ANALYSIS OF NATIONAL ROAD NETWORK CONNECTIVITY IN BALI PROVINCE

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ABSTRACT

Bali Province has an area of 5,636.66 km2 or 0.29% of the area of the Unitary State of the Republic of Indonesia. Transportation in the Province of Bali is quite unique because the Province of Bali is a connecting road between the islands of Java and Nusa Tenggara and there is almost no public transportation, this causes transportation in the Province of Bali to be quite busy. Bali Province consists of 57 Districts. Transportation in the Province of Bali is the lifeblood and an important part in terms of supporting development that has economic, social and strategic values which are expected to be able to provide services that benefit the wider community. In addition, transportation also greatly influences the direction of development of the Province of Bali in the future, if there are good transportation facilities and infrastructure between sub-districts, development will be faster and easier to carry out. The literature study used in the connectivity analysis in this study used the literature from Dr. Jean-Paul Rodrigue in his book which discusses Transportation and Accessibility. In the book Rodrigue (2020) mentions Accessibility is a key element in transportation geography and geography in general because it is a direct expression of mobility in terms of people, goods or information.

Keywords: connectivity; network; national roads

INTRODUCTION

Transportation has become a human need today. Transportation is a work product that can make it easier for humans to carry out their activities, this can support the development and economic development of a region. The role of transportation in developing the economy is as an activity related to increasing human needs by changing the geographic location of people and goods, apart from that, transportation is also a means of connecting to support development activities. Effective and efficient transportation is needed to support economic development and development. To support an effective and efficient transportation system, facilities, infrastructure and good management and human resources are needed so that a network of infrastructure and service networks can be formed. Therefore, feasibility studies are needed that can support each policy that will be taken.

There are four things that can be used as benchmarks in assessing transportation in an area, namely safety, security, affordability and comfort in existing transportation arrangements. This is non-negotiable because we all certainly don't want disaster to happen to ourselves and others. Bali Province has an area of 5,636.66 km2 or 0.29% of the territory of the Unitary State of the Republic of Indonesia. Transportation in Bali Province is quite unique because Bali Province is a road connecting the islands of Java and Nusa Tenggara and there is almost no public transportation, this makes transportation in Bali Province quite busy. Bali Province consists of 57 sub-districts. Transportation in Bali Province is the lifeblood and an important part of supporting development which has economic, social and strategic value which is expected to be able to provide beneficial services to the wider community. Apart from that, transportation also greatly influences the direction of future development of Bali Province. If there are good

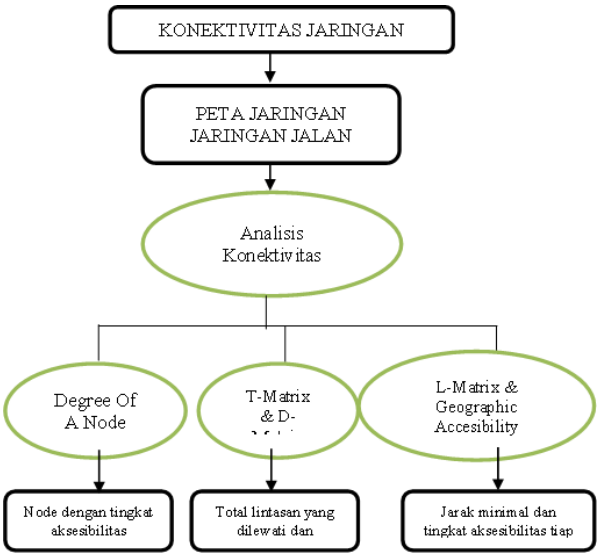
transportation facilities and infrastructure between sub-districts, development will be faster and easier to carry out.

Looking at the current transportation situation in Bali Province, it would be good for the government and transportation organizers in Bali Province to direct more studies and research into the connectivity of the existing road network on the island of Bali. Looking at the current situation and conditions that occur in Bali Province, it is very necessary to conduct a study regarding transportation connectivity problems in the area, so that solutions can be found for the various connectivity problems that occur in the area. Apart from studying, this can also help local governments find solutions to transportation problems that have occurred in Bali Province.

METHOD

Connectivity Data Analysis

The following is a thought map and the steps that will be taken to obtain research location connectivity results.



RESULTS AND DISCUSSION

National Road Network and Nodes

The National Roads in the Bali Island region are shown in Figure 1 and the determination of the node points in the province of Bali is by using the Regency Capital, Port and Airport in the Province of Bali, namely in Figure 2. Figure 2 explains the Node points used in this research, namely Regency capitals in the province of Bali, ports and airports in the province of Bali, where these nodes are the points used in the connectivity analysis that will be carried out.

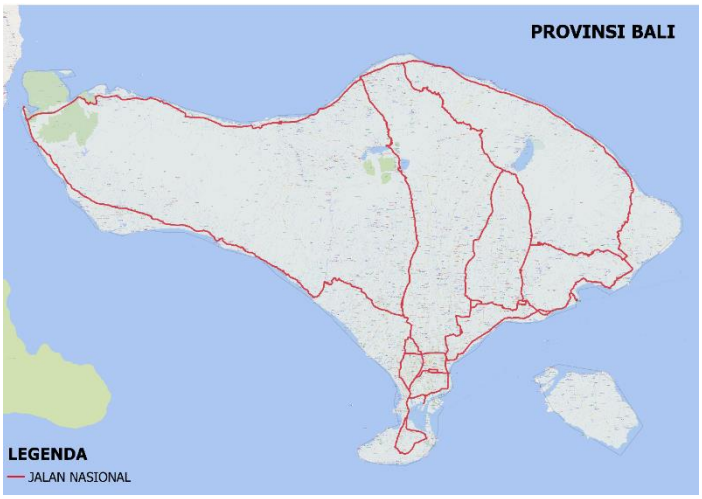


Figure 1. National Road Map of Bali Province

Figure 2. Bali Province Node Points

Analysis of Node Characteristics

Denpasar City

Denpasar is the capital of the province of Bali, Indonesia. Denpasar is the largest city in the Nusa Tenggara Islands and the second largest city in Eastern Indonesia after Makassar City. The growth of the tourism industry on the island of Bali has pushed the city of Denpasar to become a center of business activity, and placed this city as an area with high per capita income and growth in the province of Bali.

Badung regency

Badung is a district located in the province of Bali, Indonesia. This area, which also includes Kuta and Nusa Dua, is a famous tourist attraction. The capital is in Mangupura, formerly Denpasar. In 1999 there was a major riot where the Badung Regent's Office in the Lumintang area, Dauh Puri Kaja, Denpasar was burned to the ground. Now the former capital of Badung Regency has become the Sewaka Dharma Building, North Denpasar Subdistrict Office, Lumintang Square, and Denpasar City Park. Badung Regency is currently led by a Regent, currently I Nyoman Giri Prasta, and the Deputy Regent is I Ketut Suiasa. The Badung Regency Government Center which includes the regent's office, DPRD office, official offices, arts building and library is now located at the Mangupraja Mandala Government Center (Puspem) Badung Regency, in Mangupura.

Tabanan Regency
Tabanan is a district in the province of Bali, Indonesia, located about 35 km west of the city of Denpasar. Tabanan borders Buleleng Regency to the north, Badung Regency to the east, Samudra Indonesia to the south and Jembrana Regency to the west. The area of Tabanan Regency is 1,013.88 km².

Gianyar Regency
Gianyar is a district in the province of Bali, Indonesia. This area is the center of carving culture in Bali. Gianyar borders Denpasar City in the Southwest, Badung Regency in the West, Bangli Regency in the North and Klungkung Regency in the East. The population of Gianyar is 519,485 people in 2021.

Klungkung Regency
Klungkung District is a sub-district in Klungkung Regency, Bali, Indonesia. This sub-district is the smallest sub-district in the district. Its area is 20.95 km². The population is 55,141 people (2010 BPS Census).

Padangbai Harbor
Padangbai is a village in Manggis District, Karangasem Regency, on the east side of Bali Island, Indonesia. This city is a ferry port for shipping to Lombok Island, Nusa Penida, Gili Islands and other islands in West Nusa Tenggara. During the Kusamba war in 1849 it was better known as Teluk Labuhan Amuk. Apart from being a port city, this city also offers tourists the life of a beautiful and calm small beach town in the form of a bay where to the east there is a promontory called Tanjung Sari whose name is taken from the name of a sacred place of Empu Bharadah's temple of worship called Pura Tanjung Sari. Apart from the main white sand beach, there are also 2 other white sand beaches, namely Padang Kurungan beach to the east and Bias Tugel beach to the west. Padang Kurungan Beach is a beautiful beach which is famous for its underwater beauty which is dominated by colorful ornamental fish and soft coral and the presence of a blue lagoon in the middle of its beautiful beach so this beach is often also called the blue lagoon beach. Meanwhile, Bias Tugel beach (White Sand Beach), which is located to the west of Padangbai's main beach, is famous for its beauty because of its wide spread white sand and clear, blue sea.

Karangasem Port
Karangasem is a sub-district in Karangasem Regency, Bali Province, Indonesia. This sub-district is about 65 km from Denpasar City. Amlapura, which is the capital of Karangasem Regency, is in this sub-district. The area of Karangasem District is 94.23 km² with a population of 97,584 people in 2016.

Benoa Harbor
Benoa Harbor is a port in Denpasar City, Bali Province, Indonesia. This port is the entrance to Denpasar City by sea.

Ngurah Rai Airport
I Gusti Ngurah Rai International Airport (English: I Gusti Ngurah Rai International Airport), is an international airport located in the south of Bali, Indonesia, precisely in the Tuban Village area, Kuta District, Badung Regency, Bali, about 13 km from Denpasar. Ngurah Rai

International Airport is the second busiest airport in Indonesia, after Soekarno-Hatta International Airport.

Bangli Regency

Bangli is a district located in the province of Bali, Indonesia. Bangli Regency is the only district in Bali province that does not have a sea area or borders the sea, so Bangli does not have a beach by the sea. Bangli Regency borders Buleleng Regency to the North, Klungkung and Karangasem Regency to the East, and Klungkung, Gianyar Regency to the South and Badung and Gianyar Regency to the West. In 2021, Bangli has an area of 519,00 km², with a population of 254,738 people. Tourist attractions in this area include Lake Batur. The capital is in Bangli district.

Bangli Regency

Singaraja is the capital of Buleleng district, Bali, Indonesia. In the past, Singaraja was the capital of the Kingdom of Buleleng, and was also the capital of the Lesser Sunda Islands Province, until later it became the capital of Bali Province, before in 1958, the capital of Bali Province was moved from Singaraja to Denpasar. The atmosphere on Jl. Diponegoro, Singaraja. Its area is 27.98 km² and its population is 80,500 people. The population density is 2877 people/km².

Bangli Regency

Jembrana is a district located at the western tip of the island of Bali, Indonesia. The capital is in Negara sub-district. This district borders Tabanan Regency in the East, Buleleng Regency in the North, the Bali Strait in the West and the Indian Ocean in the South. In 2021, the population of Jembrana district will be 321,931 people.

Gilimanuk Harbor

Gilimanuk is a sub-district in Melaya sub-district, Jembrana Regency, Bali, Indonesia. In this sub-district there is Gilimanuk Harbor which serves ferry crossings to Ketapang Harbor, East Java. In this area there is also a bay called Karang Sewu. There is a dragon monument called Gelungkori.

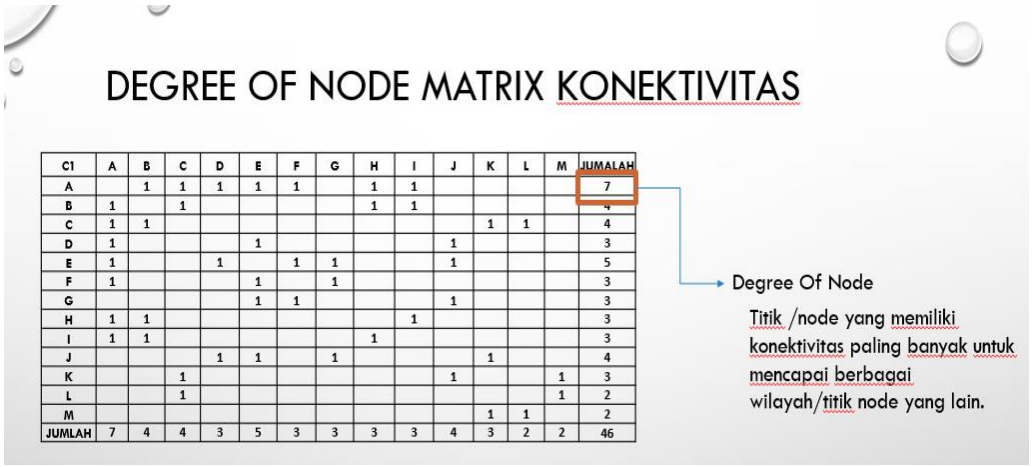
Connectivity Analysis

The basic measure of accessibility measurement is “network connectivity”, where the network is represented as a “connectivity matrix” and is given the symbol C1. There are five connectivity matrix analyzes used in this research, namely: degree of a node, total accessibility matrix (T), shimbel distance matrix (D-Matrix), valued graph matrix (L-Matrix) and geographic accessibility (A(G)).

The meaning of each analysis above is as follows:

Degree of a node

This analysis is carried out to find nodes with the highest level of accessibility. This node is also a node that is in a central location in the network. The results of this degree of node analysis are used to find out how far away each warehouse is from the node with the highest accessibility in each business network. The measure used is the standard deviation value.



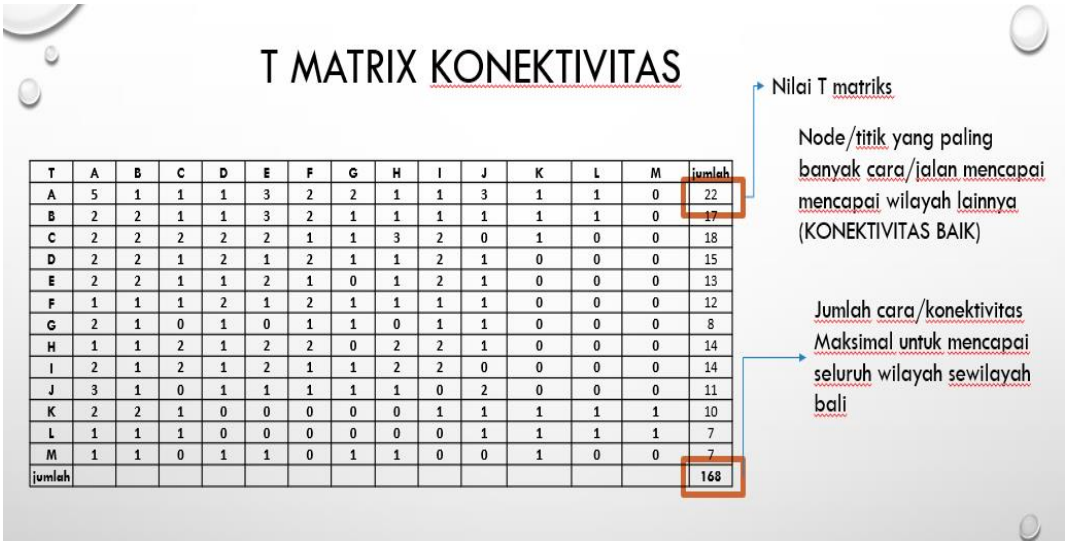
CI	A	B	C	D	E	F	G	H	I	J	K	L	M	JUMALAH
A		1	1	1	1	1		1	1					7
B	1		1					1	1					
C	1	1									1	1		4
D	1				1					1				3
E	1			1		1	1			1				5
F	1				1		1							3
G					1	1				1				3
H	1	1							1					3
I	1	1						1						3
J				1	1		1				1			4
K			1							1			1	3
L			1										1	2
M											1	1		2
JUMLAH	7	4	4	3	5	3	3	3	3	4	3	2	2	46

Figure 3. Degree Of Node

Figure 3 Explains the Degree of Node connectivity of Bali Island Province, located at Point A (Denpasar City) which has the most connectivity to reach/reach other areas (node points).

Total accessibility matrix (T)

This analysis is used to calculate the total number of paths in the network, which includes the direct distance between nodes.



T	A	B	C	D	E	F	G	H	I	J	K	L	M	jumlah
A	5	1	1	1	3	2	2	1	1	3	1	1	0	22
B	2	2	1	1	3	2	1	1	1	1	1	1	0	17
C	2	2	2	2	2	1	1	3	2	0	1	0	0	18
D	2	2	1	2	1	2	1	1	2	1	0	0	0	15
E	2	2	1	1	2	1	0	1	2	1	0	0	0	13
F	1	1	1	2	1	2	1	1	1	1	0	0	0	12
G	2	1	0	1	0	1	1	0	1	1	0	0	0	8
H	1	1	2	1	2	2	0	2	2	1	0	0	0	14
I	2	1	2	1	2	1	1	2	2	0	0	0	0	14
J	3	1	0	1	1	1	1	1	0	2	0	0	0	11
K	2	2	1	0	0	0	0	0	1	1	1	1	1	10
L	1	1	1	0	0	0	0	0	0	1	1	1	1	7
M	1	1	0	1	1	0	1	1	0	0	1	0	0	7
jumlah														168

Figure 4. T-Matrix

Figure 4 explains that the T matrix value shows that point A (Denpasar city) is the point with the most ways to reach other areas and it can be concluded that point A has the best T matrix connectivity. The maximum number of ways/connectivity of the T matrix to reach various points throughout the region in Bali Province is 168 ways.

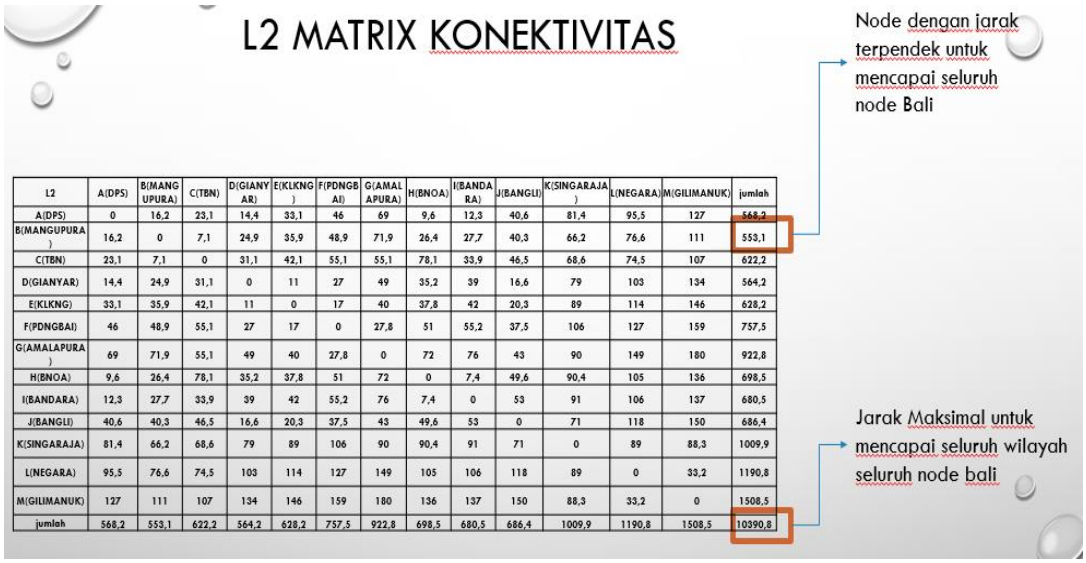
Shimbel distance matrix (D-Matrix)

This analysis is to find the total number of shortest paths between nodes in the network. The node with the fewest number of shortest paths is the easiest to access.

D2	A	B	C	D	E	F	G	H	I	J	K	L	M	jumlah
A		1	1	1	1	1		1	1					7
B	1		1					1	1					4
C	1	1									1	1		4
D	1				1					1				3
E	1			1		1	1			1				5
F	1				1		1							3
G					1	1				1				3
H	1	1							1					3
I	1	1						1						3
J				1	1		1				1			4
K			1							1			1	3
L			1										1	2
M											1	1		2
jumlah	7	4	4	3	5	3	3	3	3	4	3	2	2	46

Figure 5. D-Matrix

Figure 5 above explains that the minimum number of ways/connectivity to reach all areas of Bali is 46 ways. Point A (Denpasar City) has 7 connectivity branches to reach all areas in Bali Province, Point A has good connectivity conditions. Valued graph matrix (L-Matrix)Analisis ini dilakukan untuk mengetahui jarak minimal yang diperlukan sebuah *node* untuk mencapai *node* lainnya di dalam jaringan.



L2	A(DPS)	B(MANGUPURA)	C(TBN)	D(GIANYAR)	E(KLKNG)	F(PDNGBAI)	G(AMALAPURA)	H(BNOA)	I(BANDARA)	J(BANGLI)	K(SINGARAJA)	L(NEGARA)	M(GILIMANUK)	jumlah
A(DPS)	0	16,2	23,1	14,4	33,1	46	69	9,6	12,3	40,6	81,4	95,5	127	568,2
B(MANGUPURA)	16,2	0	7,1	24,9	35,9	48,9	71,9	26,4	27,7	40,3	66,2	76,6	111	553,1
C(TBN)	23,1	7,1	0	31,1	42,1	55,1	55,1	78,1	33,9	46,5	68,6	74,5	107	622,2
D(GIANYAR)	14,4	24,9	31,1	0	11	27	49	35,2	39	16,6	79	103	134	564,2
E(KLKNG)	33,1	35,9	42,1	11	0	17	40	37,8	42	20,3	89	114	146	628,2
F(PDNGBAI)	46	48,9	55,1	27	17	0	27,8	51	55,2	37,5	106	127	159	757,5
G(AMALAPURA)	69	71,9	55,1	49	40	27,8	0	72	76	43	90	149	180	922,8
H(BNOA)	9,6	26,4	78,1	35,2	37,8	51	72	0	7,4	49,6	90,4	105	136	698,5
I(BANDARA)	12,3	27,7	33,9	39	42	55,2	76	7,4	0	53	91	106	137	680,5
J(BANGLI)	40,6	40,3	46,5	16,6	20,3	37,5	43	49,6	53	0	71	118	150	686,4
K(SINGARAJA)	81,4	66,2	68,6	79	89	106	90	90,4	91	71	0	89	88,3	1009,9
L(NEGARA)	95,5	76,6	74,5	103	114	127	149	105	106	118	89	0	33,2	1190,8
M(GILIMANUK)	127	111	107	134	146	159	180	136	137	150	88,3	33,2	0	1508,5
jumlah	568,2	553,1	622,2	564,2	628,2	757,5	922,8	698,5	680,5	686,4	1009,9	1190,8	1508,5	10390,8

Figure 6. L2-Matrix

Figure 6 explains that point B (Badung) has the shortest distance to reach all nodes in Bali Province with a value of 553.1 Km. The maximum distance to reach all areas/nodes of Bali Province is 10390.8 KM.

Geographic accessibility (A(G))

This analysis considers that the accessibility of a location is the sum of all distances between locations, divided by the number of locations. The lower the value of each node, the higher its accessibility.

G	A(DPS)	B(MANGUPURA)	C(TBN)	D(GIANYAR)	E(KLKNG)	F(PDNGBAI)	G(AMALAPURA)	H(BNOA)	I(BANDARA)	J(BANGLI)	K(SINGARAJA)	L(NEGARA)	M(GILIMANUK)	Σ/n
A(DPS)	0	16,2	23,1	14,4	33,1	46	69	9,6	12,3	40,6	81,4	95,5	127	35,5125
B(MANGUPURA)	16,2	0	7,1	24,9	35,9	48,9	71,9	26,4	27,7	40,3	66,2	76,6	111	34,56875
C(TBN)	23,1	7,1	0	31,1	42,1	55,1	55,1	78,1	33,9	46,5	68,6	74,5	107	38,8875
D(GIANY														

Gambar 7. L2-Matrix

Figure 7 above explains that the geographic value, namely the total distance between nodes in all regions in Bali, is 649,425. From the results of the Connectivity Analysis carried out, point A (Denpasar city) has a good Connectivity value where the value of Degree Of Node is the largest of all the points that have been analyzed, namely with a value of 7. Point A has a good T-Matrix value where Point A has maximum connectivity to reach all 12 nodes in 22 ways. Point A also has a good D2 matrix value where point A has minimum connectivity to reach 12 other node points in 7 ways. Point A has the total distance to reach all node points with the second best ranking after Point B (Badung) where this result includes the best connectivity value, namely 568.2 KM. Point A in the Geographic Accessibility analysis (comparison of the overall distance with the number of existing nodes) shows the location that has the 2nd best accessibility after Point B (Badung), namely with a value of 35.5.

CONCLUSION

Determining the node points in Bali Province, namely using the Regency Capital, Port and Airport in Bali Province. From the results of the Connectivity Analysis carried out, point A (Denpasar city) has a good Connectivity value where the value of Degree Of Node is the greatest of all the points that have been analyzed with a value of 7. Point A has a good T-Matrix value where point A has maximum connectivity to reach all 12 node points in 22 ways. Point A also has a good D2 matrix value where point A has minimum connectivity to reach 12 other node points in 7 ways. Point A has the total distance to reach all node points with the second best ranking after Point B (Badung) where this result includes the best connectivity value, namely 568.2 KM. Point A in the Geographic Accessibility analysis (comparison of the overall distance with the number of existing nodes) shows the location that has the 2nd best accessibility after Point B (Badung), namely with a value of 35.5.

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