Research article

Network Analysis for Village Adat at Badung

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Abstract

Badung regency of Bali Province is one of the most popular tourist destinations that offers natural beauty and cultural wealth that attracts local and foreign tourists. One of the main attractions in this area is the traditional tourism village, whose management is guided by Bali provincial regulation No. 4 year 2019 about Indigenous villages. There are 17 traditional tourism villages that have their own uniqueness and 3 of them are leading traditional villages, namely Munggu, Sangeh, and Mengwi villages based on the highest number of visits. This study aims to determine the distribution pattern of traditional tourism villages and in Bandung Regency and find out the fastest route to 3 leading tourism villages, namely Munggu Village, Sangeh Village, and Mengwi Village. This research uses network analysis and Average Nearest neighbor (ANN) method. This study is expected to provide recommendations for the government and stakeholders in optimizing the tourism road network and supporting the development of sustainable culture-based tourism villages for the welfare of local communities.

Keywords: tradisional tourist village, road network analysis, average nearest neighbour

1. Introduction

Badung Regency is one of the regions in Bali Province that plays a strategic role in the tourism industry, which is a destination for tourists to enjoy its beauty, both natural beauty such as beaches, agricultural areas, fisheries, and marine life, as well as cultural beauty. The tourism sector is the main source of income for Badung Regency, and most of the community's economy is growing rapidly in line with the development of tourism (Swastika et al., 2017). One of the tourist attractions in Badung Regency is the traditional tourist village.

A traditional village is a customary law community that has original rights, traditional rights, and original autonomy rights to govern its own territory. It is recognized by the Republic of Indonesia and its existence is confirmed by Bali Provincial Regulation No. 4 of 2019 concerning Traditional Villages in Bali. Traditional villages in Bali have legal subject status in the government structure and their position is stated in Bali Provincial Regulation Articles 4 and 5 of 2019.

Traditional Tourism Villages in Bali, especially in Badung Regency, adhere closely to Tri Hita Karana, which is derived from six local wisdom values of prosperity and happiness, namely: purification of the soul (atma kerthi), purification of the sea (segara kerthi), purification of water sources (danu kerthi) (4), purification of plants (wana kerthi), purification of humans (jana kerthi), and purification of the universe (jagat kerthi) (PRATHAMA, 2022). Traditions, customary laws, and local wisdom in the traditional villages of Badung Regency, Bali Province, continue to be preserved. In addition, the traditional tourist villages in Badung Regency have regulations that are enforced by the community and monitored by the pecalang. Traditional villages are attractive to visit not only because of their natural beauty but also because of their well-preserved culture, the hospitality of the community, and their religious purposes. Traditional tourist villages are also targeted by the government to become sustainable tourism destinations.

In order to support the development of sustainable tourism, the Badung Regency Government has initiated and implemented the Tourism Village concept through Badung Regent Regulation No. 22 of 2021 concerning the Establishment of Tourism Village Areas in Badung Regency. The existence of these traditional villages is an example of how the government plays an active role in preserving and maintaining existing traditions and customs. To date, there are 17 tourism villages located in North Badung (Petang District) and Central Badung (Mengwi and Abiansemal Districts).

The 17 Traditional Tourism Villages scattered throughout Badung Regency each have their own characteristics and beauty, making them attractive to visit, namely: Munggu Village, Bongkasa

Pertiwi Village, Sangeh Village, Carangsari Village, Petang Village, Pelaga Village, Belok Village, Mengwi Village, Pangsan Village, Kapal Village, Penarungan Village, Abiansemal Village, Kuwum Village, Bongkasa Village, Sobangan Village, and Cemagi Village. According to data from the Tourism Office (2022), of the 17 Traditional Tourism Villages in Badung Regency, there are 3 leading traditional tourism villages that are most visited, namely Sangeh Village, Munggu Village, and Mengwi Village. Munggu Village has a total of 27,788 visitors per day, Sangeh Village has a total of 13,981 visitors per day, and Mengwi Village has 5,275 visitors per day. Meanwhile, the average total number of visitors to the 17 traditional tourism villages per day is 3,025.

Munggu Village is the most visited tourist destination because of its prominent cultural attractions, namely the ngerebek or mekotek tradition. This tradition is, of course, an ancestral heritage that has been passed down from generation to generation to pray for safety and ward off evil spirits. The distinctive feature of the mekotek tradition is the use of long sticks arranged in a pyramid shape, accompanied by Baleganjur gamelan music throughout the tradition. Sangeh Village is famous for its nutmeg forest with monkeys and the sacred area of Pura Pucak Sari. This homogeneous nutmeg forest park, inhabited by hundreds of monkeys, became the first monkey forest to be developed as a tourist forest in Bali. Meanwhile, Mengwi Village is famous for having been the center of the Mengwi Kingdom. The Mengwi Kingdom itself was a large kingdom that reached its heyday in the Middle Bali era. This kingdom is known for its strong spiritual history, first established by I Gusti Agung Putu as the first king of the Mengwi Kingdom. Apart from being three leading traditional villages with their own history and characteristics, another reason tourists tend to visit these three tourist attractions is because the other 14 Traditional Tourism Villages are less well known, the roads are not very strategic, and the location of the traditional villages is not very strategic as they are not close to other tourist attractions. The benchmark for the success of tourism development can be seen from the total number of tourist visits, both domestic and foreign tourists.

The high interest in visiting the three traditional tourist villages (Munggu, Sangeh, and Mengwi) has resulted in congested roads connecting to these traditional villages. Therefore, a road network analysis using the analysis network method is needed to determine the fastest route to the three leading traditional tourist villages from I Gusti Ngurah Rai Airport and Mengwi Terminal, as well as the average nearest neighbor (ANN) method to determine the distribution pattern of traditional tourist villages in Badung Regency in 2025. The results of this study are expected to provide a real contribution to tourists in determining the fastest route and helping to optimize travel time to the three leading traditional tourist villages within a period of one day.

2. Research Methods

This study was conducted to analyze the transportation network connecting various tourist attractions in traditional villages in Badung Regency. The methods used in this study consisted of several stages, namely data collection, spatial analysis, and visualization of results.

The first stage was data collection, which included data on the location of traditional village tourist attractions, transportation network data, and data on distances and routes for various modes of transportation, such as terminals and airports to leading villages. The research data required was a combination of primary and secondary data obtained through field surveys, secondary data from relevant agencies, and the use of geographic information system (GIS) technology. The secondary data required includes the number of traditional villages and tourist visits in Badung Regency, the location of traditional tourist villages in Badung Regency, and the number of public transportation facilities in Badung Regency. Data on visits to traditional tourist villages was obtained from the Badung Regency Tourism Office in 2022, while data on the coordinates of traditional tourist villages was obtained from Google Earth software.

Furthermore, spatial analysis was conducted using the Analysis Network method to evaluate the connectivity between tourist locations and available transportation infrastructure. This analysis includes calculating the fastest route from the terminal and airport to the featured villages and calculating the closest distance between tourist attractions. Average Nearest Neighbor (ANN) is a statistical method that can be used to analyze the spatial distribution pattern of feature points within an area. This method can also be used to measure the observed average distance with the expected average distance if the distribution of points is random. The results of the analysis using this method can show whether the distribution pattern tends to be clustered, scattered, or random (Handayani et al., 2021). The Analysis Nearest Neighbor (ANN) method was applied to

understand the distribution pattern of objects in the Badung Regency's Leading Traditional Tourism Village.

The final stage was the visualization of the results, which was done by presenting the data in the form of thematic maps, histograms, and tables. The maps produced include a map of the distribution of tourist attractions, a map of the fastest routes from the airport and terminal to the leading villages, and a table of distances between tourist attractions. The results of this visualization aim to provide a clearer picture of the accessibility and efficiency of transportation routes that can be used for tourism development in the traditional villages of Badung Regency.

3. Results and Discussion

This study produced several results, such as the Average Nearest Neighbor histogram, the distribution of tourism data in Badung Regency, and the coverage route using the Network Analysis method. The first result is the histogram and table of the Average Nearest Neighbor processing results.
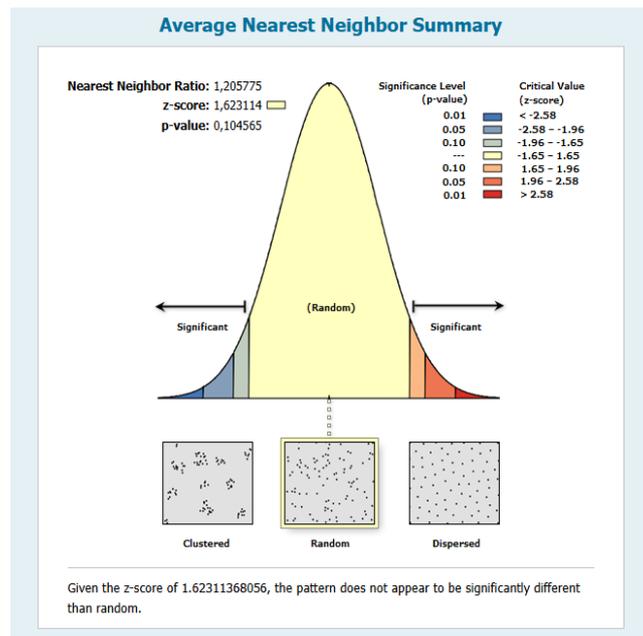

Figure 1. Histogram

Average Nearest Neighbor Summary

Observed Mean Distance:	2859,2863 Meters
Expected Mean Distance:	2371,3256 Meters
Nearest Neighbor Ratio:	1,205775
z-score:	1,623114
p-value:	0,104565

Figure 2. Result of Average Nearest Neighbour Summary

Spatial analysis of the distribution of traditional tourist villages in Badung Regency shows a random pattern. This conclusion is based on the results of the Average Nearest Neighbor (ANN) calculation implemented using ArcGIS 10.8 software. The calculation produced a T index value of 1.205, which statistically classifies the distribution pattern as random. This random pattern indicates that the locations of traditional tourist villages are scattered without following a structured clustering or dispersed pattern. The implications of this random distribution pattern are quite significant for tourism management and promotion strategies in Badung Regency.

One implication is the need to improve infrastructure efficiency and accessibility. Because tourist villages are not concentrated in one area, tourism managers need to ensure good connectivity between locations. This may include road improvements, the provision of adequate public transportation, and clear information about routes and access to each village. In addition, promotional strategies can be focused on areas with a higher concentration of traditional tourist villages or on villages that have outstanding tourist attractions. By focusing promotion on these

strategic points, it is hoped that a domino effect will be created that attracts tourists to visit other villages in the surrounding area.

Furthermore, tourism managers can design tourist routes that connect culturally significant villages that are geographically close to each other. These routes can offer a more comprehensive tourist experience and encourage tourists to explore a wider area. This also has the potential to reduce the concentration of visitors in one particular location, which can prevent overtourism and its negative impacts on the environment and local communities.

However, effective management is essential to ensure the sustainability of the natural and cultural resources that are the main attractions of tourist villages. Good management must also ensure that the economic benefits of tourism are distributed evenly to the local community. Without proper management, the concentration of visitors in certain areas has the potential to cause various problems, such as environmental damage, negative socio-cultural changes, and inequality in income distribution. Therefore, a careful analysis of this random distribution pattern is necessary to support sustainable tourism development and provide equitable benefits to all stakeholders in Badung Regency. The next result is the distribution of tourist villages in Badung Regency.
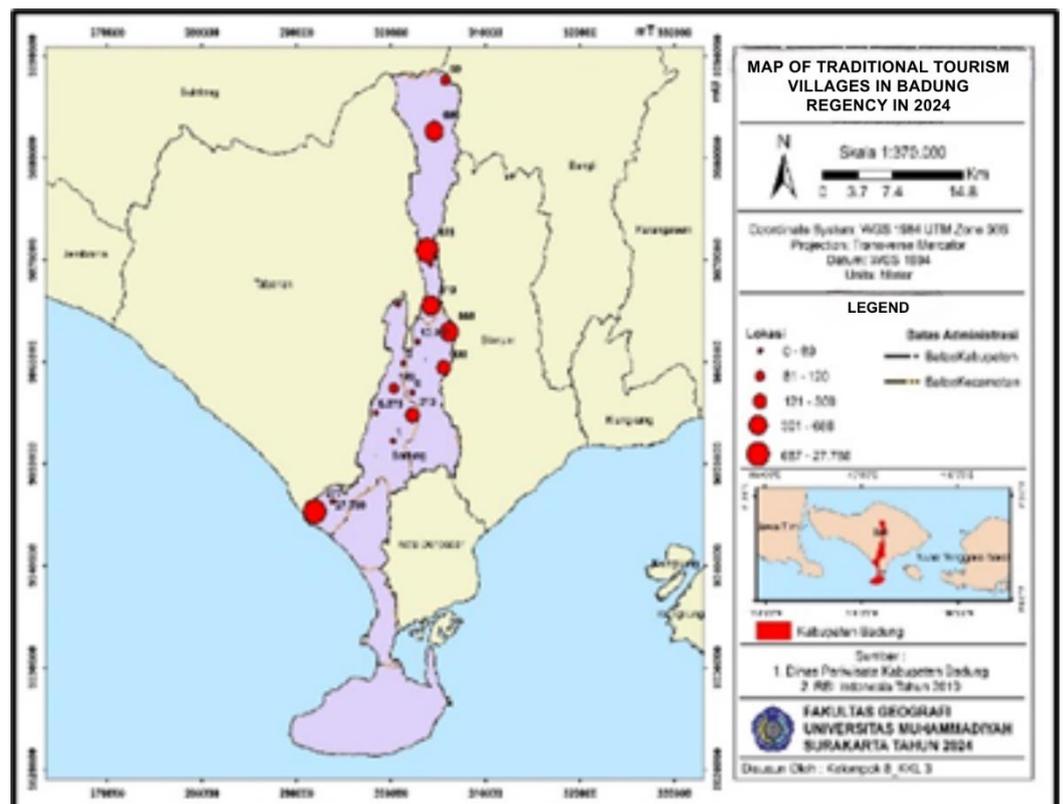

Figure 3. Map of Tradisional Tourism Vilages in Badung Regency in 2024

Table 1. Tourism Village Visitor Data In Badung Regency As Of March 2022

No	Tourism Villages	Visitors
1	Munggu Village	27.788
2	Baha Village	120
3	Bongkasa Pertiwi Village	558
4	Sangeh Village	13.981
5	Carangsari Village	619
6	Petang Village	828
7	Pelaga Village	686
8	Belok Village	80
9	Mengwi Village	5.275
10	Pangsan Village	0
11	Kapal Village	1
12	Penarugan Village	213
13	Abiansemal Dauh Yeh Cani Village	0

No	Tourism Villages	Visitors
14	Kuwum Village	0
15	Bongkasa Village	300
16	Sobangan Village	0
17	Cemagi Village	977
	Total Visitors	**51.426**

Based on an analysis of the distribution map of traditional tourist villages in Badung Regency, there are 17 traditional tourist villages spread across various regions. Each village has a varying number of tourist visits, ranging from villages with low visitor numbers to villages that have successfully attracted large numbers of tourists. According to data on tourist village visits in Badung Regency as of March 2022, there are three villages that stand out with the highest visitation rates, namely Munggu Tourist Village with 27,788 visitors, Sangeh Tourist Village with 13,981 visitors, and Mengwi Tourist Village with 5,275 visitors. These three villages are considered leading destinations in Badung Regency because each has its own unique appeal. These attractions include authentic cultural richness, stunning natural beauty, and tourist facilities that support visitor comfort. In addition to being favorite destinations individually, these three villages also have great potential to complement each other as part of an integrated tourist route. Collaboration between these villages can provide a richer and more varied experience for tourists, thereby strengthening Badung Regency's position as one of the main tourist destinations in Bali. The following results are from the Network analysis method, namely the Fastest Route for each Mode of Transportation (Terminal and Airport).
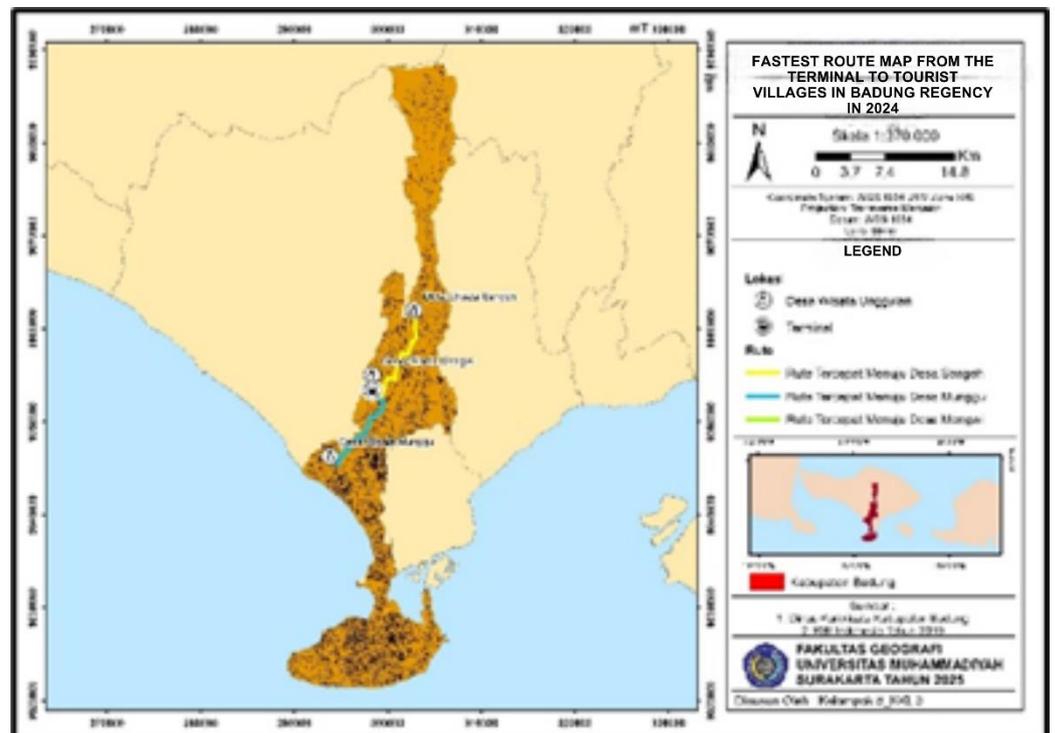

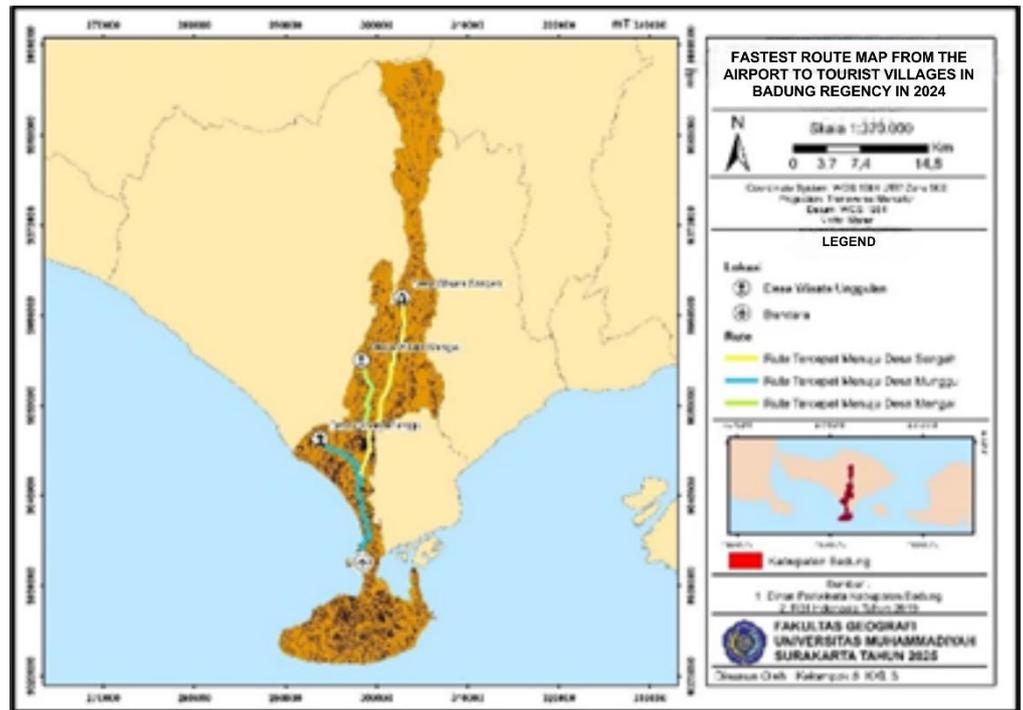**Figure 4**. Fastest Route Map from The Terminal to Tourist Villages in Badung Regency in 2024

Figure 5. Fastest Route Map from The Airport to Tourism Villages in Badung Regency in 2024

The route determination results are presented based on the minimum travel time estimate using Network Analyst in the ArcGIS application, which provides information on the fastest route to the Tourist Village in Badung Regency. The distance from the Terminal to Sangeh with the best and fastest route is 13,200 meters, which can be covered in 12 minutes at an average speed of 1,100 m/s, demonstrating high efficiency thanks to good road conditions and minimal obstacles. The route from the Terminal to Munggu, with a distance of 9,700 meters, takes 18 minutes at a speed of 539 m/s. Although the travel time is longer than the distance, this route is the most efficient. The distance between the Terminal and Mengwi is the least efficient, with a distance of 3,100 meters covered in 7 minutes at a speed of 443 m/s, indicating suboptimal road conditions.

The journey from the airport to Sangeh is the most efficient route, with a distance of 35,100 meters covered in 70 minutes at an average speed of 501 m/s. Despite having the longest distance, the proportional travel time indicates that this route is supported by good road conditions and minimal obstacles. The route from the airport to Mengwi, with a distance of 29,400 meters covered in 63 minutes at a speed of 467 m/s, demonstrates the efficiency of the travel route. Meanwhile, the route from the airport to Munggu, despite having the shortest distance of 20,300 meters with a travel time of 57 minutes at a speed of 356 m/s, is still efficient because the travel time is proportional to the distance. Overall, all these routes are efficient in supporting the transportation network connectivity in the Traditional Villages of Badung Regency. The next result is the Network Analysis method, namely the Fastest Route to the Leading Tourism Traditional Villages from Transportation Facilities in Badung Regency.
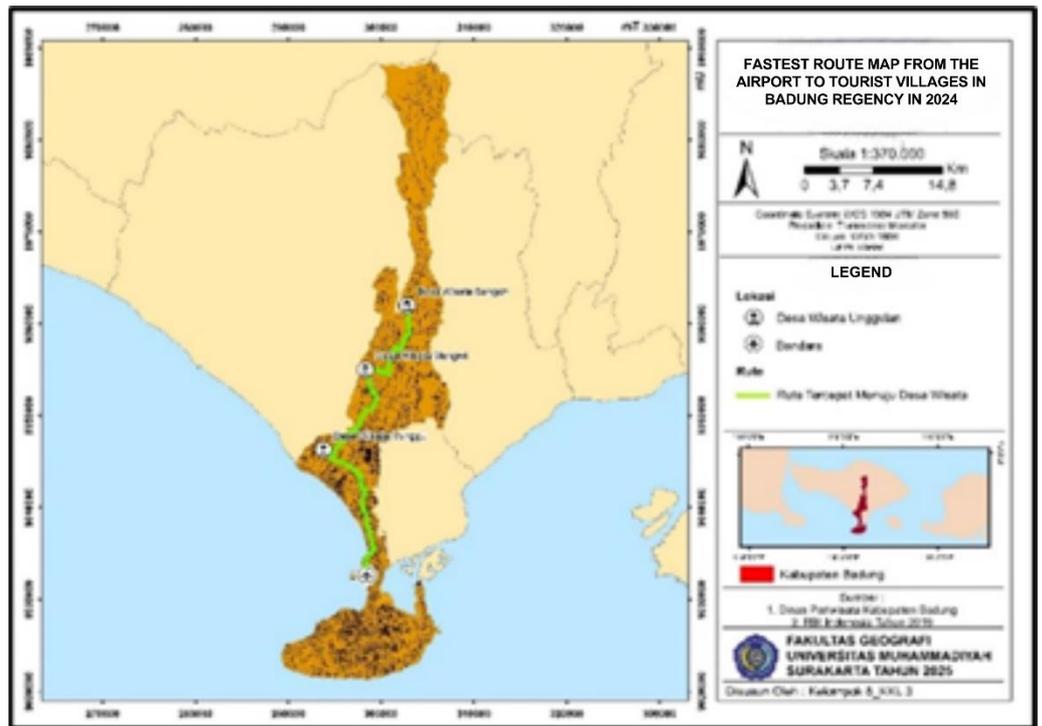
Figure 6. Fastest Route Map from The Airport to Tourism Village in Badung in 2024
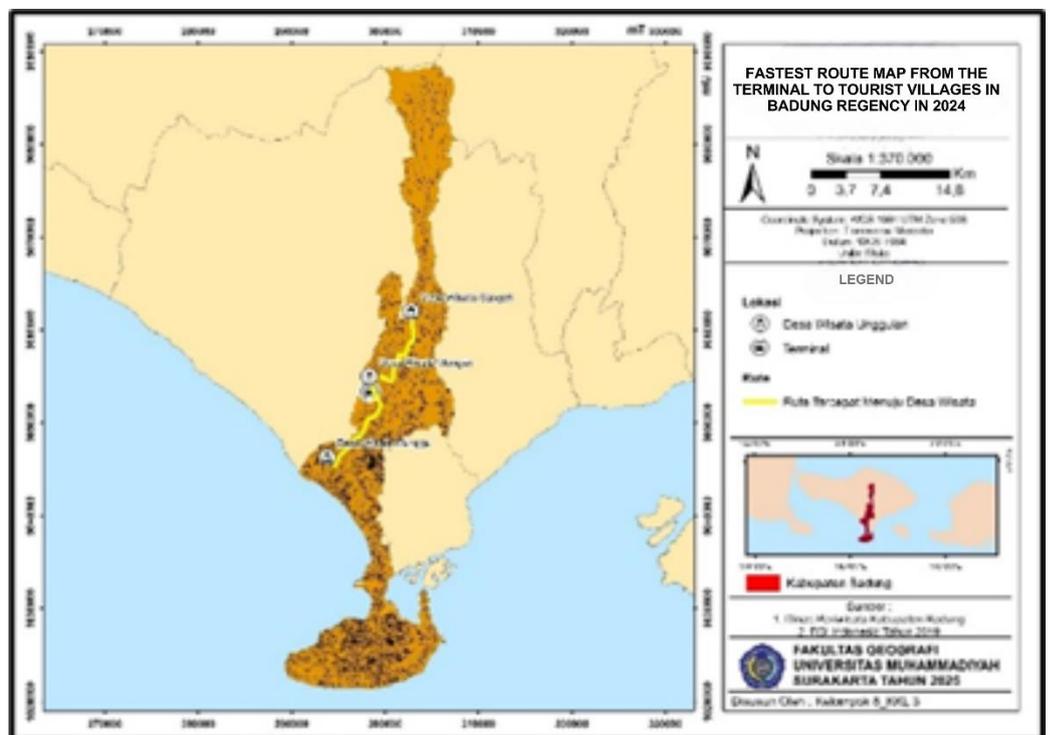

Figure 7. Fastest Route Map from The Terminal to Tourist Village in Badung Regency in 2024

Network analysis of the route from the airport to Sangeh via Munggu and Mengwi shows that the connectivity between nodes in this transportation network has linear characteristics with a total distance of 42,700 meters and a total travel time of 98 minutes. From the calculation of the average speed on each segment, the route from the airport to Munggu has the lowest speed of 35.6 m/second, while the segment from Munggu to Mengwi shows an increase in speed to 51.8 m/second, and the last segment from Mengwi to Sangeh has the highest speed, which is 57.9 m/second. Based on connectivity analysis, the Mengwi node plays an important role in the network with the highest betweenness value, effectively connecting the airport and Sangeh. The fastest route overall is dominated by the Mengwi to Sangeh segment, which offers the best time efficiency.

Network analysis of the route from the Terminal to Sangeh via Munggu and Mengwi shows that this transportation network has a linear structure with a total distance of 32,100 meters and a total travel time of 58 minutes. Of each travel segment, the Terminal to Munggu segment has the highest average speed of 539 m/minute, followed by the Mengwi to Sangeh segment with a speed of 611 m/minute, which is the fastest segment in this network. Meanwhile, the Munggu to Mengwi segment has the lowest average speed of 518 m/minute, with a travel time of 22 minutes.

In terms of connectivity, the structure of the road network between traditional villages in Badung Regency allows for more efficient travel for visitors, with a total travel time of 2 hours and 32 minutes from both the airport and the terminal, providing flexibility for visitors with limited schedules. For visitors who only have one day, this route is quite optimal, with a focus on utilizing the fastest routes, such as Mengwi to Sangeh, to save travel time and extend exploration time at tourist destinations. Based on the network analyst and average nearest neighbor analysis of the three leading traditional tourist villages, namely Munggu Village, Sangeh Village, and Mengwi Village, they can be visited within a day via the best/fastest route.

3. Conclussion

Based on calculations using the Average Nearest Neighbor (ANN) method, the distribution of Traditional Tourism Villages in Badung Regency has a random distribution pattern with a T-index of 1.205. This random distribution pattern has significant implications for tourism management strategies, especially in terms of improving infrastructure and accessibility connecting scattered tourism villages. Promotional strategies should also focus on major tourism villages such as Munggu, Sangeh, and Mengwi, which have unique attractions and high visitor numbers. In addition, it is possible for villages to collaborate in the form of integrated tourist routes in order to provide a more attractive tourist experience and reduce the excessive density of tourists in these areas. Good management should ensure environmental and cultural sustainability, as well as equitable economic benefits for the local community, thereby supporting sustainable tourism development in Badung Regency.

The results of the analysis of routes to tourist villages in Badung Regency based on minimum travel time estimates show varying levels of efficiency. The route from the Terminal to Sangeh Village is the most efficient route (13,200 meters, 12 minutes, 1,100 m/s), supported by good road conditions. Then, the route from the Terminal to Munggu can be considered efficient, namely (9,700 meters, 18 minutes, 539 m/s), even though the travel time is relatively longer. Conversely, the route from the Terminal to Mengwi is a less efficient route due to suboptimal road conditions, resulting in a route of (3,100 meters, 7 minutes, 443 m/s). The routes from the airport to the villages of Sangeh, Munggu, and Mengwi, which are accessible in their entirety, indicate that the transportation network connectivity in Badung Regency supports optimal mobility to tourist villages and contributes positively to tourism.

Furthermore, based on the transportation network analysis of the routes from the airport and terminal to Sangeh via Munggu and Mengwi, the linear network structure is efficient. The route from the airport to Sangeh covers a distance of 42,700 meters in 98 minutes, with the Mengwi to Sangeh segment being the fastest (57.9 m/second), while the airport to Munggu segment has the lowest speed (35.6 m/second). Mengwi plays a strategic role as the main connector with the highest betweenness value, which strengthens connectivity between nodes. The route from the Terminal to Sangeh covers a distance of 32,100 meters in 58 minutes, with the Mengwi to Sangeh segment being the fastest (611 m/minute). This network structure supports efficient travel, provides flexibility for tourists with limited schedules, and allows for longer exploration of tourist destinations through the optimization of the fastest segments.

Author Contributions

Conceptualization: Selebeting Probo Pamungkas, Imam Mu'tamad, Lutfi Ardiansyah; **methodology**: Bintang Bezopanosti Islam, Dwi Aprian Sugiarta, Hanif Fadhilah Rahmadhani; **investigation**: Bayu Aji Saputra, Ratna Alya Diani; **writing—original draft preparation**: Arifah Dien Ramadhani, Nur Uswatun Hasanah; **writing—review and editing**: Natalia Maharjanti; **visualization**: Octaniana Lestyan Saputri.. All authors have read and agreed to the published version of the manuscript.

Conflict of interest

All authors declare that they have no conflicts of interest.

References

Handayani, A. P., Deliar, A., & Abdulharis, R. (n.d.). Pola Spasial Harga Tanah untuk Perencanaan Strategis dalam Perspektif Pembangunan Berkelanjutan (Studi Kasus: Kota Bandung, Jawa Barat, Indonesia).

Jayanti, N. P. (2019). Pengembangan Objek Wisata Pantai Gandoriah Kota Pariaman. *(Development of Gandoriah Beach Tourist Attraction in Pariaman City).* Jurnal Pariwisata, 6(2), 141–146. https://doi.org/10.31311/par.v6i2.5691

Pemerintah Daerah Provinsi Bali. (2019). Peraturan Daerah Provinsi Bali Nomor 4 Tahun 2019 Tentang Desa Adat di Bali. Bali.

Pemerintah Pusat. (2014). Undang-undang (UU) Nomor 6 Tahun 2014 tentang Desa. Jakarta.

Pemerintah Pusat. (2009). Undang-undang (UU) Nomor 10 Tahun 2009 tentang Kepariwisataan. Jakarta.

Pemerintah Pusat. 2004. Undang-undang (UU) Nomor 32 Tahun 2004 tentang Pemerintahan Daerah. Jakarta.

PRATHAMA, A. A. G. A. I. (2022). Desa Adat Sebagai Subyek Hukum Dalam Struktur Pemerintahan Provinsi Bali.*(Traditional Villages as Legal Subjects in the Provincial Government Structure of Bali).* Jurnal Yustitia, 16(1), 62–70. https://doi.org/10.62279/yustitia.v16i1.901

Purnama, D. G. A. S. Y., & Dewi, A. A. I. A. A. (2019). Desa adat Dalam Pengelolaan Tanah Adat Bali Berbasis Kebijakan Daerah. *(Traditional Villages in the Management of Traditional Land in Bali Based on Regional Policy).* Acta Comitas, 4(2), 343. https://doi.org/10.24843/ac.2019.v04.i02.p16

Riani, N. (2021). Pariwisata Adalah Pisau Bermata 2. *(Traditional Villages in the Management of Traditional Land in Bali Based on Regional Policy Tourism is a Double-Edged Sword).* Jurnal Inobasi Penelitian, 2(5), 1469–1474.

Suarto, E. (2017). Pengembangan Objek Wisata Berbasis Analisis SWOT. *(Development of Tourist Attractions Based on SWOT Analysis).* Jurnal Spasial, 3(1), 19–24. https://doi.org/10.22202/js.v3i1.1597

Swastika, I. P. D., Sri Budhi, M. K., & Urmila Dewi, M. H. (2017). Analisis Pengembangan Agrowisata Untuk Kesejahteraan Masyarakat Di Kecamatan Petang, Kabupaten Badung.*(Analysis of Agrotourism Development for Community Welfare in Petang Subdistrict, Badung Regency).* E-Jurnal Ekonomi Dan Bisnis Universitas Udayana, 12, 4103. https://doi.org/10.24843/eeb.2017.v06.i12.p03