	Bandung City	183,009,563	183,836,704
Cianjur Regency	44,657,815	44,690,131	Banjar City	3,547,904	3,612,026
Cirebon Regency	42,793,982	42,769,268	Bekasi City	358,658,814	356,901,754
Garut Regency	51,365,617	51,270,129	Bogor City	126,234,838	126,955,190
Indramayu Regency	33,392,646	33,864,916	Cimahi City	61,340,593	61,927,503
Karawang Regency	75,173,822	72,726,709	Cirebon City	6,179,743	6,205,325
Kuningan Regency	21,124,205	21,154,721	Depok City	294,317,432	296,143,081
Majalengka Regency	23,448,849	23,640,865	Sukabumi City	6,191,794	6,412,318
Pangandaran Regency	8,060,002	7,824,890	Tasikmalaya City	12,733,648	13,098,489
Purwakarta Regency	18,720,824	18,681,948	Total	2,838,671,816	2,841,997,359

Source: National Transportation Database System, 2018

Data Analysis

The analysis was carried out in several stages. First, the road network and zoning system were built in the PTV Visum *Network Editor*. Second, trip production and attraction were forecast by correlation and linear regression on socioeconomic variables. Third, trip distribution was analysed using the doubly constrained gravity model (DCGR) [1,18]. Fourth, traffic assignment was analysed using the equilibrium assignment method, which is based on Wardrop's equilibrium principle [19]. Finally, the model was validated by linear regression between modelled flows and observed flows in the screenline area.

RESULT AND DISCUSSION

Network Modelling in PTV Visum

The national road network of West Java Province was modelled in the PTV Visum *Network Editor* with 27 zones corresponding to the regencies and cities. The zoning in the *Network Editor* is shown in Figure 3.



Figure 3 Zoning in the PTV Visum Network Editor, West Java Province

Source: PTV Visum Analysis Results, 2021

Trip Generation Forecasting

Trip generation is the modelling stage that estimates the number of trips produced by a zone (production) and the number of trips attracted to a zone (attraction), for both home-based and non-home-based trips [2]. Regression on socioeconomic variables is the

usual way to model trip production and attraction, as shown for the Jakarta Metropolitan Area [20] and in census-based trip generation models [21], and regression is also used to forecast traffic volumes [22]. Because the 2018 model of West Java Province used secondary data, the production and attraction data only needed to be entered into PTV Visum for analysis in the next stage. Forecasting trips for 2019–2025, however, required production and attraction models for those years. Fourteen socioeconomic variables were tested as candidate independent variables; their correlations with the 2018 trip production and attraction of West Java Province are presented in Table 2.

Table 2 Correlation of Trip Production and Attraction with Socioeconomic Variables, 2018

No	Independent variable	Code	r with production (Y1)	r with attraction (Y2)
1	Area (km^2)	X1	-0.0238	-0.0235
2	Population	X2	0.8689	0.8694
3	Paved road length (km)	X3	0.4449	0.4448
4	Hospitals (units)	X4	0.8555	0.8539
5	Male population	X5	0.7484	0.7505
6	GRDP (current prices)	X6	0.6856	0.6840
7	GRDP per capita	X7	0.2858	0.2834
8	Employed population	X8	0.7363	0.7374
9	Number of schools	X9	0.3061	0.3081
10	Vehicle ownership	X10	0.5477	0.5466
11	Number of companies	X11	0.6450	0.6444
12	Company employees	X12	0.6268	0.6254
13	School students	X13	0.7403	0.7414
14	Road length by regency/city (km)	X14	0.3045	0.3039

Source: Analysis Results, 2021 Full inter-variable correlation matrices are available as supplementary material.

Statistical analysis of the socioeconomic data produced the following trip production model for West Java Province for future years:

$$Y = -73{,}941{,}812.13 + 1{,}658.217893\ X_2 \quad (1)$$

where X_2 is population (persons). This regression model was selected because the coefficient of the independent variable has the expected positive sign, with a coefficient of determination (R^2) of 0.7945.

The resulting trip attraction model for West Java Province for future years is as follows:

$$Y = -74{,}298{,}645 + 1{,}662.56197530303\ X_2 \quad (2)$$

where X_2 is population (persons). This model was selected because the coefficient has the expected positive sign, with $R^2 = 0.7954$. Both models indicate that population is the most influential variable for both trip production and trip attraction, which is also reflected in the high correlations of production and attraction with population (0.8689 and 0.8694, respectively).

Trip Distribution

Trip distribution is the allocation of the trips produced by a zone to other zones, known as inter-zonal trips [6]. The model used was the doubly constrained gravity model (DCGR), which has recently been applied to inter-island freight flows in Indonesia using BPS data [23]. It is given by the following equation [18]:

$$T_{id} = A_i \cdot B_d \cdot O_i \cdot D_d \cdot f(C_{id}) \quad (3)$$

where T_{id} is the number of trips from zone i to zone d (trips/day), A_i and B_d are the production and attraction balancing factors, O_i is the number of trips originating in zone i, D_d is the number of trips destined for zone d (trips/day), and $f(C_{id})$ is the impedance (deterrence) function.

After several impedance functions were tested and iterated, the Tanner function produced the pattern closest to the observed trip pattern, compared with the exponential and power functions. The Tanner function is expressed as:

$$F(C_{ij}) = a \cdot C_{ij}^{\,b} \cdot e^{c \cdot Uij} \quad (4)$$

where C_{ij} is the travel cost between zones i and j, U_{ij} is the travel utility ($U_{ij} = 1/C_{ij}$), and a, b, and c are calibrated parameters.

The estimated parameters a, b, and c of the impedance function are presented in Table 3.

Table 3 Impedance Function Parameters

Transport demand	Parameter a	Parameter b	Parameter c	Impedance function $f(C_{id})$
Population	0.00012	1	−0.00000000003638	$0.0012 \cdot (C_{ij})^1 \cdot e^{-0.00000000003638 \cdot (Cij)}$

Source: Analysis Results, 2021

The trip distribution was calibrated over 27 iterations until the results converged. Table 4 presents the trip distribution from PTV Visum for 2018 and the forecasts for 2019–2025.

Table 4 Trip Distribution Results, 2018–2025

Year	Trip distribution (persons/day)	Growth (%)
2018	3,808,395,180	–
2019	4,570,074,216	20.0
2020	5,484,089,059	20.0
2021	6,580,906,871	20.0
2022	7,897,088,245	20.0
2023	9,476,505,894	20.0
2024	10,424,156,484	10.0
2025	11,466,572,132	10.0

Source: PTV Visum Analysis Results, 2021

Table 4 shows that trip distribution grows by about 20% per year in 2019–2023 and by about 10% per year in 2024–2025, an average of about 17.1% per year. Overall, trips in 2025 are projected to be about three times those in 2018.

Table 5 Ten Largest Origin-Destination Flows from the PTV Visum Model, 2018

Rank	Origin zone	Destination zone	Trips (persons/day)
1	Depok City	Bogor Regency	117,097,364
2	Bogor Regency	Depok City	117,057,118
3	Bogor Regency	Bogor City	88,152,088
4	Bogor City	Bogor Regency	88,121,730
5	Bandung Regency	Bandung City	85,301,382
6	Bekasi Regency	Bogor Regency	75,977,053
7	Bekasi City	Bekasi Regency	72,631,691
8	Bekasi Regency	Bekasi City	71,185,430
9	Bekasi Regency	Depok City	41,316,440
10	Depok City	Bekasi Regency	41,066,484

Source: PTV Visum Analysis Results, 2021 Derived from the full 27 × 27 OD matrix (available as supplementary material); cells illegible in the source manuscript were excluded.

The 2018 OD matrix produced by the model covers 27 × 27 zone pairs; the ten largest flows are listed in Table 5. The largest flows are between Depok City and Bogor Regency (about 117 million persons/day in each direction), followed by Bogor Regency–Bogor City, Bandung Regency–Bandung City, Bekasi Regency–Bogor Regency, and Bekasi City–Bekasi Regency. This pattern shows that inter-zonal trips in West Java are concentrated between neighbouring zones around Jakarta (Bogor, Depok, and Bekasi) and within the Greater Bandung area.

Desire Lines in 2018

Desire lines represent the trips taking place: the thicker the line, the greater the volume of trips [18]. Figure 4 shows the inter-zonal desire lines drawn by PTV Visum.

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Figure 4 Desire Lines of West Java Province, 2018

Source: Analysis Results, 2021



Figure 5 Modelling Screenline

Source: Analysis Results, 2021

Traffic Assignment

Traffic assignment loads the travel demand produced by the distribution stage onto the road network. Its purpose is to obtain the flows on road links or the total trips on the network. This study used equilibrium assignment, in which no road user can reduce their travel cost by switching routes [19]. The equilibrium is found iteratively, for example with the method of successive averages [24], and static equilibrium assignment is suited to long-term strategic planning [15]. The model was validated by linear regression between the modelled flows and the observed flows.

Validation was carried out within an area bounded by a cordon line, or screenline. A cordon line marks the boundary of the study area and usually follows natural or physical barriers such as rivers or railway lines. In this model, the railway line served as the cordon line, so the zones used for validation were Karawang Regency, West Bandung Regency, and Purwakarta Regency (Figure 5). Screenline-based validation is also efficient, because a well-calibrated four-stage model can reproduce traffic flows with fewer survey locations [25].

The comparison of modelled and observed flows yielded $R = 0.8569$ with a *p-value* < 0.05, indicating that the traffic assignment produced by PTV Visum is valid. Table 6 presents, for each road link in the screenline area, the observed and modelled daily flows together with the estimated 2018 peak-hour volumes.

Table 6 Observed and Modelled Traffic Flows and Estimated Peak-Hour Volumes, 2018

Regency	Road link	Nodes	Daily flow (veh/24 h)		Peak-hour volume (veh/h)		
			Observed	Modelled	Motor-cycle	Car	Public transport
Karawang	JLN. RAYA DAWUAN (CIKAMPEK)	254–262	19,472	24,255	1,091	327	437
	LINGKAR KARAWANG	82–260	28,640	30,090	1,354	406	542
	JLN. BY PASS JOMIN (CIKAMPEK)	12–258	19,051	22,919	1,031	309	413
	BTS. KOTA KARAWANG - BTS. KOTA CIKAMPEK	254–256	20,763	19,470	876	263	350
	JLN. JEND. A. YANI (CIKAMPEK)	12–257	38,082	41,248	1,856	557	742
	JLN. IR. H. JUANDA (CIKAMPEK)	82–259	20,091	18,273	822	247	329
	BTS. KOTA CIKAMPEK - BTS. KAB. SUBANG/KARAWANG	255–261	34,551	33,155	1,492	448	597
	JLN. JEND. SUDIRMAN (CIKAMPEK)	257–259	23,566	28,581	1,286	386	514
	AKSES TOL KALIHURIP (DAWUAN) - KARAWANG	256–260	21,454	22,141	996	299	399
	JLN. RAYA JATISARI (CIKAMPEK)	258–261	24,269	22,620	1,018	305	407
	JLN. PANGKAL PERJUANGAN (KARAWANG)	6–262	30,683	30,379	1,367	410	547
Purwakarta	BTS. KAB. KARAWANG/PWK - SADANG (CIKAMPEK - SADANG)	12–314	21,621	18,582	836	251	334

Regency	Road link	Nodes	Daily flow (veh/24 h)		Peak-hour volume (veh/h)		
			Observed	Modelled	Motor-cycle	Car	Public transport
	JLN. VETERAN/TUPAREV (PURWAKARTA)	139–314	34,974	27,323	1,230	369	492
	JLN. JEND. SUDIRMAN (PURWAKARTA)	139–315	35,232	39,172	1,763	529	705
	JLN. R.E. MARTADINATA (PURWAKARTA)	140–315	31,068	38,574	1,736	521	694
	JLN. BASUKI RACHMAT (PURWAKARTA)	140–316	17,035	16,701	752	225	301
	JLN. TERUSAN IBRAHIM SINGADILAGA (PURWAKARTA)	316–317	17,790	16,306	734	220	294
	JLN. RAYA CIGANEA (PURWAKARTA)	317–318	20,674	17,422	784	235	314
	JLN. JEND. A. YANI (PURWAKARTA)	141–318	27,186	20,628	928	278	371
	SADANG - BTS. KOTA PURWAKARTA	141–357	16,587	15,058	678	203	271
	JLN. IBRAHIM (PURWAKARTA)	319–357	27,581	20,147	907	272	363
	BTS. KOTA PURWAKARTA - CISOMANG	211–319	6,256	3,087	139	42	56
	JLN. RAYA RAJAMANDALA (RAJAMANDALA)	277–304	22,390	18,775	845	253	338
	JLN. RAYA PURWAKARTA (PADALARANG)	288–303	10,985	9,862	444	133	178

Regency	Road link	Nodes	Daily flow (veh/24 h)		Peak-hour volume (veh/h)		
			Observed	Modelled	Motor-cycle	Car	Public transport
West Bandung	CISOMANG - BTS. KOTA PADALARANG	210–211	9,108	4,210	189	57	76
	JLN. RAYA PADALARANG (PADALARANG)	32–209	18,287 / 14,262	15,059	–	–	–
	CIMAREME - BATUJAJAR	94–95	6,277	9,606	–	–	–
	CITARUM - RAJAMANDALA - BTS. KOTA PADALARANG	95–183	20,875	19,338	–	–	–
	EKS TOL RAJAMANDALA	32–243	16,636	13,749	–	–	–
	BTS. KOTA PADALARANG - BTS. KOTA BANDUNG	94–209	35,953	35,972	–	–	–

Source: Analysis Results, 2021 Values apply to each direction of the link; where the two directions differ, both are shown (A→B / B→A). – = not reported.

The R value of 0.8569 obtained in this study is higher than that of the travel pattern model for Denpasar City (R = 0.4090) [6] and the OD matrix estimation for small cities (R = 0.709) [7], but lower than that of the transport demand model for the Anamorava Region (0.9912) [8]. This shows that a provincial-scale traffic assignment model built in PTV Visum can represent observed traffic flows well.

CONCLUSION

Using West Java Province as a case study, this research modelled trip distribution and traffic assignment with a doubly constrained gravity model (DCGR) and equilibrium assignment in PTV Visum. The model produced 3,808,395,180 trips (persons/day) in 2018, and the forecast rises to 11,466,572,132 persons/day in 2025, an average growth of about 17% per year. The 2018 traffic assignment modelled in PTV Visum and validated in the

screenline area yielded R = 0.8569 with a *p-value* < 0.05, so the traffic assignment produced by PTV Visum is valid. These results can serve as a basis for planning the national road network in West Java Province. Future studies should add the modal split stage to complete the four-step model.

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REFERENCES

1. Pramesti ND, Wulandari WL, Riyanto B, Basuki KH. Analisis Distribusi Perjalanan Menggunakan Model Gravitasi Dua Batasan dengan Optimasi Fungsi Hambatan Studi Kasus: Kota Semarang dan Kota Surakarta. Jurnal Karya Teknik Sipil. 2014;3(1):228–39. Available from: https://ejournal3.undip.ac.id/index.php/jkts/article/view/4681
2. Tamin OZ. Perencanaan, Pemodelan, dan Rekayasa Transportasi: Teori, Contoh Soal, dan Aplikasi. Bandung: Penerbit ITB; 2008.
3. Ortúzar JdD, Willumsen LG. Modelling Transport. 4th ed. Chichester: John Wiley & Sons; 2011. https://doi.org/10.1002/9781119993308
4. Alvinsyah, Hadian E. A Demand and Capacity Analysis on Bus Semirapid Transit Network (Case: Jabodetabek Public Transport Network). MATEC Web of Conferences. 2018;181:10001. https://doi.org/10.1051/matecconf/201818110001
5. Lubis HAR, Pantas VB, Farda M. Demand Forecast of Jakarta-Surabaya High Speed Rail Based on Stated Preference Method. International Journal of Technology. 2019;10(2):405–16. https://doi.org/10.14716/ijtech.v10i2.2442
6. Suthanaya PA, Maulidawati C. Analisis Pola Pergerakan di Kota Denpasar. Jurnal Ilmiah Teknik Sipil. 2019;23(2):1–8. https://doi.org/10.24843/JITS.2019.v23.i02.p01
7. Novačko L, Šimunović L, Krasić D. Estimation of Origin-Destination Trip Matrices for

Small Cities. Promet – Traffic&Transportation. 2014;26(5):419–28. https://doi.org/10.7307/ptt.v26i5.1501

8. Duraku R, Atanasova V, Krstanoski N. Building and Calibration Transport Demand Model in Anamorava Region. Tehnički vjesnik. 2019;26(6):1784–93. https://doi.org/10.17559/TV-20171019161950
9. Ramli M, Adisasmita S, Yatmar H, Rauf S, Hustim M, Aly S, et al. Aplikasi Program Visum untuk Analisis Estimasi Pembebanan Jaringan Jalan di Kota Sungguminasa Kabupaten Gowa. Jurnal TEPAT: Teknologi Terapan untuk Pengabdian Masyarakat. 2024;7(1):45–53. https://doi.org/10.25042/jurnal_tepat.v7i1.361
10. Pangestu SA, Simangunsong JE, Alkas MJ. Analisis Tingkat Pelayanan pada Jaringan Jalan di Kecamatan Balikpapan Selatan Menggunakan Aplikasi PTV Visum. Teknologi Sipil: Jurnal Ilmu Pengetahuan dan Teknologi. 2024;8(2):23–34. https://doi.org/10.30872/ts.v8i2.17523
11. Yuni SW. Evaluasi Kinerja Rute Kendaraan Angkutan Barang Kota Dumai dan Pemodelan Menggunakan Aplikasi PTV Visum 22. Jurnal Inovtek Seri Teknik Sipil dan Aplikasi (TekLA). 2022;4(2). Available from: https://garuda.kemdiktisaintek.go.id/documents/detail/3261211
12. Ar Z, Tuati A, Wadu A. The Trip Distribution Analysis of Water Trucks as Heavy Vehicles with PTV Visum Application. In: Proceedings of the 5th International Conference on Applied Science and Technology on Engineering Science (iCAST-ES). Setúbal: SciTePress; 2022. p. 1056–61. https://doi.org/10.5220/0012057300003575
13. Ar Z, Tuati AA. The Analysis of Trip Assignment of Water Trucks as Heavy Vehicles with PTV Visum. Angkasa: Jurnal Ilmiah Bidang Teknologi. 2024;16(2):103–12. https://doi.org/10.28989/angkasa.v16.i2.2007
14. Ranceva J, Ušpalytė-Vitkūnienė R. Specifics of Creating a Public Transport Demand Model for Low-Density Regions: Lithuanian Case. Sustainability. 2024;16(4):1412. https://doi.org/10.3390/su16041412
15. Azmain M, Tiwari A, Abdulaal JAE, Gbban AM. Developing a Simulation-Based Traffic Model for King Abdulaziz University Hospital, Saudi Arabia. Sustainability. 2025;17(24):10985. https://doi.org/10.3390/su172410985
16. PTV AG. PTV Visum 2020 Manual. Karlsruhe: PTV AG; 2020.
17. Badan Pusat Statistik Provinsi Jawa Barat. Provinsi Jawa Barat Dalam Angka 2018.

Bandung: BPS Provinsi Jawa Barat; 2018. Available from: https://jabar.bps.go.id/publication/2018/08/16/d8b96de222796402938666e4/provinsi-jawa-barat-dalam-angka-2018.html

18. Tamin OZ. Perencanaan dan Pemodelan Transportasi. 2nd ed. Bandung: Penerbit ITB; 2000.
19. Wardrop JG. Some Theoretical Aspects of Road Traffic Research. Proceedings of the Institution of Civil Engineers. 1952;1(3):325–62. https://doi.org/10.1680/ipeds.1952.11259
20. Yagi S, Nobel D. Remodeling Generation of Trip Activities in Search of "New" Method of Demand Forecast in Developing Countries: A Case Study of Jakarta Metropolitan Area. Journal of the Eastern Asia Society for Transportation Studies. 2017;12:616–31. https://doi.org/10.11175/easts.12.616
21. Anand A, George V. Modeling Trip-Generation and Distribution Using Census, Partially Correct Household Data, and GIS. Civil Engineering Journal. 2022;8(9):1936–57. https://doi.org/10.28991/CEJ-2022-08-09-013
22. Duraku RK, Ramadani R. Development of Traffic Volume Forecasting Using Multiple Regression Analysis and Artificial Neural Network. Civil Engineering Journal. 2019;5(8):1698–713. https://doi.org/10.28991/cej-2019-03091364
23. Mulyono T, Hadi W, Wangi IP. Distribusi Angkutan Barang Melalui Laut dengan Model Double Constraint Gravity untuk Pelabuhan Utama Antar Pulau di Indonesia Berdasarkan Data BPS. Logistik. 2025;18(2):417–29. Available from: https://journal.unj.ac.id/unj/index.php/logistik/article/view/59369
24. Nugroho TS. Perbandingan Kinerja Algoritma Modified MSA (Method of Successive Average) untuk Pembebanan Jaringan Jalan. Jurnal Transportasi. 2025;25(2):93–108. https://doi.org/10.26593/jtrans.v25i2.8603.93-108
25. Maulana A, Santoso I, Rizki M. Origin Destination Matrix Estimation for Increasing Traffic Survey Efficiency. Journal of the Eastern Asia Society for Transportation Studies. 2022;14:501–10. https://doi.org/10.11175/easts.14.501