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Article

Transportation connectivity development strategy in the Wakatobi islands, Indonesia

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Abstract: This study aims to analyze connectivity or accessibility between regions in Wakatobi islands, both within and between islands, to understand the available transportation network. Based on an understanding of the dynamics of connectivity, it is expected to provide a solid foundation for the development of more efficient and sustainable transportation infrastructure in the future. A combination of qualitative and quantitative approaches is used to explore data more comprehensively and accurately. The two primary airports and several ports are still insufficient in enhancing connectivity for both the residents and tourists within the archipelago. Improving road, sea, and air transportation networks is a necessity and expectation to improve connectivity between regions. An analysis of accessibility potential provides an overview of transportation costs and expensive and long travel fares. There are several needs that need to be met in the form of the revitalization of local ports, the development of the concept of Air Buses between crossing ports, optimizing routes between airports, and the implementation of Bus/BRT (Bus Rapid Transit) on each island with feeder lines. Furthermore, the development of connectivity in Wakatobi must consider various alternative modes of transportation, increasing service frequencies, and developing supporting infrastructure. This conclusion is the basis for the preparation of a holistic and sustainable connectivity development plan in the Wakatobi archipelago.

Keywords: accessibility and connectivity; Wakatobi; marine tourism; sea transportation; sustainable mobility

1. Introduction

Indonesia is an archipelagic region that has many marine tourism destinations with beautiful and unique underwater views (Aryawan et al., 2022). One choice that is quite popular is Wakatobi. In 2015, this destination became one of the National Tourism Strategic Areas. This determination aims to develop marine tourism potential in Wakatobi and attract more domestic and foreign tourists. The Indonesian government has issued various policies aimed at creating comfort for tourists and the local community. Feeling comfortable and safe visiting tourist destination islands is a bridge to becoming a leading tourism sector and a stimulant for driving the local economy (Hayati et al., 2020; Winchenbach et al., 2022).

The pandemic has impacted tourists' preferences. On the one hand, changes in travel patterns occurred due to government appeals not to travel. Conversely, issues such as transportation activities, and sustainable mobility need to be considered due to a decrease in travel demand and changes in their preferences (Tarasi et al., 2021).

Therefore, the government encourages tourism activities and invites travelers to visit the designated tourism sites.

Until now, the condition of infrastructure, accessibility, and tourist facilities is still very limited. Transportation costs are high with minimal modes of transportation and low travel frequency. Therefore, it is necessary to carry out integrated planning and involve tourism operators and other stakeholders regarding marine tourism travel infrastructure as part of the 'Blue Growth' initiative which must consider sustainability issues (Winchenbach et al., 2022).

Wakatobi Islands, located in the heart of the world's coral triangle or known as the 'Coral Triangle', become an enchanting region with an extraordinary diversity of coral reefs and marine life (Minsaris et al., 2019). Large islands such as Wanci-Wanci, Kaledupa, Tomia, and Binongko, along with other smaller islands, hold special interest tourism potential that has not yet been fully explored (Syahadat, 2022). As a marine tourism destination, Wakatobi offers various tourist activities such as snorkeling, diving, and exploring underwater caves such as Walea Cave and Lapogo Cave as well as beautiful beaches such as Kora Beach and Watu Moli Beach.

Access to the Wakatobi Islands is currently made via traditional shipping vessels and speedboats to ports in Kaledupa, Tomia, Binongko, and other islands. However, limited transport accessibility between islands is still an obstacle that limits community activities in this region (Nurhaeny et al., 2021). Although external connectivity from/to the Wakatobi Regency area is available by air, sea, and crossing, the limited frequency and capacity of services make reaching this area efficiently (quickly and cheaply) still a challenge.

In the context of internal connectivity, every big island in Wakatobi regency, such as Wangi-Wangi, Kaledupa, Tomia, and Binongko, is generally connected through transportation networks, especially through docks and people's shipping that have existed for a long time (Puriningsih, 2018). However, the existence of roads and road transportation networks on each island is still relatively limited, so internal transportation costs on the island and between islands in Wakatobi remain high (Meng et al., 2018).

Wangi-Wangi Island, as the center of government and economy of Wakatobi Regency, shows better connectivity with the existence of collection ports, crossing ports, airports, as well as road networks and road transportation services that are better than other islands. Meanwhile, Kaledupa, Tomia, and Binongko Islands still rely heavily on Wangi-Wangi for external connectivity, and their internal connectivity is still traditional, relying on people's harbor services and charter road transportation.

This research was conducted in the Wakatobi archipelago (**Figure 1**), with the aim of analyzing connectivity between regions, both within and between islands, and analyzing community perceptions and expectations regarding the available transportation networks. Based on understanding the dynamics of connectivity, it is hoped that it can provide a solid foundation for the development of more efficient and sustainable transportation infrastructure in the future.

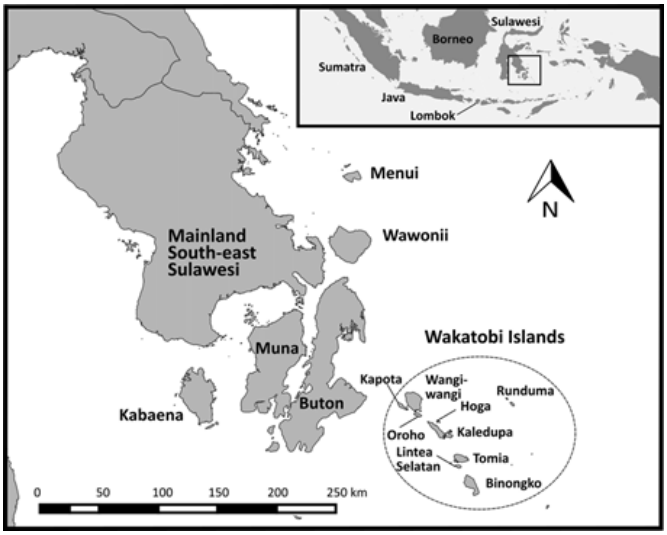

Figure 1. Map of Wakatobi islands.

Source: O'Connell et al. (2020).

2. Literature review

Researchers have diverse views on transportation connectivity and accessibility in the region. Agius et al. (2021) highlights the important role of air and sea transport in connecting remote islands with the mainland, while Heide et al. (2009) emphasizing the great potential of network connectivity to improve economic, social, and political well-being among these regions. Castanho et al. (2021) highlights the significant impact of accessibility and connectivity patterns on the socio-economic dimension of the population. However, an extensive literature review has explored various dimensions and indicators of access, including mobility, quality of transportation costs, and system connections (Ewing and Cervero, 2010). Labi et al. (2019) discusses the concepts of connectivity, accessibility, and mobility (CAM), while Vulevic (2016) highlights the importance of the quality of transport infrastructure in determining accessibility and location advantages. In addition, the importance of sustainable infrastructure is also emphasized by Agius et al. (2021), highlighting the improvement of connectivity services and environmentally friendly infrastructure to support ecotourism potential in the archipelago. In accessibility-based planning, it is important to consider the quality of service and security, given that accessibility plays a crucial role in both aspects (Jamei et al., 2022).

Nevertheless, Yaacoub and Alouini (2020) Highlight key cost-efficiency challenges in improving inland connectivity and advocate for solutions tailored to the unique characteristics of each region. Resi dents living in isolated areas with seasonal accessibility, such as roads that can only be passed during certain seasons, typically incur higher transportation costs to reach service centers compared to those residing in areas with good road access throughout the year (Stringer and Kim, 2023).

Through illustrative images and graphic concepts, Rodrigue et al. (2016) describes that the connectivity of a location is determined by the transport network, while accessibility adds dimensions of quantity and quality of service as shown in **Figure 2**. Research in the Canary Islands indicates that improved connectivity through better transportation networks can contribute to a more sustainable future (Castanho

et al., 2020). In Penghu County, China, a similar strategy can enhance connectivity between islands by expanding public transportation services, which in turn will improve accessibility, facilitate inter-island travel, and support more sustainable environmental management (Kao and Yang, 2023). The research is intended to improve the comprehension of connectivity challenges in the Wakatobi archipelago, as well as to offer implementable solutions to facilitate the development of more efficient and sustainable transportation infrastructure.

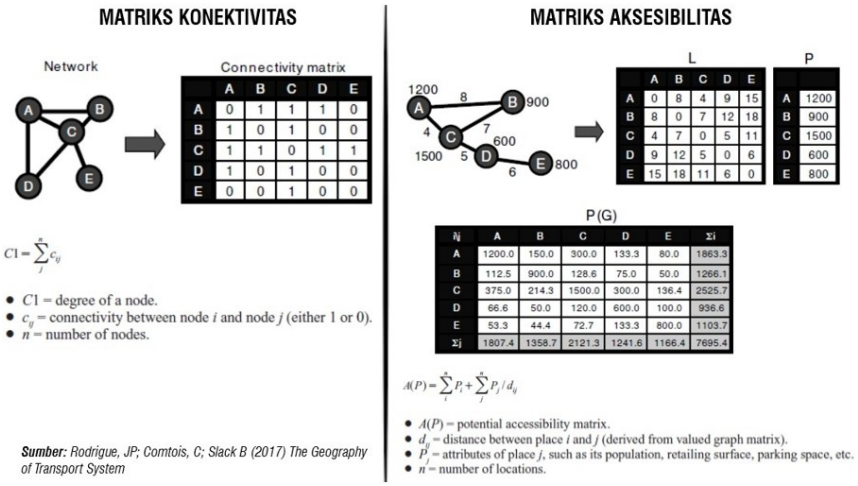

Figure 2. Visual and matrix descriptions of connectivity and accessibility (Rodrigue et al., 2016).

3. Methods

Data collection is carried out through direct interviews and observations on site. The direct interviews are conducted by the researcher in strategic locations such as ports, airports, bus terminals, and tourist areas. Interviews are conducted with residents and tourists traveling within the island, between islands, and outside the Wakatobi region. Samples are randomly selected to cover various age groups, genders, professions, and travel purposes. The survey instrument is a structured questionnaire that includes questions about travel frequency, travel purposes, modes of transportation used, and demographic characteristics of the respondents.

This study uses a combination of qualitative and quantitative descriptive analysis design. This approach was chosen to gain a holistic and in-depth understanding of the existing conditions and dynamics of transportation connectivity in the Wakatobi Islands (Creswell and Creswell, 2018). Qualitative descriptive analysis provides an in-depth picture of the existing conditions, challenges, and potential for connectivity development in the region. Through interviews, observations, and literature studies, the research gained more comprehensive insights into the sustainability of transportation infrastructure and its impact on local community activities. Meanwhile, quantitative approaches are used to measure more measurably specific aspects of connectivity, such as service frequency, transportation capacity, and travel costs. Numerical data obtained from surveys and statistical analysis provide empirical support to complement qualitative understanding and ensure research results are more objective. The combination of these two approaches is expected to produce more

comprehensive and accurate findings and provide a solid basis for formulating appropriate policy recommendations.

Data collection through interviews, observations, and discussions with related parties includes: (1) regulators (Ministry of Transportation (Directorat General of Maritime Transportation, Directorat General of Land Transportation, Directorat General of Air Transportation), Ministry of Tourism and Creative Economy, and Wakatobi Regional Government), (2) operators (node operators and transportation operators (bus, crossings, sea, rental transportation), and (3) users/communities. Qualitative data collection is done through in-depth interviews, observation, and document analysis. The use of this technique is designed to understand the context and complexity of phenomena. Quantitative data collection is done through surveys. The use of this technique aims to obtain data that can be measured and analyzed statistically. The object of research, namely the components of transportation services in Wakatobi, namely: (1) transportation infrastructure, namely in the form of ports, airports, terminals, along with basic and supporting facilities and their transfer facilities (2) facilities, in the form of connectivity of service networks and service systems (including ticketing systems), (3) services, in the form of characteristics of travelers, characteristics of trips made and the performance of transportation services in the Wakatobi area.

CSI (Customer Satisfaction Index), which will measure the level of user satisfaction (general public and tourists) with the level of intermodal integration as well as connectivity and accessibility in the Wakatobi area, which includes 2 aspects of assessment: (1) user satisfaction with existing services, (2) public expectations for improving service conditions in the future. This customer satisfaction index (CSI) analysis method is applied to carry out the scope of research No. 6, namely the evaluation of the level of satisfaction and inventory of the aspirations of tourist and community needs regarding connectivity and integration between transportation modes in Wakatobi.

To find out the amount of CSI, the following steps can be taken (Chu, 2002):

1) Determine the Mean Importance Score (MIS) of each variable and the Mean Satisfaction Score (MSS).

$$MIS = \frac{\sum_{i=1}^{n} Yi}{n} \qquad MSS = \frac{\sum_{i=1}^{n} Xi}{n}$$

where *n* represents the number of respondents, Yi represents the importance value of attribute *i*, and *Xi* represents the service performance on attribute *i*.

2) Create Weight Factors (*WFi*) per variable. This weight is the percentage of the MIS value per variable against the total MIS of all variables.
3) Create a Weight Score (*WSi*) for each variable. This weight is the multiplication between *WFi* and *MSSi* or *WSi = WFi x MSS*
4) Determine the Customer Satisfaction Index (CSI).

$$CSI = \frac{\sum_{i=1}^{P} WSi}{5}\ x\ 100\%$$

where *P* is the number of importance attributes, and 5 is the number of scales.

5) The Customer Satisfaction Index (CSI), value criteria as in the **Table 1**.

Table 1. Limiting values for the Customer Satisfaction (CSI) criteria.

No	Value Index (100%)	Criteria
1.	80% < satisfaction index ≤ 100%	Very satisfied
2.	60% < satisfaction index ≤ 80%	Satified
3.	40% < satisfaction index ≤ 60%	Quite satified
4.	20% < satisfaction index ≤ 40%	Less satified
5.	0% < satisfaction index ≤ 20%	Not satified

Sources: Helia et al. (2018).

4. Results and discussion

4.1. Travel characteristics of residents and tourists in Wakatobi

The results of the study revealed that the travel pattern in the Wakatobi archipelago area was dominated by inter-island travel (46%), this was in accordance with the type of area consisting of several, then within the island (37%) and the rest traveled between islands from/outside the Wakatobi area (17%). Meanwhile, travel speed is an indicator of mobility (Labi et al., 2019). High mobility is one of them when the travel time is relatively low, although there are other indicators such as economical costs, and travel comfort. Local travel within the district is still relatively dominant.

Judging from the purpose of travel, it can be revealed that the majority (67%) of Wakatobi residents travel for work/business/business, for local resident recreation or tourism is not the main need Residents as travelers are mostly of productive age with professions as civil servants/TNI (Indonesian National Army)/Polri, private employees, and entrepreneurs/self-employed. The frequency of trips is made by 43% every 3–4 times a week, and about 39% of the population only occasionally or not every week. This shows that there is a relatively balanced proportion of formal and non-formal work activities.

For daily travel, most Wakatobi people use motorbikes and/or private cars (76%) as the main mode, the rest travel on foot or using a car with a rental system. Depending on the distance traveled and the importance for the long term, it is necessary to anticipate and reduce people's dependence on private vehicles by developing a public transportation system. Public transportation/transportation can become more attractive, among other things, by providing more accessible services (Saif et al., 2019). Therefore, the accessibility factor in the design of public transportation infrastructure is very important. In the long term, transportation infrastructure will increase economic development (Alam et al., 2021). Thus, transportation infrastructure is an important input for economic development, so the right transportation policy must be implemented to increase economic growth in the region.

In the Wakatobi archipelago, the conditions of connectivity and availability of intermodal integration, comfort, and safety are still very lacking. Therefore, in addition to improving transportation infrastructure, it is also necessary to improve services in the form of providing access to public transportation on routes and online at arrival transportation nodes, equipped with advanced transportation routes that represent the level of safety and comfort of services in accordance with international standards. Not

only the performance of public transportation, but also the impact on other social aspects must be considered when planning public facilities (Saif et al., 2019).

4.2. Existing conditions of transportation network connectivity in Wakatobi

Table 2. Existing conditions of connectivity/accessibility provision and connectivity/accessibility evaluation.

Mode of transport	Connectivity/accessibility provision	Connectivity/accessibility evaluation
Air Transport	Air Transport Node: • Matahora Airport (Runway 2000 m × 30m (PCN 24 F/B/X/T), design aircraft ATR 72-500/600), taxiway 107m × 18 m, Appron 103 m × 73 m, terminal 1524 m^2 • Maranggo Airport (Tomia) (private in the process of handing over assets to the Wakatobi Local Government): Runway length 1070 m • Air Transport Service Network: • Kendari-Matahora (1 round-trip flight / day ATR-72 aircraft type) • Denpasar-Maranggo (unscheduled)	• Only 50% (2 of the 4 major islands) of Wakatobi area has been served by air transportation. • Available air transport capacity up to 48 seats/day • In general, there is a reduction in the number of aircraft arrivals in Wakatobi from 2015 to 2019, with a total arrival of around 373 and passengers transported as many as 43,954 people (pp).
Sea Transportation	Marine Transport Node: • Operational: PP Wanci (Wangi-Wangi) • Construction: PL Kaledupa (Kaledupa/Construction) • Rencana: PL Papalia (Binongko), PL Kapota, PL Runduma, PL Waha/Usuku (Tomia) • People's Jetty on each large/small island (total 29 ports/piers) • Sea Transportation Service Network: • KM Sirimau Pioneer (1–2 × per month) • KM Belt Nusantara Sea Toll 44 (Wanci-Tomia-Binongko) (2 × per month) • KFC Jetliner Kendari-Wanci (2 times per week) • People's Cruise: connecting to all the islands in Wakatobi (41 bertrayek transport, 2 non-swarming transports)	• 100% of large and inhabited islands in the Wakatobi area are already available seaports/docks with a minimum shipping network of people's shipping (generally ships with a capacity of 20–30 passengers) • Ship visits at Wanci Port in 2019 were only 406 calls, with a total GT of 711,445, with an estimated volume of loading and unloading goods of around 38,565 tons and good passengers/disembarking around 52,393 people
Crossing transportation	Crossing Transport node: • Class II crossing port: Wanci (O) • Port crossing plan: Kaledupa (K), Tomia, Binongko • Crossing Transportation Service Network: • Kamaru-Wanci (once every 1 day)	• Currently only 1 island crossing transport is served (25% of the 4 Major Islands) • The carrying capacity (KM Bahteramas II) is available only around 19 units of vehicles and 188 passengers
Road transportation	Road Transport Nodes and Infrastructure: • Total length of road network = 530.08 km • Construction of Numana Type B Bus Terminal Road Transportation Service Network: • 53 units of Rural Transport (Wangi-Wangi and Kaledupa) • 46 units (spread throughout Wakatobi)	• The road accessibility index in Wakatobi is only about 1.12 km of road/km^2 land area, meaning that every village has road access but is still limited (not every village has road access) • Road transport service network is only available on 2 major islands (Wangi-Wangi and Kaledupa)

Sources: Own elaboration based on data from interviews with the Waktobi Transportation Agency (2020).

Sea transportation is the main choice for travelers. The problems faced in this transportation are bad weather, erratic sea winds, and high transportation costs. In addition, limited access between islands, uneven road conditions, limited public transportation, and limited transportation information make it more difficult for local residents and tourists to mobilize. In detail, the conditions for providing

connectivity/accessibility and existing connectivity/accessibility evaluation in Wakatobi Regency are presented in **Table 2**.

There are several aspects in air, sea, crossing, and land transportation modes. In the air transportation sector, Wakatobi has two main airports, namely Matahora in Wangi-Wangi and Maranggo in Tomia. Even though Maranggo Airport is handed over as an asset of the Wakatobi Regional Government, only 50% of the Wakatobi area is served by air transportation. In the period from 2015 to 2019 there was a reduction in the number of arrivals and aircraft capacity to only 48 seats and from 2015 to 2019, with air transport capacity reaching 48 seats per day.

Sea transportation is equipped with operational piers and several large islands, with people's shipping connecting all the islands in Wakatobi. Ship visits at Wanci Port reached 406 times in 2019. The results of the evaluation showed that the crossing condition only had one mode option.

The total road network is 530.08 km long, with the construction of the Numana type B bus terminal. Although the road accessibility index reaches about 1.12 km of roads/km^2 of land area, every village has access to roads, there are still limited accessibility, especially on small islands. The land transportation service network is only available on two large islands, Wangi-Wangi and Kaledupa. The results of the overall evaluation show a number of limitations and potential improvements that need to be made to improve transportation connectivity and accessibility in Wakatobi. It is therefore recommended to develop more transport infrastructure in all sectors, such as roads (land), air, ports and crossing ports. The increase in the achievement of economic development through infrastructure is due to the direct and indirect benefits that are spread to the economy (Alam et al., 2021).

Considering that Wakatobi is an archipelago, the role of air and sea transportation becomes crucial, as it will facilitate the connection between the islands and the mainland (Agius et al., 2021). Although sea transportation is the main choice, bad weather and erratic sea conditions are often annoying. High transportation costs, especially for tourists from outside the area, are also a serious obstacle. In addition, limited inter-island access, uneven road conditions, limited public transportation, and limited transportation information further complicate the mobility of residents and tourists.

Infrastructure connectivity plays an important role in bridging various regional regions (Li et al., 2023). In the case of Wakatobi, a well-functioning and easily accessible port and airport is the key to improving intra-regional connectivity, because Wakatobi is an archipelago. Infrastructure connectivity can increase regional productivity and competitiveness by expanding regional production networks and facilitating the movement of goods, services, and human resources, generating economies of scale, encouraging trade and foreign direct investment in the region, creating new business opportunities, and stimulating industrialization inclusive (Yu, 2017). In the case of Wakatobi, a well-functioning and easily accessible port and airport is the key to improving intra-regional connectivity, because Wakatobi is an archipelago. Infrastructure connectivity can increase regional productivity and competitiveness by expanding regional production networks and facilitating the movement of goods, services, and human resources, generating economies of scale, and encouraging trade and foreign direct investment in the region, creating new

business opportunities, and by stimulating industrialization inclusive (Bisbey et al., 2020).

4.3. Inter-regional connectivity in Wakatobi

Connectivity between regions in Wakatobi has a crucial role in supporting economic development and growth. Based on the information on the availability of transportation networks in each mode, a connectivity matrix is displayed that states the availability of connectivity and the type of transportation mode from each island in Wakatobi. **Table 3** presenting Wakatobi transportation connectivity.

Connectivity or connections between regions is absolutely necessary, especially in archipelago-shaped areas. With good connectivity, it will make it easier for the public, tourists, and investors to invest in the development of industries, services, and various potential tourist destinations on all islands. To support connectivity between islands, sea transportation is currently one of the most commonly used and available transportation. Based on the availability of transportation networks in each mode, 69 percent of inter-island transportation networks do not have alternative connectivity. The same thing happens with connectivity within the island, as there is no public transportation available.

Table 3. Wakatobi transport connectivity matrix.

Location	Wangi wangi	Kaledupa	Tomia	Binongko
Wangi wangi	J, D	L, P	L, U	L
Kaledupa	L, P	J, D	L	L
Tomia	L, U	L	J	L
Binongko	L	L	L	J

Sources: Primary data (2020) (processed).
Description: J = road mode, D = land mode, L = sea mode, P = crossing mode, U = air mode.

Table 3 shows that connectivity within the island, only in Wangi-Wangi and Kaledupa has alternative connectivity other than through the road network mode (J). Until now on Tomia and Binongko Islands there is no road public transportation mode. For connectivity between islands, Wangi-Wangi Island has a relatively more diverse alternative mode of transportation to reach other islands, in addition to the sea mode through piers and tradisional shipping. Binongko Island can only be reached from other islands using the sea mode.

Transportation is a driver in the economic and tourism sectors so it is considered able to be a driver for the development of related sectors such as creating new job opportunities and business opportunities, increasing the number and variety of production in the food and non-food industry sectors (Sukwika, 2018). Transportation is one of the tools to unify and pave the way for economic activities, so that the region develops and is taken into account in economic activities. For this reason, the government is expected to improve facilities and infrastructure as well as supporting infrastructure such as building supporting facilities so that they are attractive and provide comfort for the community/visitors. In addition, the distance traveled by a place and the connectivity between islands can facilitate access for the community and visitors to tourist attractions in Wakatobi (Kodir et al., 2020). The results of the study

(Isnaini et al., 2024), also said that good accessibility and positive experiences significantly affect the intention to revisit.

To see the potential for transportation accessibility, see **Table 4**, which illustrates the potential accessibility matrix for each island in Wakatobi. This matrix generally combines the travel potential of residents with the level of transportation cost barriers.

Table 4. Wakatobi transportation accessibility potential matrix.

Transportation Cost (Thousand Rp)					**Travel potential resident**
Location/zona	**Wangi-wangi**	**Kaladupa**	**Tomia**	**Binongko**	**(Person)**
Wangi-wangi	23.34	71.52	95.84	120.16	59,908
Kaladupa	71.52	23.34	69.01	105.90	20,850
Tomia	95.84	69.01	23.34	68.17	17,810
Binongko	120.16	105.90	68.17	23.34	16,032
Location/zona	**Wangi-wangi**	**Kaladupa**	**Tomia**	**Binongko**	**Accessibility Potential (AP)**
Wangi-wangi	2566.75	837.64	625.08	498.57	4528.04
Kaladupa	291.53	893.32	302.13	196.88	1683.86
Tomia	185.83	258.08	763.07	261.26	1468.24
Binongko	133.42	151.39	235.18	686.89	1206.88
Accessibility Potential (AP)	3177.53	2140.42	1925.46	1643.60	

Sources: Primary data (2020) (processed).

Looking at **Table 4** it can be seen that transportation costs in Wakatobi for the island using road modes in general are worth IDR 23.34 thousand/trip. With an average travel distance within the island of around 5.76 km, the cost of road transportation in Wakatobi is around Rp 4050/km/passenger. This figure is relatively expensive compared to the basic cost of BRT/bus which ranges below Rp 200/km/passenger, the figure of Rp 4000/km/passenger is closer to the cost of ASK/taxi). This is because public transportation routes have not developed in Wakatobi. Furthermore, for inter-island transportation costs, the average in the Wakatobi area ranges from Rp. Rp 1484/km/passenger (or around Rp 2378/mile/passenger). This figure is quite large compared to the Production unit of pioneer ships/crossings whose value ranges from Rp 400/mile/passenger. This is because most of the inter-island sea transportation in Wakatobi still uses people's shipping ships.

4.4. Perceptions and expectations of residents in Wakatobi

The perceptions and expectations of non-tourist travelers (local residents) towards the provision of transportation connectivity and integration between transportation modes in Wakatobi are presented in **Table 5**. In general, the level of transportation service needs of Wakatobi residents related to aspects of connectivity, integration, travel time, travel costs, comfort, safety, and security is at the level of 'good-very good' (slightly above number 7).

The assessment of the Wakatobi community towards the provision of existing transportation networks for all aspects including connectivity, integration, travel time,

travel costs, comfort, safety, and security, shows an insufficient figure of around 4–4.5. The assessment distance between "satisfaction" and "expectations" is 3 points, which are around 4–4.5 and around 7–7.5. This gap is relatively large, so it is necessary to identify public perceptions of transportation infrastructure and analyze needs as an effort to meet public expectations. In developing countries, including Indonesia, innovative solutions are needed to improve accessibility and the provision of transportation networks (Szymańska et al., 2021).

Table 5. Needs, satisfaction and expectations of non-tourists towards transportation connectivity in Wakatobi.

Indicator	Level of Need	Satisfaction Level	Expectations	Statement on the ground
Network connectivity	7.45	4.56	• There should be road access to all locations (59%) • There should be transport services to all locations (41%)	• The road accessibility index in Wakatobi is only around 1.12 km of road/km^2 land area, meaning that every village has road access but is still limited (not every village has road access) • Sea freight services/crossings already exist (although mostly Pelra) to the rest of the island, but road public transport is only available in Wangi-Wangi and Kaledupa
Intermodal integration	7.55	4.12	• There should always be a connecting transport service (56%) • There must be information and facilities for changing modes (44%)	• Generally, there is no further transportation route at the port/airport node • Mode transfer facilities have not been well designed at every port/airport node
Travel time	7.60	4.28	• Maximum waiting time: 21 min • Maximum travel time 77 min • Total travel time maximum 98 min	• Existing waiting time 49 min (2.33 × expectations) • Existing travel time 84 min (1.09 × expectations • The total travel time is around 133 min • Need to increase the integration of the antramodal schedule (especially with connecting transportation) to reduce waiting times
Travel expenses	7.08	4.02	The average total trip cost is around Rp.145,341	The total cost of the existing trip is around Rp 155,094 (only 6.71% above expectations). More expected reduction in pre/after-transport costs
Comfort	7.49	4.02	• Must have a seat • Air conditioning (AC) available	• Generally there is no overcapacity (still getting a seat) • Most modes of transportation by land, sea, crossings have not been equipped with air conditioning
Safety	7.37	4.49	• Compliance with infrastructure safety standards • There must be emergency facilities	• Supervision of the seaworthiness of ships and the airworthiness of public transportation has not been optimal (related to the condition of the area in the form of islands • Most modes of transportation have not met emergency requirements (except those provided by the Government/SOEs)
Security	7.86	4.40	There must be a security post/officer	Security personnel are already at each node, but the complaint information board "Security Disturbance Number" has not been provided

Source: Primary data (2020) (processed).

The chronology of the travel of the locals, both inter and inter-island travel, is illustrated in **Table 6**. The distance of transportation access from and to the main node ranges from 5.28–6.23 km, with the cost of transportation access using land transportation worth 15.278–31.400 IDR/trip or around 2.452–5.947 IDR/km. This

access fee is relatively expensive because most of them use private or rented vehicles. The total travel time from the point of origin to the destination including the waiting time reached 133 min (84 min + 49 min). The proportion of waiting time is about 49/133 = 36.84% of the total trip, including a large portion specifically for waiting for the main mode. Access costs and waiting times can be reduced by providing public transportation (Gkiotsalitis and Cats, 2020).

Table 6 Characteristic of inter-island travel (non-tourists) in Wakatobi

Characteristic	**Pra-Utama*)**	**Main**)**	**Purna-Main***)**	**Total**
Approximate distance (km)	5.28	41.22	6.23	52.73
Travel time (min)	19	49	17	84
Waiting time (min)	7	32	10	49
Estimated Cost (IDR)	31.400	108.417	15.278	155.094

Source : Primary data (2020) (processed).
Description: *) pre-main = mode used from origin location to inter-island departure node, **) main = main mode used for inter-island travel, ***) purna-main = mode used from arrival node to destination location.

4.5. The need for increased regional connectivity and intermodal integration in Wakatobi

Based on the results of the analysis of connectivity and accessibility of the Wakatobi area) and also the analysis of the characteristics and perceptions of travelers, it can generally be suspected that there is a need to increase connectivity and intermodal integration in Wakatobi. Conceptually, the need to improve connectivity in Wakatobi (as also proposed by the Wakatobi Regional Government) can be summarized in **Table 7** and described in **Figure 3.**

Table 7. Connectivity development needs of Wakatobi area.

Scale Connectivity	**Connectivity Needs**	**Network and Main Node**
External connectivity	Wakatobi Regency with Other Regions in Indonesia especially the capital of Sultra Province (Kendari) and the capital of the State (Jakarta)	• Inter-island sea transportation between provinces through Wanci/Pangalubelo Collecting Port • Kendari-Bau Bau- Wanci crossing transportation through Wanci Crossing Port • Air transportation from Makassar/Jakarta via Kendari via Matahora Airport
Internal connectivity	Inter-Island within Wakatobi Regency	• Local Sea Transport (revitalization of Pelra from Numana Port-Ambeua Port, Usuku Port, Popalia Port • Transportation Crossing with Water Bus concept from Wanci Crossing Port-Ollo Crossing Port-Kolosoha Crossing Port-Makoro Crossing Port • Air Transportation from Matahora Airport to Maranggo Airport
	Within the island on each Island in Wakatobi Regency	• Bus/BRT transportation on every major island is equipped with angkot feeder lines, • Provision of non-route transportation as an alternative mode of transportation as needed Service level

Source : Primary data (2020) (processed).

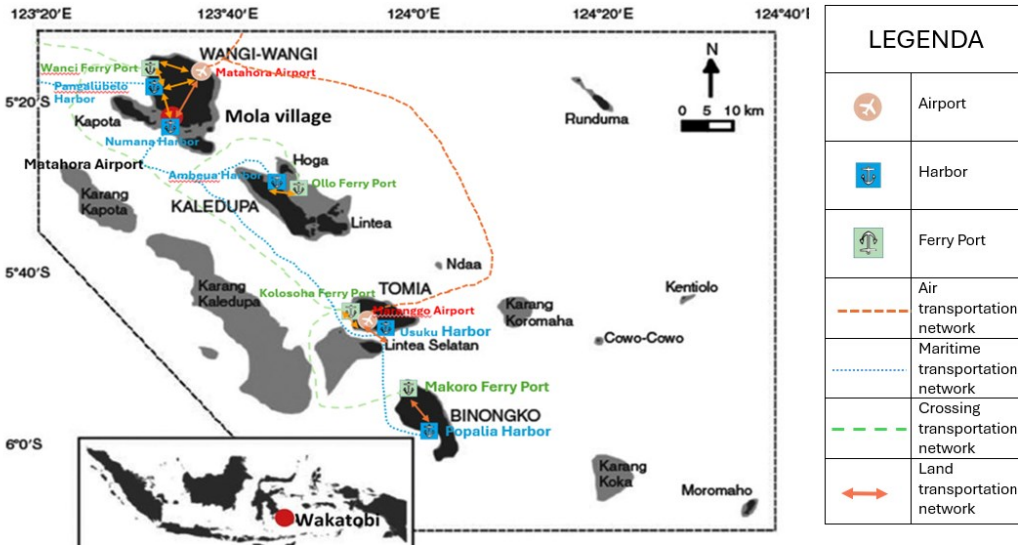

Figure 3. Concept of Wakatobi transportation connectivity development needs.

Improving connectivity and transportation services in the Wakatobi area can be done by:

a) Increased road accessibility up to 1.5 km/km^2 of land area, allowing for more efficient mobility within the island.

b) The development of a rural/urban road transportation service system in the form of public buses, especially on Wangi-Wangi Island which is already characterized by urbanism.

c) The construction of a Feeder Sea Port and a Class II Crossing Port on each major island as the main node of inter-island connectivity in Wakatobi Regency.

d) Improving the reliability of air, sea, and crossing transportation services serving the Wakatobi area, both external and internal through: (a) increasing the frequency of scheduled flights and pioneer ships as well as sea tolls as crossings to Wakatobi through Wanci Port and Matahora Airport; (b) Optimization of sea transportation services in the form of people's shipping to serve the needs of the movement of people and goods between islands.

4.6. Implications of improving transportation connectivity in the Wakatobi islands

Increased transportation connectivity in the Wakatobi archipelago can have various social and economic implications. Socially, better transportation connectivity, makes it easier for residents to interact and stay in touch, and access health services, education, and entertainment (Lucas, 2012; Pereira et al., 2017). Economically, increasing transportation connectivity will stimulate the entry of investors who have the opportunity to accelerate development, and open up job opportunities, and business opportunities, conditions that directly bring changes to the local economy.

Simultaneously, increasing transportation connectivity plays a role in reducing transportation costs and encouraging an increase in the number of local tourists and the number of tourists visiting Wakatobi, both domestic and foreign. As an archipelago, the increase in land and sea connectivity greatly affects the development of tourism with scattered destinations (Koukounaris and Stephanedes, 2023). The arrival of

investors and tourists comes with various ideas and creative economic activities, in developing natural resources and social resources of the local community.

To enhance connectivity between regions in Wakatobi, a technology-based approach and innovation are needed. The development of a mobile application that provides real-time information on schedules, ticket prices, and routes will facilitate access for the community. A technology-based transportation management system will improve efficiency and reduce access constraints. Currently, there are a number of ships serving inter-island routes, but the number is still limited and insufficient to meet existing transportation needs. Therefore, the addition of ship fleets and the development of green infrastructure such as eco-friendly ports, as well as the introduction of innovative transportation modes, such as water buses, will expedite travel and reduce costs (Banick et al., 2021). The integration of these solutions, along with public-private partnerships, will accelerate the development of a responsive and quality transportation network in Wakatobi. The improvement of accessibility in the Wakatobi Islands region requires a comprehensive multi-level policy approach. The main focus of this approach is on the development of a transportation system that is responsive to demand and the implementation of effective governance mechanisms involving various actors at the central and regional levels, across sectors (Brovarone and Cotella, 2020).

The impact of transportation connectivity on the development of tourists and the economy of the community in Wakatobi requires special study and analysis. This study indicates that improving transportation networks can attract business interest, boost tourism, and create job opportunities. By analyzing travel habits and preferences, transportation providers can optimize their routes, schedules, and services (Castanho et al., 2020). Focusing on reducing travel time, waiting time, and costs will help ensure that transportation choices meet the needs of residents and visitors.

5. Conclusion

Enhancing the transportation connectivity in Wakatobi remains a significant challenge. Despite having two primary airports and multiple ports, accessibility is still quite restricted, particularly in the smaller islands. It is imperative to improve the land, sea, and air transportation networks to enhance inter-regional connectivity. The travel patterns of the residents highlight that inter-island travel continues to be prevalent in the regency, especially for work and business purposes. The infrastructure limitations, such as Maranggo Airport only catering to 50% of the area, and the operational data indicating limited flight and shipping frequencies, underscore the urgent need for improvement

The development of connectivity in Wakatobi must consider various alternative modes of transportation, increasing service frequency, and developing supporting infrastructure. User satisfaction surveys also indicate dissatisfaction with frequency, timeliness, and travel comfort. Improving transportation accessibility in small islands is expected to drive economic growth, strengthen interregional integration, and enhance community welfare. To achieve this, new infrastructure development, increased frequency and transportation routes, and the implementation of better transportation management technology are required.

The methodology and findings of this study, although specifically focused on the Wakatobi Islands, can be applied broadly to island regions or geographically dispersed areas. The approach to assessing transportation connectivity, analyzing the characteristics of resident and tourist travel, and evaluating existing transportation infrastructure can serve as a model for similar regions facing similar challenges.

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