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The Purchasing Power of Water Transportation Pioneer Services in the Archipelago Region of North Sulawesi

Sri Hardianto[1,2*], Muhammad Yamin Jinca[3], Jamaluddin Jompa[4], Muhammad Yamin Saud[1]

[1] Development Studies Program, Graduate School, Hasanuddin University, 90245 Makassar, Indonesia
[2] Directorate General of Land Transportation, Ministry of Transportation, 10110 Jakarta, Indonesia
[3] Transportation Engineering, Graduate School, Hasanuddin University, 90245 Makassar, Indonesia
[4] Department of Marine and Fisheries Science, Hasanuddin University, 90245 Makassar, Indonesia

[*] Correspondence: Sri Hardianto (sri_hardianto@dephub.go.id)

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Abstract: North Sulawesi's geography includes both its mainland and the island regencies of Sangihe, Talaud, and Sitaro (Siau Tagulandang Biaro). This study examines the economic and service disparities between the island regencies of Sangihe, Talaud, and Sitaro and mainland North Sulawesi. In 2023, the Human Development Index (HDI) and Gini ratio for these island regencies were below the averages for both Indonesia and North Sulawesi. To address these gaps, the Ministry of Transportation implemented subsidized sea and ferry transport programs. Using a mixed-methods approach, the research combines a quantitative analysis of purchasing power with a qualitative review of relevant regulations. The study surveyed residents in the island regencies who utilize these subsidized services to assess their Ability to Pay (ATP) and Willingness to Pay (WTP). The findings reveal a significant gap: ATP for both passengers and freight is consistently lower than WTP, indicating a willingness to pay more than they can currently afford. Further analysis shows a disconnect between these ATP-WTP values and government-regulated fares, creating inconsistencies that influence consumer travel choices. This lack of alignment between bottom-up demand for affordable transport and top-down regulatory frameworks has led to inefficient service integration. While multimodal transshipment could offer a potential solution, its implementation is currently hindered by significant geographic and regulatory challenges, perpetuating the economic and service disparities faced by the island regencies.

Keywords: Water transportation; Archipelago; Purchasing power; Regional development

1 Introduction

1.1 Background

North Sulawesi Province is renowned for its marine features, which are reflected in its culture, tourism, and geography. The geography of North Sulawesi includes both the mainland and the island districts of Sangihe, Talaud, and Sitaro (Siau Tagulandang Biaro) [1–6]. In 2023, the Human Development Index (HDI) and Gini ratio for these island districts were below the averages for both Indonesia and North Sulawesi [7–13].

To address these disparities, the Government of Indonesia, through the Ministry of Transportation, provides subsidized water transportation services in North Sulawesi via pioneering sea transportation programs, sea tolls, and ferry services [14–16]. Private companies operate commercial passenger transportation from mainland North Sulawesi to the islands, while crossing services that transport passengers, vehicles, and cargo are managed by PT ASDP Indonesia Ferry Bitung Branch.

Fare subsidies for water transportation in archipelagic regions are likely to have significant effects on community travel frequency. By decreasing the cost burden of transportation, these subsidies can promote increased mobility and accessibility among residents of islands and coastal communities, which may be isolated geographically [17, 18].

1.2 Problem Statement

The geographical distance from mainland North Sulawesi, coupled with extreme water conditions and limited ship capabilities, increases travel time and transportation costs for island communities. This situation requires attention as poverty remains a significant economic challenge in the archipelago [19–22]. This research aims to identify the purchasing power of water transportation services among communities in the Sangihe, Talaud, and Sitaro Islands Regencies by analyzing socio-economic factors that influence their travel destinations.

Studies emphasize the essential nature of transport subsidies, particularly where alternative modes of transport are limited. In the context of maritime connectivity, ferry services act as critical mediators of access to education, healthcare, and economic opportunities [23–25]. Subsidies, by easing financial barriers, can increase the frequency of travel and foster stronger socio-economic connections throughout the archipelago [26, 27].

1.3 Research Objectives

The initial stage of this research involved a literature review of previous studies to identify similarities in perspective between the research topic and the analysis stage. The literature review was conducted to highlight research gaps in prior studies and to identify differences that contribute to the novelty of this research. Previous studies have shown that sea toll programs are among the government's flagship initiatives aimed at supporting the maritime axis by distributing basic and essential commodities from economic centres to underdeveloped, remote, outermost, and border areas (referred to as "3TP"). These programs aim to reduce economic inequality, address price disparities, and support sustainable and equitable economic development [28, 29].

Moreover, effective implementation of subsidies can lead to communities expressing a higher Willingness to Pay (WTP) for continued access to vital travel routes, reflecting a perceived fairness and essential utility derived from subsidized transport options [30–32].

1.4 Significance of the Study

Water transportation plays a critical role in supporting inter-island connectivity within the 3TP region of North Sulawesi. This includes the provision of infrastructure, such as ports in Bitung, Manado, Likupang, and Amurang [33], as well as the establishment of water transportation networks [34, 35].

The measurement of people's purchasing power for transportation services is conducted to assess their Ability to Pay (ATP) and WTP. This serves as a basis for making strategic decisions, such as determining water transportation tariffs and setting the amount of government subsidies [36–38]. Previous research [28, 29, 33–35], has substantial relevance to this study, though key differences exist. For example, research [35] focuses on the performance of Bitung Port and its connectivity to the hinterland, primarily analyzing land transportation aspects, while this study focuses on the island districts of Sangihe and Sitaro to evaluate service availability.

The analysis method in research [36] measures purchasing power using the Composite Performance Index method, producing index values categorized by specific proportions. In contrast, this study employs the Travel Cost Method to generate financial values. The research [37] uses the same method as this study but differs in its research object. While previous studies primarily analyse crossing transport rates for passengers, this study examines passenger and vehicle fares, along with cargo from various groups. Additionally, earlier research does not cover the island regencies of Sangihe, Talaud, and Sitaro. Research [35] discusses purchasing power normatively as a recommendation for further investigation. This study advances the analysis by examining purchasing power from a quantitative perspective and comparing it with regulatory frameworks. The novelty of this research lies in its focus on location, object, and method of analysis.

2 Research Methods

This research employs a mixed-methods approach, integrating quantitative and qualitative analyses. Primary data were collected through a survey using a questionnaire instrument, employing a random purposive sampling method. The respondents were individuals from the Sangihe, Talaud, and Sitaro regencies who use water transportation, with a total of 100 participants. The survey was conducted at three port locations Amurang, Bitung, and Likupang in May 2024, as well as at the ports of Bitung, Pananaru, Melonguane, and Minangga between November and December 2024. The sample size was determined using the Slovin formula with a 10% margin of error, balancing the feasibility of the study with the need for representative data given the geographically dispersed population of 3TP water transportation users.

Additional primary data were obtained through focus group discussions (FGDs) with relevant stakeholders. Respondents for the FGDs were selected using purposive sampling, targeting representatives from the Ministry of Transportation, local governments, and ship operators with managerial and operational authority [38]. This approach reduces potential bias while recognizing the limitations inherent in fieldwork in remote areas. From the survey results, the Ability-to-Pay/Willingness-to-Pay (ATP-WTP) calculation will be based on the Travel Cost

Method. This analytical option is particularly relevant for assessing purchasing power in this context as it links actual travel behaviour to spending patterns, avoiding the hypothetical bias common in stated-preference methods.

Secondary data included information on transportation production, hinterland connectivity, water transportation routes, tariffs, and related regulations. These data were sourced from official entities such as regulators, operators, and statistical agencies.

The analysis began by identifying hinterland aspects with connectivity as the main indicator—measured by the availability of routes and vessels linking respondents' trip origins and destinations [39]. Port and hinterland selection focused on representativeness of capital islands and outermost islands in each district: Tahuna Sea Port and Pananaru Ferry Port for Sangihe Regency's capital island; Kawaluso Port and Marore Port for its outermost islands; Melonguane Sea Port and Ferry Port for Talaud Regency's capital island; Marampit and Miangas Ports for its outermost islands; Siau Port for Sitaro Regency's capital island; and Makalehi Port for its outermost island.

Two parallel analyses were conducted:

• A qualitative review of regulations comparing the Minister of Transportation Regulations PM 55/2019 (pioneer sea tariffs) and PM 66/2019 (pioneer ferry tariffs), supplemented by FGD findings [40].

• An ATP-WTP analysis using the Travel Cost Method to assess purchasing power for water transportation services. Indicators included travel purpose, income, expenditure, and travel frequency [41]. The integration of these analyses provides a comprehensive understanding of community purchasing power for water transportation services, which can be seen in Figure 1.

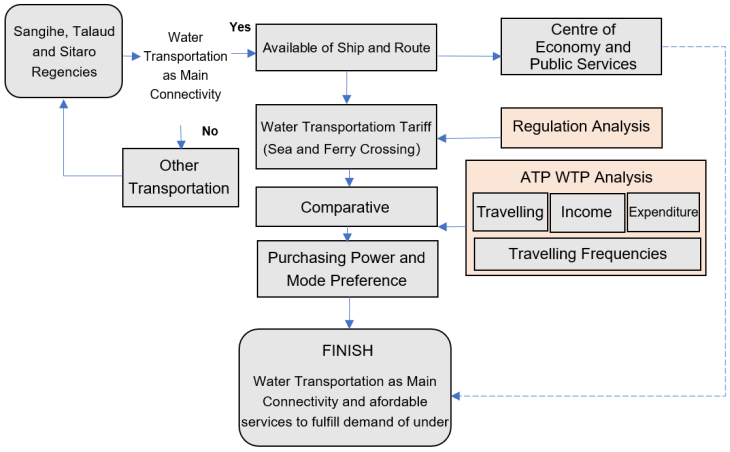


Figure 1. Research framework

3 Analysis and Discussion

The Sangihe, Talaud, and Sitaro Island Regencies are among Indonesia's outermost, and most remote border areas. Their geographical features, population demographics, and the potential for plantation production are detailed in Table 1. These regions include 12 small outer islands in North Sulawesi: Bongkil, Mantehage, Makalehi, Kawaluso, Kawio, Marore, Batuwaikang, Miangas, Marampit, Intata, Kakorotan, Kabaruan [42].

Table 1. Regional geography, population GRDP of plantation products

Regency	Islands	Area (km^2)	Road (km)	District: Village	Population	GRDP (Billions)	Plantation Production (Ton)		
							Coconut	Cloves	Nutmeg
Sangihe	137:28	597.260	779.750	15:22:145	141,980	3.559	24,081.43	668.05	1,104.42
Talaut	16:8	1,012.140	447.475	19:11:142	97,310	1.843	19,575.00	24.00	4,318.00
Sitaro	55:10	217.287	281.099	10:10:83	73,400	1.862	2,975.16	-	3,126.85

Within the Sangihe Islands Regency, the districts of Tahuna, Tahuna Timur, and Tahuna Barat (Outside Lokpri) have been designated as National Strategic Activity Centers (NSAC) for maritime activities. These locations are part of priority growth corridors outlined in Indonesia's National Medium-Term Development Plan for 2020–2024. Specific priority areas include six locations in the Sangihe Islands (North Tabukan, Nusa Tabukan, Kendahe, Tahuna, East Tahuna, and Marore Islands), five locations in the Talaud Islands (Nanusa, Kabaruan, Melonguane, Damau, and Miangas), and one location in the Sitaro Islands (West Siau) [43].

In 2023, the HDI and the Gini Ratio (a measure of economic inequality) for the Sangihe, Talaud, and Sitaro regions were below Indonesia's national averages. The HDI scores were as follows: Indonesia (74.39), North Sulawesi (75.04), Sangihe (73.94), Talaud (72.22), and Sitaro (70.81). The Gini Ratios were: Indonesia (0.313), North Sulawesi (0.345), Sangihe (0.356), Talaud (0.339), and Sitaro (0.366) [7, 8].

Water transportation is the primary mode of transport between islands and the mainland in North Sulawesi for these regions. According to the National Port Master Plan (2017–2032), 70 seaports and ferry ports are planned for development by 2032. Currently, operational ports include: Sangihe (sea port 12, ferry port 3), Talaut (sea port 11, ferry port 3), Sitaro (sea port 6, ferry port 3), Port development plans: Sangihe (sea port 9, ferry port 7), Talaut (sea port 3, ferry port 5), Sitaro (sea port 3, ferry port 30) [44].

In 2014, the government launched pioneering and sea toll services to enhance connectivity for the Sangihe, Talaud, and Sitaro Islands. These services included five pioneer ships with base ports in Bitung (R-35, R-36) and Tahuna (R-37, R-38). Direct routes from mainland Sulawesi were established, such as Likupang-Tagulandang (R-35) and Likupang-Biaro (R-36), with plans for 12 trips annually.

Additionally, six Ro-Ro (Roll-on/Roll-off) passenger pioneer ships were introduced to serve the following routes: Amurang-Pananaru, Bitung-Tagulandang, Likupang-Biaro, Likupang-Pananaru, Likupang-Melonguane, Tanjung Perak-Makasar-Tahuna-Tanjung Perak Sea Toll. For remote and outermost areas served by sea pioneers and Ro-Ro passengers: Makalehi, Kawaluso, Marore, Marampit, and Miangas. Details of the provision of pioneer subsidies by the Ministry of Transportation, commercial transportation, and island services can be seen in Tables 2, 3, 4 and 5.

R-35 connects mainland Sulawesi: 3 islands in Sitaro, Sangihe island, 7 islands in Talaut, R-36 connects mainland Sulawesi: 6 islands in Sitaro, R-37 specifically serves 7 islands in Sangihe, R-37 connects Tahuna on Sangihe island with 9 islands in Talaut and with mainland Sulawesi, R-39 connects mainland Sulawesi with 6 islands in Sangihe. P-01 connects mainland Sulawesi: 4 islands in Sitaro, P-02 serves mainland Sulawesi: to 2 islands in Talaut, P-03 serves mainland Sulawesi to 5 islands in Talaut, P-04 serves mainland Sulawesi to Sangihe Island and Karakelang Island, P-05 serves mainland Sulawesi: 4 islands in Sitaro, P-06 serves Sulawesi mainland to 3 islands in Sangihe.

R-36, P-01 and P-05 serve mainland Sulawesi to the Sitaro islands, R-35, R-38, P-02 and P-03 serve mainland Sulawesi to the Talaut islands, R-39 and P-06 serve mainland Sulawesi to the Sangihe islands.

In Table 5 and Figure 2, there are similar services on the island for the region: Sangihe (Sangihe, Kalawaluso, Marore), Sitaro (Biaro, Gunatin, Makalehi, Siau, Tagulandang), Talaut (Kabaruan, Karakelang, Marampit, Miangas, Salibabu). This condition is interesting if discussed from different perspectives: bottom-up and top-down.

Table 2. Subsidy provision of pioneer sea transportation

Home Base	Route
Bitung R-35	Mile: 917,47; Round Voy: 12 days; Target/year: 30 freq; Vessel: KM. Sabuk Nusantara 69; Bitung-(55)-Likupang-(55)-Tagulandang-(59)-Para-(26)-Ngalipaeng-(33,8)-Petta-(95)Damau -(15)-Lirung-(51)-Gemeh-(27)-Kakorotan-(7,67)-Karatung-(3)-Dampulis-(64)Miangas-(108) -Melonguane-(19)-Damau-(120)-Tahuna-(28)-Kalama-(41)-Makalehi-(110)Bitung
Bitung R-36	Mile: 383,18; Round Voy: 8 days; Target/year: 45 freq; Vessel: KM. Sabuk Nusantara 70; Bitung-(55)-Likupang-(38)-Biaro-(19)-Tagulandang-(32)-Buhias-(4)-Sawang-(4)-Ulu Siau -(32)-Makalehi-(14,8)-Pehe-(25)-Para-(29)-Ulu Siau-(4,78)-Buhias-(32)-Tagulandang-(19) -Biaro-(74)-Bitung
Tahuna R-37	Mile: 241,78; Round Voy: 7 days; Target/year: 52 freq; Vessel: KM. Sabuk Nusantara 95; Tahuna-(26)-Peta-(9.5)-Bukide-(16,2)-Lipang-(19,4)-Kawaluso-(26)-Matutuang-(21) -Kawio-(5,14)-Marore-(5,14)-Kawio-(21)-Matutuang-(26)-Kawaluso-(19,4)-Lipang-(21)- Petta-(26)-Tahuna
Tahuna R-38	Mile: 840,98; Round Voy: 11 days; Target/year: 33 freq; Vessel: KM. Sabuk Nusantara 109; Tahuna-(119)-Mangaran-(8,32)-Lirung-(4)-Melonguane-(41)-Dapalan -(25,30)-Kakorotan -(7,67)-Karatung-(3)- Marampit-(69,6)-Miangas-(69,6)-Marampit-(3)-Karatung-(7,67) -Kakorotan-(40)-Esang-(23)-Beo-(19,5)-Melonguane-(4)-Lirung-(8,32)-Mangaran-(212) -Bitung-(176)-Tahuna
Tahuna R-39	Mile: 551,08; Round Voy: 8 days; Target/year: 45 freq; Vessel: KM. Kanon Moon; Tahuna-(28)-Lipang-(19,4)-Kawaluso-(26)-Matutuang-(21)-Kawio-(5,17)-Marore-(5,14) -Kawio-(21)-Matutuang-(26)-Kawaluso-(19,4)-Lipang-(28)-Tahuna-(176)-Bitung-(176)-Tahuna
Tanjung Perak H-1	Mile: 2286; Round Voy: 30 days; Target/year: 12 freq; Vessel: KM logistik nusantara 2; Tanjung Perak-(438)-Makasar-(766)-Tahuna-(1082)-Tanjung Perak

Source: Ministry of Transportation [44].

Table 3. Subsidy provision of pioneer crossing transportation

Home Base	Cross
Bitung P-01	Mile: 264; Round Trip: 3 days; Target/vear: 22 freq; Vessel: KMP. Lokong Banua; Bitung-(60)-Tagulandang-(36)-Buhias-(6)-Siau-(60)-Pananaru-(60)-Siau-(6)-Buhias-(36) -Bitung Mile: 204; Round Trip: 2 days; Target/vear: 88 freq; Vessel: KMP. Lokong Banua; Bitung-(60)-Tagulandang-(36)-Buhias-(6)-Siau-(6)-Buhias-(36)-Tagulandang-(60)-Bitung
Bitung P-02	Mile: 472; Round Trip: 2 days; Target/vear: 88 freq; Vessel: KMP. Bawal; Bitung-(212)-Mangaran-(20)-Musi-(4)-Melonguane-(4)-Musi-(20)-Mangaran-(212)-Bitung Note: Bitung-Mangaran (layanan komersial), Mangaran-Musi dan Musi-Melonguane (Perintis)
Likupang P-03	Mile: 705 ; Round Trip: 3 days; Target/vear: 22 freq; Vessel: KMP. Watunapato; Likupang-(209)-Melonguane-(67,5)-Marampit-(62,1)-Miangas-(62,1)-Marampit-(67,5) -Melonguane-(209)-Likupang
Likupang P-04	Mile: 418; Round Trip: 2 days; Target/vear: 18 freq; Vessel: KMP. Tarusi; Likupang-(117)-Pananaru-(92)-Melonguane-(92)-Pananaru-(117)-Likupang Mile: 314; Round Trip: 1 day; Target/year: 83 freq; Vessel: KMP. Tarusi; Likupang-(117)-Pananauu-(117)-Likupang
Likupang P-05	Mile: 209; Round Trip: 3 days; Target/vear: 83 freq; Vessel: KMP. Lohoraung Likupang-(43)-Biaro-(25)-Tagulandang-(24)-Makalehi-(22)-Ulu Siau-(22)-Makalehi-(24) -Tagulandang-(24)-Biaro-(25)-Likupang
Amurang P-06	Mile: 520; Round Trip: 2 days; Target/year: 22 freq: Vessel: KMP. Porodisa

Source: Ministry of Transportation [44].

Table 4. Commercial sea and crossing transportation

Home Base	Cross
Manado M-01	Mile: 276; Round Trip: 2 days; Target/year: 145 freg: Vessel: KM. Mercy Teratai; Mile: 276; Round Trip: 2 days; Target/year: 47 freq: Vessel: KM. Saint Mary; Manado-(138)-Tahuna-(138)-Manado
Manado M-02	Mile: 260,8; Round Trip: 2 days; Target/year: 39 freq; Vessel: KM. Saint Mary; Manado-(85,4)-Siau-(55)-Tahuna-(55)-Siau-(85,4)-Manado
Manado M-03	Mile: 177,8; Round Trip: 2 days; Target/vear: 116 freq: Vessel: KM. Glory Mary; Mile: 177,8; Round Trip: 2 days; Target/vear: 52 freg; Vessel: KM. Marina Bay I; Manado-(62,9)-Tagulandang-(26)-Siau-(26)-Tagulandang-(62,9)-Manado
Manado M-04	Mile: 420,74; Round Trip: 2 days; Target/year: 76 freg; Vessel: KM. Gregorius; Mile: 420,74; Round Trip: 2 days; Target/vear: 78 freg; Vessel: KM. Barcelona VA; Manado-(190,8)-Lirung-(2,8)-Melonguane-(16,77)-Beo-(16,77)-Melonguane-(2,8) -Lirung-(190,8)-Manado
Manado M-05	Mile: 188,8; Round Trip: 2 days; Target/year: 82 freq; Vessel: KM. Marina Bay I; Manado-(52,9)-Biaro-(15,5)-Tagulandang-(26)-Siau-(26)-Tagulandang-(15,5)-Biaro -(52,9)-Manado
Manado M-06	Mile: 267,8; Round Trip: 2 days; Target/year: 112 freq; Vessel: KM. Espress Bahari 2E; Manado-(52,9)-Tagulandang-(26)-Siau-(55)-Tahuna-(55)-Siau-(26)-Tagulandang -(52,9)-Manado
Bitung P-02	Mile: 212; Round Trip: 2 days; Target/year: 88 freg; Vessel: KMP. Bawal; Bitung-(188)-Mangaran-(20)-Musi-(4)-Melonguane-(4)-Musi-(20)-Mangaran-(188) -Bitung Note: Bitung-Mangaran (Commercial services), Mangaran-Musi and Musi-Melonguane (Pionerers)
Bitung P-07	Mile: 212; Round Trip: 3 days; Target/vear: freg; Vessel: KMP. Labuhan Haji; Bitung-(212)-Melonguane-(212)-Bitung Note: Serving January to June 2024

Source: Ministry of Transportation [44].

Table 5. Commercial sea and crossing transportation

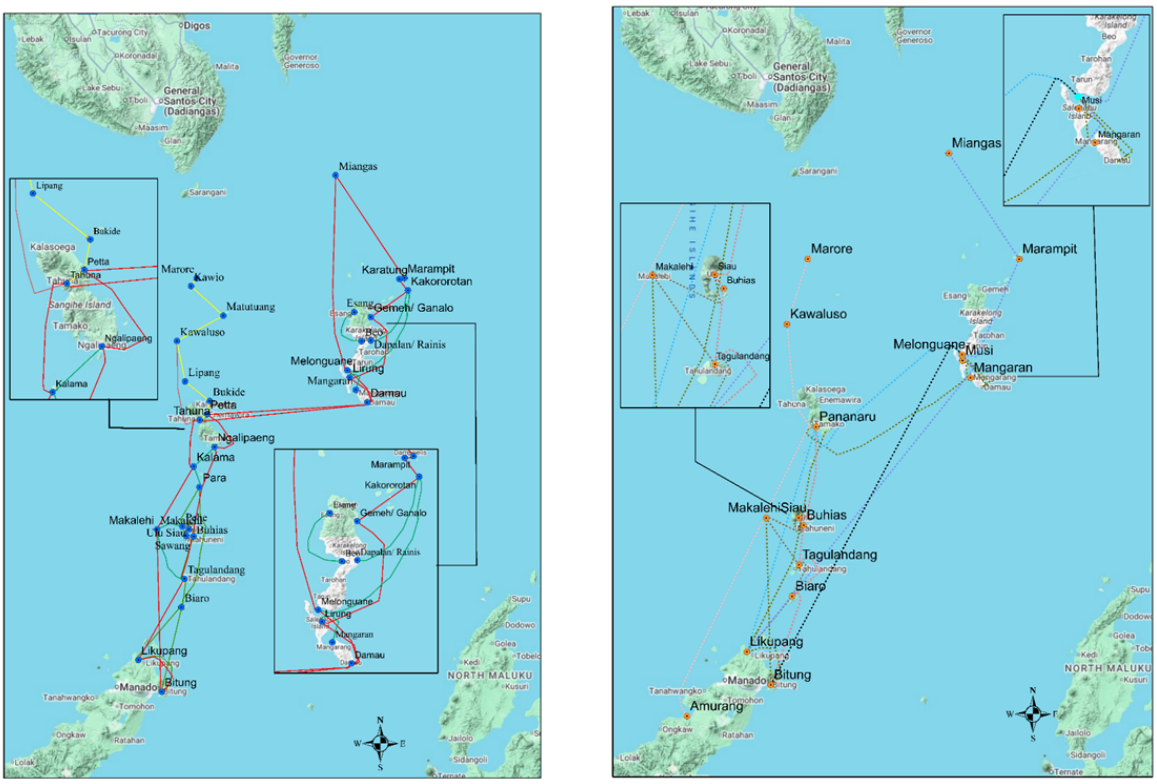
District/Island	Area (Km^2)	Population (2023)	Port			Freq (2024)		
			RoRo	Sea	Sum	RoRo	Sea	Sum
			Sangihe					
Kalama	8.67	886		1	1	0	30	30
Kawaluso	4.00	670	1	1	2	44	194	238
Kawio	1.41	504		1	1	0	194	194
Lipang	2.00	357		1	1	0	194	194
Nusa	8.66	2.445		1	1	0	52	52
Marore	2.50	716	1	1	2	22	97	119
Matutuang	0.31	443		1	1	0	194	194
Para	5.37	1.338		1	1	0	75	75
Sangihe	na		1	4	5	185	499	684
			Sitaro					
Biaro	19.19	3.388	1	1	2	166	90	256
Gunatin	4.38	2.232		1	1	0	90	90
Makalehi	9.75	1.185		1	1	166	75	241
Siau	140.11	30.420	1	3	4	215	180	395
Tagulandang	53.22	20.986	1	1	2	364	120	484
			Talaud					
Kabaruan	94.63	10.847		2	2	176	126	302
Kakorotan	1.71	666		1	1	0	96	96
Karalelang	801.00	60.544	1	5	6	220	195	415
Karatung	7.43	1.221		1	1	0	96	96
Marampit	12.75	1.605	1	2	3	44	96	140
Miangas	2.39	811	1	1	2	22	63	85
Salibabu	99.36	20.431	1	1	2	194	96	290
Main Sulawesi			3	2		514	303	817

Source: Ministry of Transportation [44].

This research adopts a top-down perspective, employing a series of quantitative and qualitative analysis processes to examine the government's role as a regulator responsible for providing transportation services in the island districts of Sangihe, Talaud, and Sitaro. Quantitative analysis was conducted to calculate the connectivity ratio of sea, and inland waterway transportation [45]. The analysis revealed that the overall connectivity value for Sangihe, Talaud, and Sitaro is 69.16, indicating that transportation in this region is predominantly reliant on water-based systems. In contrast, land transportation connectivity remains very limited. Public land transport services, such as liner routes, are sparse and concentrated mainly in regency capitals like Tahuna (Sangihe), Melonguane (Talaud), and Ulu Siau (Sitaro). These services cater only to internal island needs, with no land transport routes connecting islands via ferry crossings.

Sea transportation and ferry crossings are the primary contributors to the connectivity ratio. These networks not only facilitate intra-island connections within each district but also link the three districts Sangihe, Talaud, and Sitaro with mainland North Sulawesi (see Figure 3). Supporting research highlights the critical role of port connectivity in eastern Indonesia, including North Sulawesi [46]. A key node in this connectivity network is Bitung Port, which serves as a bridge between western Indonesia (the national economic hub) and eastern Indonesia, which includes underdeveloped areas classified as 3TP (frontier, outermost, and underdeveloped regions). Bitung Port's potential is underscored by its designation as a sea port capable of supporting both commercial and pioneer routes, as outlined in the National Port Master Plan (RIPN). Additionally, Likupang and Amurang Ports connect mainland North Sulawesi with Sangihe, Talaud, and Sitaro.

Bitung Port has an extensive network linking North Sulawesi trade to regions like Jakarta, East Java, and North Maluku. This trade connectivity is further bolstered by government initiatives such as the Sea Toll Program, which uses ports like Bitung (mainland North Sulawesi), Tahuna (Sangihe), Melonguane (Talaud), and Ulu Siau (Sitaro) as hubs or sub-hubs. These hubs feed into other 3TP areas through pioneering sea transportation and crossings [33]. The provision of similar services such as sea transportation, ferry crossings, and commercial operations at ports directly impacts the market share for passenger transport. Pioneer sea vessels typically utilize coaster-type ships for transporting passengers and general cargo, while pioneer ferry vessels employ Ro-Ro ferries designed to carry passengers, vehicles, and cargo. The overlap in functionality between these two types of vessels, both serving the same geographic areas, leads to direct competition between the government's two water transportation programs. This competition is evaluated using performance indicators such as passenger transport production [47, 48].



(a) (b)

Figure 2. Route network of (a) sea transportation pioneer and (b) ferry crossing pioneer

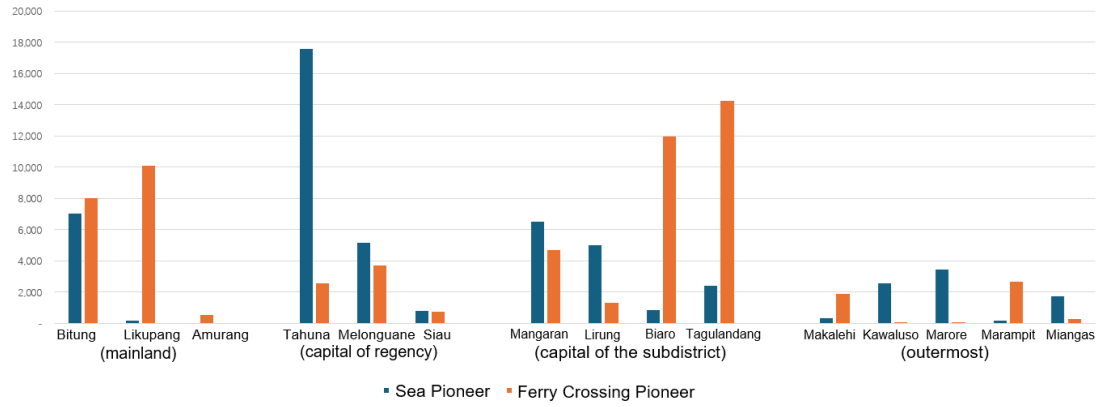


Figure 3. Comparison of passenger productivity

A comparison of passenger transport production between sea pioneer and ferry crossing pioneer (see Figure 3) shows that cumulatively sea pioneer transport carries more passengers than ferry crossing with the greatest productivity on the capital island in Tahuna and Melonguane, for access to the outermost island in Sangihe and Talaud is also still dominant using sea pioneer. On the other hand, in Sitaro regency, ferry crossing pioneer transportation has the highest passenger transportation productivity compared to sea pioneer, including when compared to the other two regencies. The government and local governments play a crucial role in the pioneer transportation sector, not only by providing facilities, infrastructure, and route networks but also by determining service tariffs. Although both sea pioneer services and ferry crossing pioneer services fall under the category of water transportation, their tariff formulations are governed by distinct regulations.

The tariff for sea pioneer services is determined based on PM 55/2019 [49], while the tariff for ferry crossing pioneer services is regulated under PM 66/2019 [50]. Both frameworks share a general similarity in that tariffs are calculated based on ship operating cost components. However, specific differences in these regulations influence

operational characteristics and result in varying tariffs applicable to each route. Comparison of regulations can be seen in Table 6. The bottom-up perspective discusses the utilization of water transport based on the consumer perspective. The analysis phase begins with identifying the travel patterns of the community, based on the water transportation production data in Figure 3 can be made tables and origin-destination matrix images that identify inter-regional travel patterns between Sangihe, Talaud, Sitaro, and Mainland North Sulawesi.

Table 6. Comparison of regulation

No.	Primary Aspect	Manager	
		PM 55 2019, Sea Pioneer	**PM 66 2019, Ferry Crossing Pioneer**
1	Tariff type	Article 3, paragraph 1 Passengers and Goods Article 4, paragraph 1 Menteri	Article 2 Passengers (Infants, Adults), Passenger Vehicles, Goods Vehicles and their cargo based on vehicle dimensions (Vehicle Classes) Article 3, paragraph 2 Tariff Determination: Minister, Governor, Mayor/Regent
2	Cost and income components	Article 3, paragraph 1 and Annex point 3 The cost component is based on the operating costs of the ship and continued by considering the aspects of achieving the performance of each route as measured by the level of occupancy of the use of passenger space and loading of goods (cluster load factor in a range of varying values) in the previous year and given public service compensation with a fixed value of 10% of the cost. Article 4, paragraph 2, 3 The units for calculating passengers and cargo use the number of passengers and the weight/volume of cargo (kg , tons and m^3). The stowage factor on pioneer sea vessels does not take into account the type of vehicle cargo. Article 2 Taking into account the cost of cargo safety insurance	Article 17, outlined in Annex II The cost components are based on vessel operating costs and combined with Unit Production (UP) at a 60% load factor, which is fixed. Not taking into account compensation for public service costs in the form of profit margins. Article 16, described by type and unit in Annex I Tariffs for passengers, passenger vehicles and goods vehicles and their loads are calculated based on fix production units, pioneer ferry ships do not yet take into account the type of tariff for general cargo loads (not loaded in vehicles). Article 6 Cargo safety insurance costs, placed separately outside the tariff

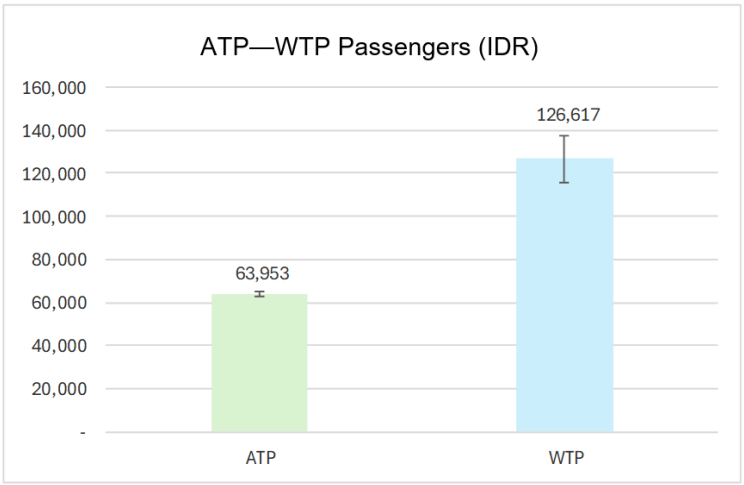
The analysis results indicate that people's travel destinations are generally motivated by family matters, business (trade), tourism, education, and health purposes. Similar patterns have been observed in previous research [51, 52]. Sangihe, Talaud, and Sitaro are administrative regions that form distinct service clusters, each with its own economic centers, government services, education facilities, and healthcare infrastructure. The population in these districts, spread across numerous small islands, predominantly travels to their respective district capitals to meet these needs. This is evident from the high volume of passenger, goods, and vehicle transportation at key ports such as Tahuna and Pananaru in Sangihe, Melonguane in Talaud, and Ulu Siau in Sitaro.

However, the increasingly complex community needs for goods and services cannot be fully met within the district capitals. The economic disparities and differences in service quality between the district capitals of Sangihe, Talaud, and Sitaro and the mainland of North Sulawesi (the provincial capital) drive additional travel from these island regions to the mainland. The mainland offers a broader range of goods, services, and public amenities. Consequently, travel volumes to the mainland surpass internal movements between these three districts (see Table 4).

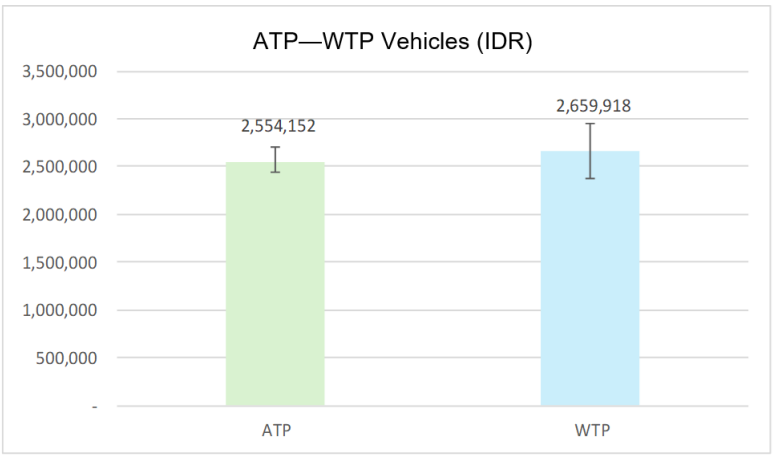
Sangihe holds a strategic position within this travel pattern. Beyond serving as an economic and public service hub for its local population, it also functions as a transshipment point for economic activities in Talaud. This strategic role is reinforced by historical factors: the three districts were once unified as the Sangihe-Talaud district. Initially, transportation accessibility and development activities such as economic infrastructure and public services were concentrated in Tahuna (Sangihe Island). As a result, community movemHistorical factors reinforce this strategic roleents were predominantly centered around this area. Following administrative divisions in 2002 (separating Talaud) and 2007 (establishing Sitaro), new patterns emerged.

Talaud Regency has direct connectivity with the mainland; however, limited vessel capacity and frequency result in lower trip volumes. In contrast, Sitaro's proximity to the mainland makes it a primary destination for its residents. Few residents of Sitaro travel to Sangihe or Talaud except for short trips related to family matters. The phrase "trade follows the ship" aptly describes travel patterns in this region. Pioneer water transportation remains crucial but heavily depends on government-regulated shipping schedules. Despite this dependence, the availability of alternative water transport options allows communities to choose their travel activities based on factors such as mode type or cost.

The ATP-WTP analysis that provides this overview is then combined with the origin-destination movement patterns with the following results (see Figure 4).



(a)



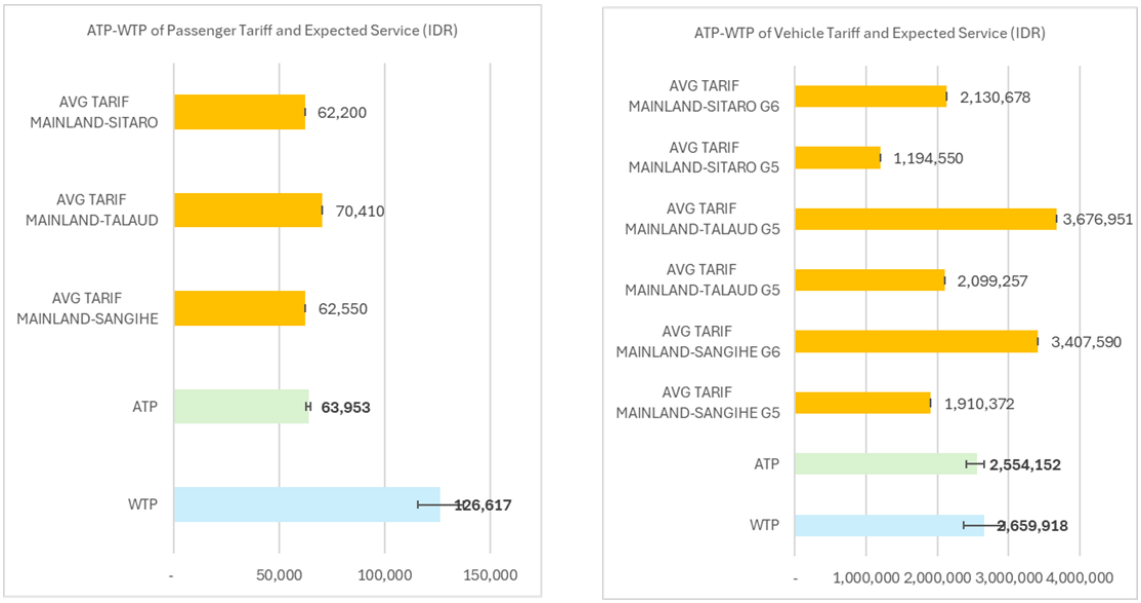
(b)

Figure 4. ATP-WTP passengers (a) and vehicles (b)

The analysis of ATP and WTP, considering community income, travel frequency, and the allocation of maritime transportation costs, reveals two distinct characteristics (see Figures 5 and 6). Trucks are transported using Ro-Ro vessels exclusively served by pioneer ferry crossings, while passengers are served by two types of vessels: Ro-Ro vessels on pioneer ferry crossings and coaster ships on sea pioneer services.

The ATP-WTP analysis for logistic truck cargo indicates that ATP is lower than WTP, suggesting that consumers in this cluster are willing to pay more for improved services. Survey results identify a general need for faster Ro-Ro vessel services compared to the current average speed of 7–9 knots. This speed is considered slow by users transporting fishery products from islands to the mainland. The demand for faster vessels aligns with cold supply chain support, such as providing electrical plugs for reefer trucks.

Limited vessel facilities affect the marketing of fishery products, requiring users to wait for direct route schedules to ports like Amurang, Bitung, and Likupang on the mainland. This issue is compounded by inadequate fish product packaging, which relies on ice cubes for voyages lasting 6–15 hours. To avoid transshipment routes involving multiple ports, users prefer direct routes.



(a) (b)

Figure 5. ATP-WTP based on origin-destination for (a) passengers and (b) vehicles

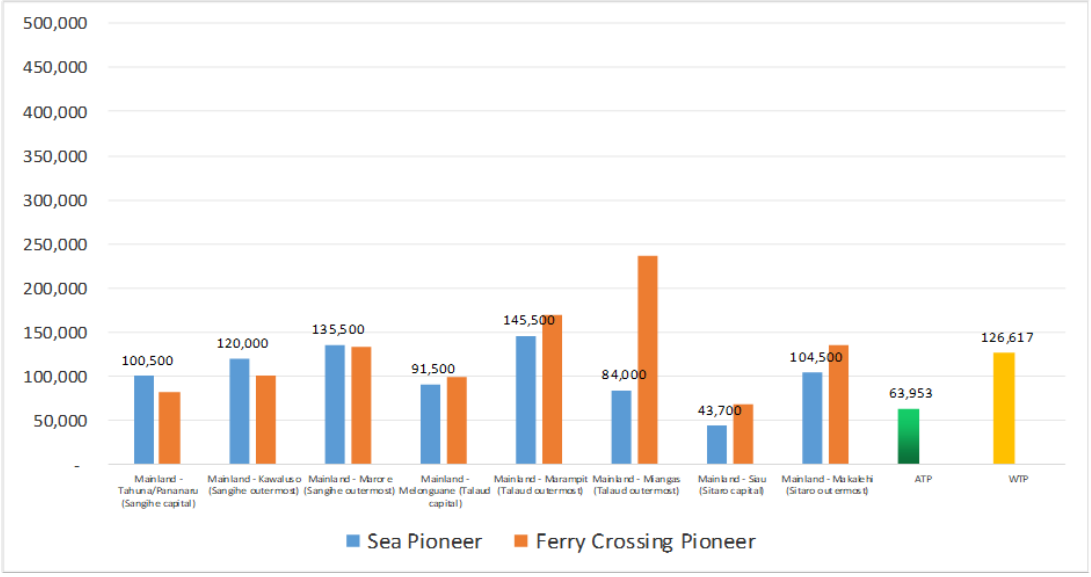


Figure 6. Comparison between passenger tariff and ATP-WTP

Currently, the Nusantara Logistics ship under the Sea Toll program operates on H-1 and T-5 routes but has limited capacity, carrying only five TEUs of reefer containers per trip. These containers must serve multiple ports, leaving only 1–2 TEUs available per port per trip. This aligns with previous research indicating that Sangihe, Talaud, and Sitaro are major fishery producers in North Sulawesi but face marketing challenges in other regions [36, 53]. For truck cargo (categories 5 and 6), ATP-WTP values cannot fully justify public purchasing power for Ro-Ro services as most cargo belongs to private companies. However, the analysis shows respondents in this cluster are willing to pay more than current fares for better services. This scientifically demonstrates a general trend where WTP exceeds ATP.

ATP-WTP analysis on passengers also shows that ATP is lower than WTP. This indicates that passengers are also willing to pay more than the available ticket, in the hope of improving facilities such as speed, safety, comfort and other facilities such as those that already exist in coaster ships on sea pioneer services.

The comparison of ATP and WTP with passenger transportation fares was conducted by selecting routes considered geographically representative of each district and connecting them to the mainland (see Figure 6).

The available route network primarily facilitates access through direct routes from the mainland to the capital, while outermost regions must rely on multiport route patterns. Limited direct accessibility impacts transportation costs per trip. For round trips, fares are assumed to double, but ATP-WTP values remain constant.

The fare regulation (see Table 6) results in different outputs for applicable tariffs. Maritime pioneer fares follow a round multiport pattern, where vessels rotate through several ports and either return directly to their home base or minimize stopovers on the return journey (e.g., A–B–C–D–E–A or A–B–C–D–E–C–A). This regulation uses a fixed distance matrix between ports to determine fares, resulting in consistent pricing. On the other hand, the fare formulation for ferry crossing pioneers also uses fixed crossing distances. However, due to limited vessel availability, ferries often serve multiple connected crossings sequentially (e.g., AB–BC–CD–DE–ED–DC–CB–BA).

This sequential route structure means passengers pay based on the number of crossings traveled. For origin-destination trips requiring only one trajectory (e.g., mainland-capital island), fares remain reasonable for both one-way and round trips. However, as the number of crossings increases, cumulative fares become costly, particularly for outermost regions.

The direct consequence of the applicable fares on ATP and WTP is the frequency of passenger trips. Residents on the capital island, with access to similarly priced ferry crossing pioneer and sea pioneer services, can typically afford two round trips per month. In contrast, residents of outermost islands can only afford an average of one round trip per month using ferry crossings. Despite the lower cost of sea pioneer services, which are preferred for up to two round trips per month, residents in outermost areas primarily opt for sea pioneer services.

This analysis aligns with other studies indicating that travel frequency occurs within the limits of affordable pricing [54]. Geographically, high costs relative to ATP-WTP are most prevalent among passengers from the outermost clusters in Sangihe and Talaud. Sitaro, being closer to the mainland, offers more transportation options. For trips originating from the mainland, Sitaro islands are often the first stop for ferry crossings and sea pioneer ships serving Talaud. Consequently, fares for residents in Sitaro remain low. Conversely, when traveling from Sitaro to the mainland, passengers can choose between ferry crossing and sea pioneer services returning from the capital and outermost areas like Talaud to their home ports in Bitung and Likupang (mainland).

Cumulatively, this scenario reflects passenger transportation productivity data showing a preference for sea pioneer services in Sangihe and Talaud, while ferry crossing pioneers are favored in Sitaro (see Figure 3). Regarding logistics distribution, local conditions mirror comparisons with other countries. Sea transportation using Lo-Lo (lift-on/lift-off) systems is more cost-efficient than Ro-Ro systems [55]. Inter-island trade logistics are predominantly handled by MSMEs (micro, small, and medium enterprises) across Sangihe, Talaud, and Sitaro. These MSMEs typically transport mixed general cargo from the mainland to the outermost islands in relatively small quantities (less than 1 ton per month), favoring sea pioneer services with fixed rates based on origin-destination distances between ports [56]. However, maritime transport data also show general cargo exceeding one-ton capacity, particularly for construction materials.

On the other hand, Ro-Ro ferry crossings lack a formulated tariff system for cargo. In logistics scenarios involving trucks on Ro-Ro vessels traveling between multiple ports from the mainland to outermost regions or vice versa, cumulative costs are significantly higher than Lo-Lo systems. Overall, Sea Pioneer services offer cheaper passenger fares but entail longer round-trip durations due to routes serving 13–20 ports per voyage. This makes them less suitable for urgent travel needs, such as transporting perishable goods like fishery products or emergency healthcare travel [57]. Meanwhile, ferry crossing pioneers provide shorter round-trip durations serving up to five ports per route but at higher cumulative costs.

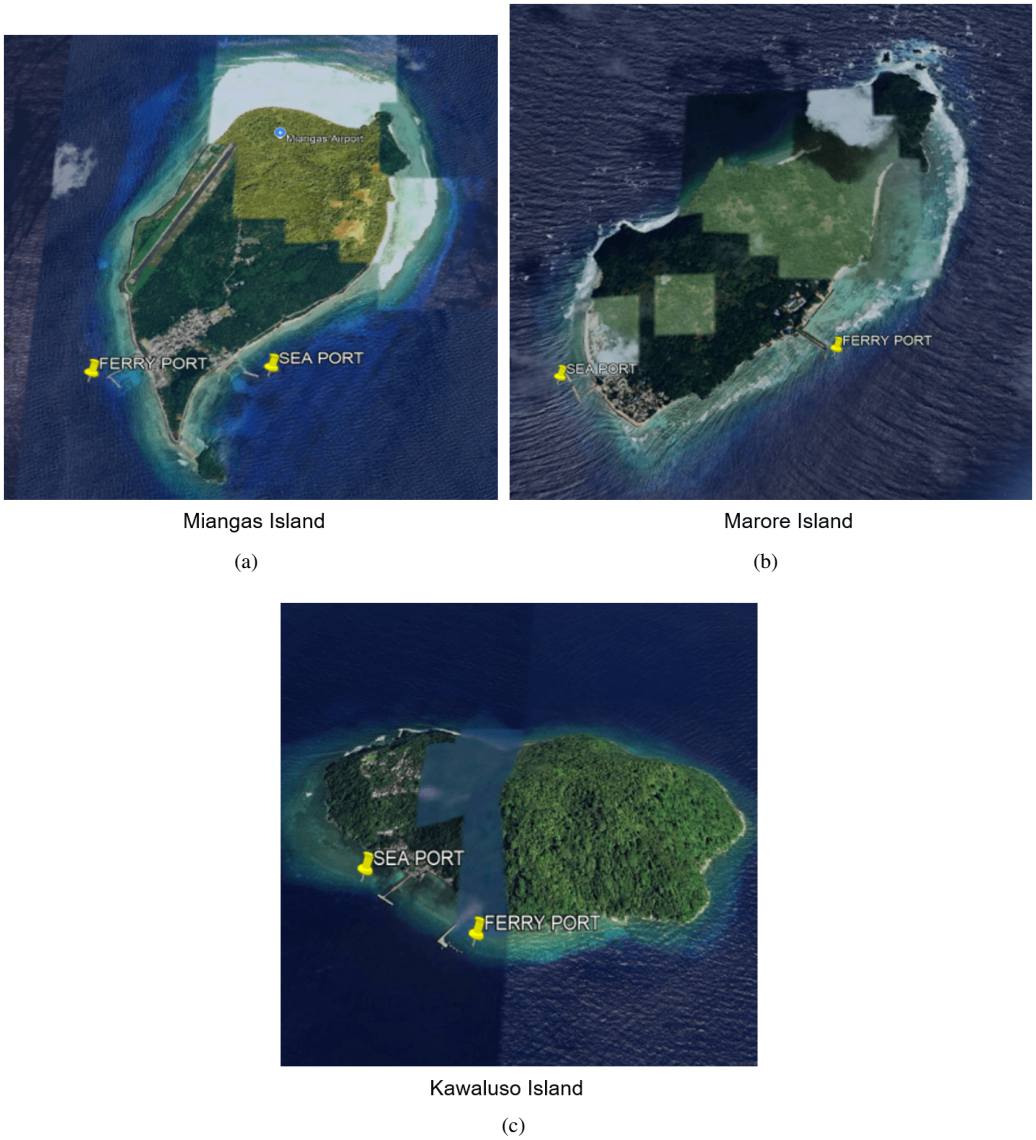
Cost efficiency is the primary preference for water transportation services in 3TP (Frontier, Outermost, and Underdeveloped) regions and must be balanced with effective route selection. For route effectiveness, residents in the outermost areas of Sangihe and Talaud typically choose intermodal transshipment routes. From smaller islands, they prioritize sea pioneer ship schedules heading to Tahuna and Melonguane (the capitals), where they then switch to ferry crossing pioneer services that connect directly to the mainland via alternative ports such as Bitung, Likupang, and Amurang, or vice versa.

The direct connectivity between sea pioneer and ferry crossing pioneer routes in Sangihe and Talaud remains partial. The differing locations of maritime ports and ferry terminals result in additional movement and transshipment costs. For example, the distance between Tahuna's maritime port and Pananaru ferry terminal in Sangihe is approximately 38 km by land, while Melonguane's maritime port and ferry terminal in Talaud are relatively close at just 1 km apart. These transshipment journeys can incur extra accommodation costs if sea pioneer and ferry crossing schedules are not synchronized. Transshipment costs for passenger and cargo movements are an additional finding of this research that has not yet been comprehensively analyzed.

The development of ports across Indonesia, including on the islands of Sangihe, Talaud, and Sitaro, remains partial and fragmented within the bureaucracy of government agencies [58]. Port infrastructure development is managed by two separate units within the Ministry of Transportation: seaports are developed by the Directorate General of Sea Transportation (DJPL), while ferry ports are developed by the Directorate General of Land Transportation (DJPD).

A regulatory framework is needed to bridge this bureaucratic gap. As stated in the RIPN, many ports are classified as ”seaports serving ferry transportation.” In this study, such ports include Amurang, Melonguane, Pananaru, Marore, Likupang, Bitung, Marampit, Miangas, Kawaluso, and Siau. Tahuna Port is classified solely as a seaport under this regulation.

The designation of ”seaports serving ferry transportation” aims not only to integrate Lo-Lo (lift-on/lift-off) and Ro-Ro systems within a single port area but also to optimize government budgets for port development. Currently, inefficiencies arise because seaports and ferry ports are often constructed in close proximity on the same small islands and serve the same hinterland market (see Figure 7). These inefficiencies are particularly evident when comparing the construction of main facilities like wharves and supporting facilities like yards, which are nearly identical. The only significant difference is the addition of mooring dolphins and/or breasting dolphins as berthing facilities at ferry ports.



Miangas Island

(a)

Marore Island

(b)

Kawaluso Island

(c)

Figure 7. Sea port and ferry port in Miangas, Marore, and Kawaluso island

The overall conditions described indicate that seamless multimodal transshipment is not fully implemented in this region. The ATP-WTP analysis and data interpretation in this study align with several previous research aspects. ATP-WTP serves as an indicator influencing passenger movement and logistics distribution, impacting efforts to provide effective and efficient transportation services in the North Sulawesi archipelago. However, numerous challenges and barriers remain, including aspects of delivery characteristics, interoperability, multimodal freight transport terminals, multimodal freight transport networks, management, regulations, and subsidies.

The identification of travel characteristics analyzed in the previous section provides a lot of information that can

be used as a consideration in government programs for regional development and development. The results of the analysis also show compatibility with some general theories of regional development. In the Sangihe, Talaud and Sitaro districts, which are archipelagic regions, it can be identified that the center of economic growth is on the capital island, which is in accordance with the conditions described in the growth pole theory [59].

The prioritization of the development of government service facilities, business and economic areas is only on the islands of Tahuna (Sangihe), Melonguenae (Talaud), and Ulu Siau (Sitaro) while facilities on the outer islands are still relatively minimal.

On the other hand, in the context of regional interaction theory, the gravity model adapted by Reilly states that inter-regional interactions are influenced by factors such as socioeconomic conditions, education levels, livelihoods, and transportation infrastructure [60].

Although Sangihe, Talaud and Sitaro are island districts that have their own development centers but still have a large dependency on the mainland, the survey results show that the dominant movement of island communities still leads to the mainland for trade, education and health services. This condition shows that there is still a gap in the availability of services, quality of services, or completeness of facilities between the islands and the mainland. This gap causes a reciprocal regional dependency between the islands and the mainland, especially in the fields of industry and trade [61].

Manado city in the mainland is the center of trade in North Sulawesi which has connections and interactions with other regions such as Java which is the center of the national economy including in cargo distribution so that it can become a transhipment point that bridges trade from the archipelago with the national economic center [62].

Regional development can also arise in the form of regional expansion, looking at the recent discourse on the formation of Nusa Raya province which will separate the districts of Sangihe, Talaud, and Sitaro from the administrative area of North Sulawesi province.

Although political in nature, this policy needs to pay attention to the results of academic studies, and based on transportation patterns, the connectivity of the islands and mainland areas is still dominant using water transportation so that in the future the route pattern is expected to remain the same as the existing conditions, including travel motives and mode selection. The ideal regional development option carried out by the current government is the construction of adequate health and education service facilities on the outer island.

4 Conclusion and Recommendation

The archipelagic regions of Sangihe, Talaud, and Sitaro continue to face economic disparities compared to mainland North Sulawesi. Subsidized sea transport and ferry services play a crucial role in improving accessibility, but challenges remain in cost efficiency, route integration, and service schedules.

This study quantitatively analyzed ATP and WTP for water transportation services. Findings indicate that ATP is lower than WTP for passengers and freight transport. A comparison of ATP-WTP values with government-regulated fares highlights inconsistencies affecting consumer travel preferences. The lack of synchronization between bottom-up demand for cost-efficient transport and top-down regulatory frameworks has resulted in suboptimal service integration. Multimodal transshipment could be a solution, but faces geographic and regulatory barriers.

To overcome these challenges, fare regulations need to be harmonized, transport routes and schedules optimized, and integrated ports developed to streamline sea and ferry services. Enhancing infrastructure and public services, particularly healthcare, would reduce dependency on mainland travel.

Author Contributions

Conceptualization: S.H., M.Y.J., J.J., and M.Y.S.; methodology: S.H., M.Y.J., J.J., and M.Y.S.; software: S.H., data curation; S.H., writing—original draft preparation; S.H., writing—review and editing: M.Y.J., J.J., and M.Y.S., visualization: S.H, supervision: M.Y.J., J.J., and M.Y.S., project administration, S.H. All authors have read and agreed to the published version of the manuscript.

Data Availability

The data used to support the research findings are available from the corresponding author upon request.

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Conflicts of Interest

The authors declare no conflict of interest.

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