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Research Article

The Suitability of Tomini Bay Gorontalo for Marine Tourism: Opportunities and Challenges

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Abstract

The waters of Tomini Bay, which boast the longest coastline in Gorontalo Province at 572.5 km, hold significant marine tourism potential, warranting further study and development. This research evaluated the potential and suitability of marine tourism in the Tomini Bay Gorontalo area, specifically snorkeling and diving. Data were collected on coral reef conditions, reef fish communities, and water quality parameters from six locations, including Pinomontiga, Kurenai, and Kaisomaru Beach, as well as Dulanga, Bitila, and Lahe Islands. Coral reef conditions were assessed using the underwater photo transect method, while reef fish data were collected using the underwater visual census method. Physical water parameter data measured were temperature (°C), salinity (‰), pH, dissolved oxygen (mg/L), current speed (cm/s), and brightness (m). The analysis of coral cover was conducted using Coral Point Count with Excel extensions (CPCe), while the suitability for snorkeling and diving tourism was assessed using the Tourism Suitability Index. The results showed that most locations had moderate to excellent coral reef conditions, high coral and fish diversity, and water quality that supported marine tourism activities. Among the six locations studied, two, namely Pinomontiga Beach and Lahe Island, were rated highly suitable for snorkeling and diving, while Kaisomaru Beach was not suitable. Other places, including Kurenai Beach and Bitila Island, were rated as suitable. These results provide essential information for developing sustainable marine tourism in Tomini Bay Gorontalo and can serve as a reference for local government in planning environmentally friendly tourism activities.

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1. Introduction

Tourism is among Indonesia's critical economic sectors, ranking as the fourth most significant contributor to foreign exchange after oil and gas. From 2016 to 2019, tourism sector contributed about 4.6-4.9 % to the Indonesian economy (Mun'im, 2021). It plays a key role in economic growth, creating jobs, boosting state revenues, and driving productivity in other sectors (Sumabrawa *et al*., 2015; Harahap and Susetya, 2020). Tourism also promotes the creation of infrastructure improvements such as roads, airports, public transportation, and cultural and sports facilities (Dmitriyev *et al*., 2022). The sector's dependence on natural resources, particularly landscapes and seascapes, is fundamental to its success (Mukayev *et al*., 2020; MacDonald *et al*., 2023). Various natural beauties are an essential value in tourism development (Hamzah, 2020). However, the rapid expansion of tourism also presents significant challenges, particularly the risk of environmental degradation.

As an archipelago with more than 17,000 islands, Indonesia is well-known for its diverse marine life and coastal beauty. This natural richness makes Indonesia a foremost destination for marine tourism (Arifin *et al*., 2019; Dwi and Subekti, 2017; Aswita *et al*., 2020; Isdianto *et al*., 2024). This condition is a significant opportunity for tourism development, specifically marine (Hamzah *et al*., 2022). Generally, marine tourism is currently an essential component in the growth of a sustainable blue economy. It is projected to be the sector with the most significant added value of 26% globally by 2030 (Nuva *et al*., 2023). Key attractions in marine tourism include pristine beaches, coral reefs, diverse fish species, and vibrant underwater ecosystems (Hamzah, 2020). Previous studies have shown a growing number of tourists visiting Indonesia's beaches and seas, which has positively impacted the economies of coastal communities (Wolok, 2016; Novianto *et al*., 2018; Monoarfa *et al*., 2019; Hamzah *et al*., 2022; Hasan *et al*., 2022).

Gorontalo, a province with significant marine potential, is an ideal area for developing marine tourism, particularly in Tomini Bay. The bay is home to well-known tourist destinations (Akbar *et al*., 2019; Hamzah *et al*., 2024; Podungge *et al*., 2023), such as Olele, often referred to as the "hidden paradise of Gorontalo" (Mahale *et al*., 2019; Hamzah *et al*., 2020; Eka, 2023) and Botubarani, famous for its whale shark population (Sino *et al*., 2016; Wolok, 2016; Anugrah, 2018; Himawan *et al*., 2022). In addition to its tourism wealth, Tomini Bay also has high marine biodiversity, including populations of economically valuable fish such as yellowstrip scad (*Selaroides leptolepis*) (Pasisingi *et al*., 2021) and nike fisheries (Gobiidae) (Sahami *et al*., 2019; Sahami *et al*., 2020; Sahami *et al*., 2024a; Sahami *et al*., 2024b). Studies on these species' population dynamics and exploitation levels indicate that an ecological and scientific data-based management approach is essential to maintaining the balance of marine resources. Therefore, in the context of marine tourism development, a deeper understanding of the visual appeal of the destination and the ecological suitability of its waters is needed. Unfortunately, despite the growing popularity of marine tourism, there has been no comprehensive assessment of the suitability of Tomini Bay's waters for snorkeling and diving activities.

Tomini Bay, with the longest coastline in Gorontalo Province at 572.5 km (Gorontalo Province Marine and Fisheries Service, 2021), offers considerable untapped potential for marine tourism. Although previous studies have highlighted growing interest in activities like snorkeling and diving (Lagarense *et al*., 2015; Mazaya *et al*., 2020), there is a need for a detailed evaluation of its suitability for these activities. A visually appealing destination is not necessarily ecologically suitable. Thus, evaluating various physical and biological parameters through the Tourism Suitability Index (IKW) is essential for sustainable development (Fikri *et al*., 2024; Spinelli *et al*., 2024). IKW value is significant for developing and managing marine tourism areas, specifically snorkeling and diving, because it helps control environmental impacts and support long-term sustainability. This research aims to address this gap by assessing the suitability of Tomini Bay's waters for snorkeling and diving. The findings will provide valuable insights to help develop sustainable marine tourism destinations in the region, contributing to the economic and environmental well-being of the area.

2. Materials and Methods

2.1 Materials

2.1.1 The equipments

The equipment used in this research are Self Contained Underwater Buoyancy Apparatus (SCUBA) diving equipment (Cressi, Italy), Underwater Camera (Canon G16, Japan), 50 meters Rollmeter, Frame, Underwater Stationery (Slate and Pencil), Digital water quality meter-AZ Instruments (AZ86031, Taiwan), Secchi Disk, Lagrange Current Meter, Global Positioning System (GPP), Coral Lifeform Identification Book (Jonker *et al*., 2020), and Reef Fishes Identification Book (Kuiter and Tonozuka, 2001).

2.1.2 The materials

The materials used in this study are marine resources, namely coral reefs and reef fish.

2.1.3 Ethical approval

This study does not require ethical approval because it does not use experimental animals.

2.2 Methods

This research was conducted from June to September 2024 in six locations representing regencies and cities in Gorontalo Province located in Tomini Bay waters, namely Pinomontiga Beach and Kurenai Beach (Bone Bolango Regency), Kaisomaru Beach (Gorontalo City), Dulanga Beach (Gorontalo Regency), Bitila Island (Boalemo Regency) and Lahe Island (Pohuwato Regency), as shown in Figure 1. The six selected sites are currently used for snorkeling and diving but have not yet developed into tourist destinations, and no scientific studies have been found on the condition of potential marine resources, potential water quality, and suitability for snorkeling and diving.

The data collected was focused on marine tourism suitability particularly snorkeling and diving (Table 1 and Table 2) at a depth of 3 m, and 10 m respectively, while the number of observation stations at each location was set at two. Observations of coral reef conditions were conducted using the Underwater Photo Transect method (Adji *et al*., 2016) with a transect line length of 50 meters. Reef fish data were observed using the underwater visual census method (Emslie and Cheal., 2018) on the same transect as coral reefs. Data collection on water physical parameters was carried out independently at the research site. Physical water parameter data measured were temperature (°C), salinity (‰), pH, dissolved oxygen (mg/L), current speed (cm/s), and brightness (m).

2.3 Analysis Data

2.3.1 Coral cover analysis

Photographic data from each frame for coral reefs were identified using CPCe (Coral Point Count with Excel extension) software to classify coral life

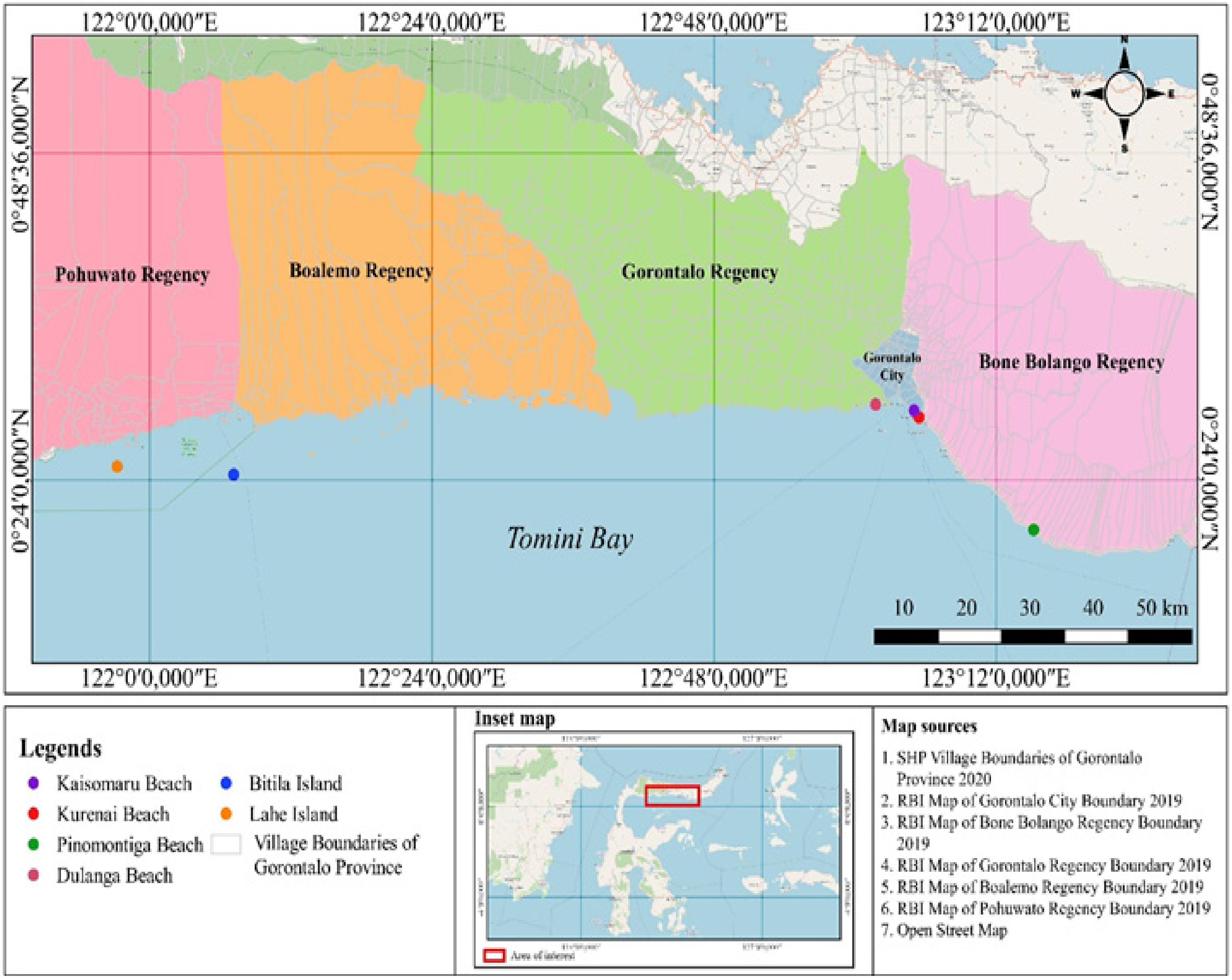

Figure 1. Map of research location.

Table 1. Marine tourism suitability matrix snorkeling tourism category (Yulianda, 2019).

No	Parameters	Weight	Categories			
			Score 3	Score 2	Score 1	Score 0
1.	Coral community cover (%)	0.375	>75	>50–75	25–50	<25
2.	Lifeform type	0.145	>12	<7–12	4–7	<4
3.	Reef fish species	0.140	>50	30–50	10–<30	<10
4.	Water brightness (%)	0.100	100	80–<100	20–<80	<20
5.	Reef depth (m)	0.100	1–3	>3–6	>6–10	>10; <1
6.	Current speed (cm/s)	0.070	0–15	>15–30	>30–50	>50
7.	Width of coral flatbed (m)	0.070	>500	>100–500	20-100	<20

Table 2. Suitability matrix for marine tourism diving tourism category (Yulianda, 2019).

No	Parameters	Weight	Categories			
			Score 3	Score 2	Score 1	Score 0
1.	Coral community cover (%)	0.375	>75	>50–75	25–50	<25
2.	Water brightness (%)	0.150	>80	50–80	20–<50	<20
3.	Reef depth (m)	0.150	6–15	>15–20; 3–<6	>20–30	>30; <3
4.	Lifeform type	0.135	>12	>7–12	4–7	<4
5.	Reef fish species	0.120	>100	50–100	20–<50	<20
6.	Current speed (cm/s)	0.070	0–15	>15–30	>30–50	>50

forms, coral cover, and others (Kohler and Gill, 2006). Photo analysis in CPCe software was carried out with several stages, namely determining the photo frame and boundaries, overlaying random points, identifying the substrate at each random point, and then storing data, which could then be processed in an Excel spreadsheet (Kohler and Gill, 2006; Giyanto *et al*., 2014). The number of random points used in one photo frame was 30, determined based on the area of the photo frame. Furthermore, the category cover percentage value for each frame was calculated using the formula (Giyanto *et al*., 2014):

Cover category (%) = (Number of category points)/(Number of random points) x 100..........................(i)

The percentage value of coral cover obtained from the analysis results was then categorized based on the Decree of the Minister of Environment Number 4 of 2001 concerning Coral Reef Damage Standard Criteria to determine the condition of coral reefs, as shown in Table 3.

2.3.2 Tourism suitability analysis

Suitability of the area for marine ecotourism was analyzed using the parameters and criteria formulated by Yulianda (2019) as follows:

$IKW = \sum_{i=1}^{n} (Bi \times Si)$...(ii)

Where :

IKW = Tourism suitability index

n = Number of suitability parameters

Bi = Weight of i-th parameter

Si = Score of i-th parameter

Based on this formula, the marine tourism suitability criteria (Snorkeling and Diving) were divided into four suitability classes (Yulianda, 2019), as shown in Table 4. The data and information collected from field surveys are analyzed and then mapped spatially using a GIS application (Akbar *et al*., 2019). This spatial mapping will determine potential locations for snorkeling and diving tourism.

Table 3. Coral reef condition assessment criteria (Decree of the Minister of Environment Number 04, 2001).

Parameter	Coral Reef Damage Standard Criteria (%)		
Percentage area of live coral reef cover	Broken	Bad	0.0 – 24.9
		Moderate	25.0 – 49.9
	Good	Good	50.0 – 74.9
		Excellent	75.0 – 100

Table 4. Marine tourism (snorkeling and diving) suitability criteria.

IKW value	Suitability criteria
IKW ≥ 2.5	Very suitable
2.0 ≤ IKW < 2.5	Suitable
1.0 ≤ IKW < 2.0	Not suitable
IKW < 1	Very unsuitable

3. Results and Discussion

3.1 Results

3.1.1 The natural resource potency of marine tourism

The coral reef clusters found in the research location were included in the fringing reef type and have unique conditions, mainly in the form of steep and deep reef walls. Surveys of coral reef ecosystems, specifically observations on corals and reef fish, showed that the potential of natural resources in each location varied. The potential of coral reefs based on the condition of live coral cover ranged from moderate to excellent (Table 5).

Coral cover at a depth of 3 m in Station 1 (Kaisomaru Beach) and 10 m in Station 2 (Pinomontiga and Kaisomaru Beach) was in the moderate category, as shown in Table 5. The highest coral cover for snorkeling and diving tourism was found at Lahe Island, with a value of 85.36% and 78.67%, respectively. Moreover, the analysis showed variations in the number and types of lifeforms found in the research location (Figure 2 and Figure 3).

As shown in Figure 2 and Figure 3, the coral growth forms found in the research location consists of Acropora Digitate (ACD), Acropora Encrusting (ACE), Acropora Submassive (ACS), Acropora Tabulate (ACT), Acropora Branching (ACB), Coral Branching (CB), Coral Encrusting (CE), Coral Heliopora (CHL), Coral Massive (CM), Coral Millepora (CME), Coral Mushroom (CMR), Coral Submassive (CS), Coral Tubipora (CTU), and Coral Foliose (CF). Based on the results of the analysis, the number of lifeforms found at the research locations at a depth of 3 m (snorkeling tourism) and a depth of 10 meters (diving tourism) ranged from 8-14. Coral branching dominated all research locations at depths of 3 and 10 meters, with an average cover of 20.13% and 22.58%, respectively. Furthermore, the analysis results showed the varying potential of reef fish for marine tourism suitability (Table 6).

The highest number of reef fish species was found at Dulanga Beach, with an average of 73 species at a depth of 3 meters and 70 species at 10 meters, as shown in Table 6. In comparison, the lowest number was found at Kaisomaru Beach, with an average of 33 species at a depth of 3 meters and 34 species at 10 meters. These results show that the appearance of reef fish is directly proportional to the condition of the coral reefs. Najmi *et al.* (2023) stated that healthy coral reefs will have a positive impact on fisheries productivity, especially reef fish. Based on the results, only five locations have potential to be used as marine tourism sites, namely Pinomontiga, Kurenai, and Dulanga Beach, as well as Bitila and Lahe Island. The main attraction offered is the beauty of the underwater coral reef ecosystem including reef fish.

3.1.2 Water quality potency of marine tourism

Water quality is one of the critical factors that support the sustainability of marine tourism and plays a role in the survival of aquatic organisms, specifically coral reefs. Data from water quality measurements are shown in Table 7.

As shown in Table 7 shows that the water quality parameters at the research locations align with the established seawater quality standards for marine tourism. However, Kaisomaru Beach is an exception, with salinity, pH, current speed, and water clarity falling below the required thresholds. This deviation in water quality is linked to the poor condition of the coral reefs and fish populations observed at the site, as shown in

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Table 5. The condition of coral reefs in waters of Tomini Bay Gorontalo.

Locations	3m Depth for Snorkeling Tourism		10m Depth for Diving Tourism	
	Coral Cover (%)	Categories	Coral Cover (%)	Categories
Pinomontiga Beach				
Station 1	82.65	Excellent	77.63	Excellent
Station 2	56.29	Good	38.83	Moderate
Average	69.47	Good	58.23	Good
Kurenai Beach				
Station 1	68.53	Good	57.20	Good
Station 2	64.53	Good	62.07	Good
Average	66.53	Good	59.64	Good
Kaisomaru Beach				
Station 1	48.96	Moderate	50.89	Good
Station 2	61.95	Good	47.06	Moderate
Average	55.46	Good	48.98	Moderate
Dulanga Beach				
Station 1	61.40	Good	65.87	Good
Station 2	68.87	Good	55.13	Good
Average	65.14	Good	60.50	Good
Bitila Island				
Station 1	72.13	Good	61.40	Good
Station 2	68.40	Good	66.13	Good
Average	70.27	Good	63.77	Good
Lahe Island				
Station 1	85.36	Excellent	72.73	Good
Station 2	76.93	Excellent	78.67	Excellent
Average	81.15	Excellent	75.70	Excellent

Table 5 and Table 6. The salinity values at Kaisomaru Beach were 23‰ at Station 1 and 20‰ at Station 2. Furthermore, the measurement results showed that Kaisomaru Beach had a relatively fast current speed of 17-30 cm/s. Based on the varied potential of water quality, the six research locations were categorized as highly suitable, suitable, and unsuitable.

3.1.3 Suitability of snorkeling tourism

The suitability of snorkeling tourism considers seven parameters, namely coral community cover, lifeform type, reef fish species, water brightness, reef depth, current speed, and coral width (Table 1). The results on IKW for snorkeling in the six research locations are shown in Figure 4.

As shown in Figure 4, the research location has categories ranging from unsuitable to very suitable. The difference in suitability categories was based on the measurement results at each research station. Locations with very suitable IKW are represented by green on the suitability map, suitable is represented by yellow, and red is used for unsuitable. The analysis results show that Kaisomaru Beach is unsuitable for snorkeling tourism because it has several limiting factors, namely coral community cover, water brightness, current speed, and width of coral flat expanse. Meanwhile, five locations, namely Pinomontiga, Kurenai, and Dulanga Beach, as well as Bitila and Lahe Island, are in the suitable to very suitable category.

3.1.4. Suitability of diving tourism

The suitability of diving tourism was determined by considering six suitability parameters including coral community cover, water brightness, coral reef depth, lifeform type, reef fish species, and current speed (Table 2). The IKW for diving ranged from 1.36 to 2.75 (Figure 5) with the category of unsuitable to very suitable.

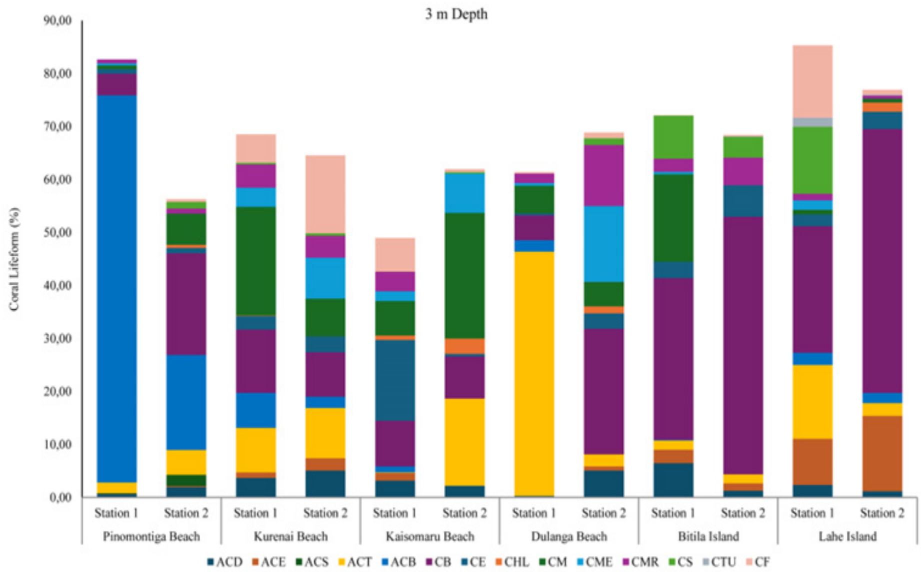

Figure 2. Percentage of lifeform cover for snorkeling tourism.

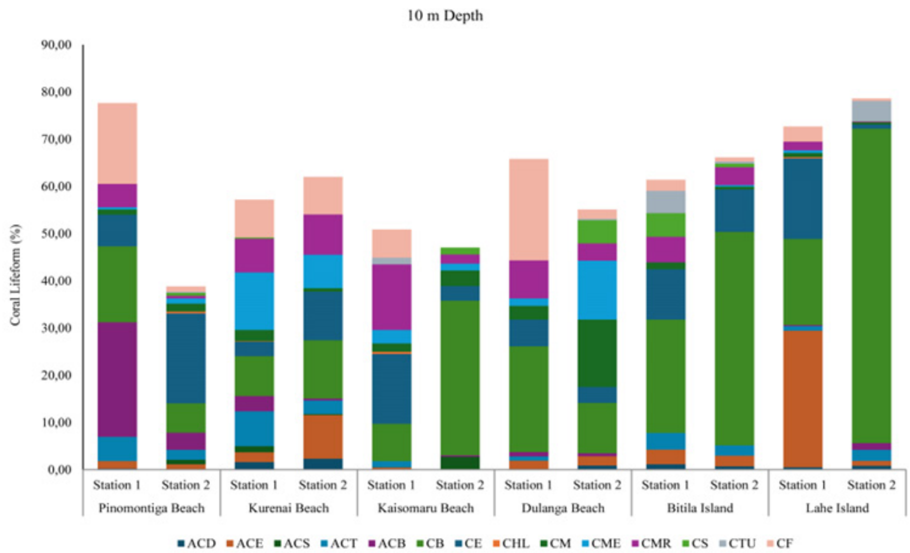

Figure 3. Percentage of lifeform cover for diving tourism.

As shown in Figure 5, Kaisomaru Beach is the only location unsuitable for diving tourism activities. Meanwhile, Pinomontiga, Kurenai, and Dulanga Beach, as well as Bitila and Lahe Islands, have suitable to very suitable.

3.2 Discussion

3.2.1 The natural resource potency of marine tourism

The waters of Tomini Bay are one of the best underwater paradises on the island of Sulawesi, which has significant marine potential. Kadim and Pasisingi (2018) stated that waters are relatively fertile, rich in natural marine potential, and known as a marine tourism area. The main attraction is the existence of coral reefs and their associated biota, which provide ideal conditions for snorkeling and diving. According to Bibin and Mecca (2020), the percentage of coral reef cover and reef fish diversity are the main requirements in marine tourism. Both are the main attractions for tourists who want to carry out snorkeling and diving activities. The high coral cover shows that the waters of Tomini Bay Gorontalo have great potential for developing snorkeling and diving tourism. However, in several research spots, moderate coral cover was found, such as at Kaisomaru Beach and Pinomontiga Beach. This result is due to the abiotic dominance,

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Table 6. Summary of reef fish composition found.

Locations	3m Depth for Snorkeling Tourism			10m Depth for Diving Tourism		
	Family	Species	Individual	Family	Species	Individual
Pinomontiga Beach						
Station 1	19	61	1224	19	72	1681
Station 2	15	57	865	19	52	1423
Average	17	59	1045	19	62	1552
Kurenai Beach						
Station 1	21	63	836	15	66	954
Station 2	16	54	579	16	58	786
Average	19	59	708	16	62	870
Kaisomaru Beach						
Station 1	13	33	196	10	37	207
Station 2	11	32	188	13	30	255
Average	12	33	192	12	34	231
Dulanga Beach						
Station 1	16	75	600	17	76	553
Station 2	18	70	416	18	64	463
Average	17	73	508	18	70	508
Bitila Island						
Station 1	12	57	469	16	63	812
Station 2	15	62	788	17	59	526
Average	14	60	629	17	61	669
Lahe Island						
Station 1	12	63	1061	13	63	1128
Station 2	13	54	572	14	66	864
Average	13	59	817	14	65	996

specifically rocks between coral reef cover. Similarly, Aswita *et al.* (2020) also note the significant presence of rocks between coral reef areas, further enhancing the uniqueness of the ecosystem.

These recreational activities provide exotic underwater scenery influenced by the expanse of the coral reef ecosystem, specifically the percentage of live coral cover and species (Lynch *et al*., 2004; Johan, 2016). Hard coral, in particular, has a variety of morphological or colony growth forms related to the conditions of the aquatic environment grouped into Acropora and non-Acropora (Coral), depending on differences such as branching, massive, encrusting, foliose, tabulate, and mushroom (English *et al*., 1997; Saptarini *et al*., 2017). Variations in the shape of growth colonies are also one of the assessment criteria for the suitability of snorkeling and diving tourism. The more variations in growth and color showed, the higher the interest of tourists (Sinaga *et al*., 2020; Mukhlis *et al*., 2022). According to Noviana (2018), the difference in the number of coral lifeforms shows the varied structure of coral organisms in forming reef communities. Dasmasela *et al.* (2019) stated that coral branching was found along the edge and top of the reef slope, generally in shallow waters to a depth of 15 meters. Coral reef ecosystems in coastal and marine areas support various human needs and are home to marine biota, including reef fish (Hoegh-Guldberg *et al*., 2019; Nama and Akter, 2020; Tuwo and Tresnati, 2020; Tony *et al*., 2021).

The presence of fish makes coral reefs the wealthiest ecosystem (Maduppa, 2013) and a primary attraction for underwater tourism, particularly snorkeling and diving (Sale, 2015; Hamzah *et al*., 2020). Reef fishes are an essential parameter for the suitability of snorkeling and diving tourism (Isdianto *et al*., 2024), as part of the scenery provided by the activities (Hara

Table 7. Water quality at the research location.

Locations	Parameters					
	Temperature (°C)	Salinity (‰)	pH	Dissolved Oxygen (mg/l)	Current Speed (cm/s)	Water brightness (m)
Pinomontiga Beach						
Station 1	29.60	30.00	7.41	7.47	13.00	>15
Station 2	29.30	30.00	7.20	7.50	16.00	>15
Kurenai Beach						
Station 1	29.10	30.00	7.22	7.62	13.00	>15
Station 2	30.00	30.00	7.32	7.21	16.00	>15
Kaisomaru Beach						
Station 1	28.40	23.00	6.78	6.80	30.85	1.5
Station 2	31.10	20.00	6.80	6.90	17.00	1.5
Dulanga Beach						
Station 1	31.30	29.00	7.40	7.60	16.00	>15
Station 2	32.20	29.00	7.20	8.10	12.00	>15
Bitila Island						
Station 1	30.30	30.00	7.30	7.70	6.00	>15
Station 2	30.10	30.00	7.20	7.40	7.00	>15
Lahe Island						
Station 1	30.10	30.00	7.12	7.10	12.00	>15
Station 2	29.00	30.00	7.20	6.40	8.00	>15
Average	30.04	28.42	7.18	7.32	13.90	12.75
Threshold	Naturala	Naturala	7 - 8.5a	>5a	0-15b	>6a

Sources: (a) Decree of the Minister of State for the Environment Number 51 of 2004; (b) Yulianda, 2019.

hap *et al*., 2019). Differences in the number of reef fish at the research location were influenced by the percentage of live coral cover. The abundance of reef fish is also influenced by other factors, such as availability of food sources (Rosdianto *et al*., 2021), adaptability to the environment (Shaughnessy and Cortesi, 2024), habitat preferences, and fishing pressure (Elston *et al*., 2020; Mostaka *et al*., 2024). The uniqueness and the existence of local and rare fish are tourist attractions (Lellotery *et al*., 2018; Hamzah *et al*., 2020). Generally, the family Pomacentridae was the most commonly found in the research locations. This family belongs to a group of significant fish that live on coral reefs, territorial, and are found abundantly both in the number of individuals and species (English *et al*., 1997). Pomacentridae family fish are resident species that rarely wander far from food sources and shelters (Runtuboi *et al.*, 2018). The presence of reef fish is a bioindicator of coral reef health (Ulfah *et al*., 2020), where fish use living coral reefs as a place to shelter, find food, breed, lay eggs, and enlarge (Aswita *et al*., 2020; Harahap *et al*., 2019).

3.2.2 Water quality potency of marine tourism

The health of coral reefs and their associated fish populations is closely linked to the quality of the surrounding waters, which is critical for maintaining marine tourism activities (Anwar, 2014). In most areas studied, the water quality at the research locations generally meets the standards for seawater quality in marine tourism. Nevertheless, Kaisomaru Beach is an exception, with issues in salinity, pH, current speed, and water clarity, all of which fall below the required thresholds. This poor water quality is closely linked to the deteriorating condition of the coral reefs and fish populations at the site. The compromised environmental conditions at Kaisomaru Beach likely hinder the growth and health of marine life, contributing to the degradation of the ecosystem. The low salinity and brightness value as well as the stronger currents at Kai

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Figure 4. Suitability map for snorkeling tourism.

somaru Beach is due to the location proximity to two large rivers (Bone and Bolango), which carry water discharge and empties into the waters of Tomini Bay, Gorontalo City. According to Wibowo *et al.* (2016) and Patty *et al.* (2019), the presence of rivers in the coastal environment can bring sedimentary materials, dissolved particles, as well as organic and inorganic materials into marine waters, which causes turbid water. As stated by Isdianto *et al.* (2024), areas near estuaries tend to experience stronger currents. Smyth *et al.* (2024) explained that high river flow can cause a decrease in salinity and increased sediment input, which eventually kills marine organisms. High river flow and sediment input can also lead to a decrease in water brightness, which is crucial for providing tourists with clear views of coral reefs and fish diversity (Saraswati *et al.*, 2017; Johan *et al.*, 2017). Furthermore, locations with strong currents can pose risks to marine tourism activities such as snorkeling and diving (Yulianda, 2019; Tangkudung *et al.*, 2018; Isdianto *et al.*, 2024). In addition to natural factors, human activities around Kaisomaru Beach, such as harbors, mooring fishing

Figure 5. Suitability map for diving tourism.

boats, and coastal settlements, can potentially increase water turbidity, contributing to environmental stress in the area. According to Yolanda (2023), anthropogenic activities such as industry, fishing, agriculture, and the influence of the port's geographical location affect the water's turbidity level.

3.2.3 Suitability of marine tourism

The poor condition of the coral reef ecosystem and water quality at Kaisomaru Beach certainly has a direct impact on marine tourism activities, both snorkeling and diving. The suitability of a location for snorkeling heavily depends on the health of the coral community and the diversity of reef fish species. Locations with well-preserved coral reefs and abundant fish species are ideal for snorkeling and diving, as these factors define the underwater beauty that attracts tourists (Simorangkir *et al*., 2021; Isdianto *et al*., 2024). Therefore, to meet the suitability value of snorkeling and diving tourism, a tourist location should have a stretch of coral reef in good condition and the appearance of abundant fish species. The presence of cor-

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al reefs with high cover and diverse growth forms is the main attraction offered in diving tourism activities (Arifin *et al*., 2019; Hamzah, 2020; Bibin and Mecca, 2020; Simorangkir *et al*., 2021). The brightness factor and safety also need to be considered for sustainability of tourism because they directly affect the visibility and comfort of snorkeling and diving tourists (Davis and Tisdell, 1996; Anwar, 2014; Isdianto *et al*., 2024).

3.2.4 Challenges and good practices in marine tourism management

Several marine tourism locations in Indonesia have also revealed challenges similar to those at Kaisomaru Beach, Tomini Bay. The problems of water quality, low coral cover, and reduced visibility at Kaisomaru Beach are in line with the challenges other marine tourism destinations face in Indonesia. For example, Karang Jahe Beach in Rembang faces problems with brightness, depth, and current speed that do not meet standards and poor conditions for coral reef ecosystems and reef fish (Rahmadanty *et al*., 2022). Jemeluk Beach in Karangasem, Bali, also faces similar problems, where low coral reef cover and the number of coral life forms contribute to less favorable conditions for underwater tourism (Hadiyanti *et al*., 2024). Furthermore, Raja Ampat, one of the world's most famous marine biodiversity hotspots, is affected by the increasing intensity of marine tourism. The sinking of the Caledonian Sky Cruise Ship in Raja Ampat, which occurred on March 4, 2017, has resulted in damage to coral reefs covering an area of 1.3270 ha for 100% damage and 0.5612 ha for 50% damage (Witomo *et al*., 2017).

Globally, marine tourism sites such as Tubbataha Marine National Park (TRNP) in the central Sulu Sea, Philippines, offer valuable comparative examples. TRNP faces challenges related to unsustainable fishing activities and mass coral bleaching. However, regular monitoring activities, active financial and governance support, and a fishing ban in the area have allowed it to remain a significant tourism destination (Burke *et al*., 2012). Furthermore, implementing the Green Fins approach to promoting compliance with environmental standards has significantly reduced the impact of the diving industry on the marine environment in the Philippines (Hunt *et al*., 2013). Ongoing efforts to protect coral reefs through coral restoration techniques and improved water quality management have ensured that marine tourism remains a viable industry in the region (Voolstra *et al*., 2023). Case studies of successful marine tourism have shown that local management practices, water quality control, and environmental conservation measures influence the success of marine tourism in a region. Therefore, effective management efforts are needed to restore water quality at degraded sites, to ensure the preservation of marine biodiversity and support the sustainability of eco-friendly tourism in the future.

4. Conclusion

In conclusion, the potential of coral reefs and fish as a tourist attraction for snorkeling and diving in the waters of Tomini Bay ranges from moderate to excellent. This potential is supported by adequate water quality to sustain marine biota and tourism activities. The IKW values for snorkeling and diving based on various criteria indicate conditions ranging from unsuitable to very suitable. Unsuitable criteria were found at Kaisomaru Beach due to several limiting factors, including the condition of coral reefs below 50%, low diversity of fish species, and low water brightness. Meanwhile, suitable to very suitable IKW values were found in five other locations, namely Pinomontiga, Kurenai, Dulanga Beach, and Bitila and Lahe Islands. This study provides critical insights into the suitability and potential of marine tourism in Tomini Bay. It underscores the role of ecological parameters, such as coral cover and reef fish diversity, in determining the viability of snorkeling and diving sites. Therefore, effective management is needed to restore water quality and coral reef resources and support the sustainability of environmentally friendly tourism. These findings serve as a valuable reference for local governments and stakeholders in planning sustainable tourism strategies that align with environmental conservation goals. In addition, long-term research related to monitoring coral reef conditions using various technologies, determining the area's carrying capacity, and assessing the socio-economic aspects of tourism are essential to planning sustainable tourism strategies in Tomini Bay.

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Authors' Contributions

The contribution of each author as follow, S.N. Hamzah; conception and design, analyzing and interpreting the data, drafted the manuscript, and designed the figures. F.M. Sahami; conception and design, analyzing and interpreting the data, and critical revision of the article. S.A. Habibie; collected the data, analyzing and interpreting the data, and critical revision of the article. S. Djunaidi; collected the data and drafted the manuscript. All authors discussed the results and contributed to the final manuscript.

Conflict of Interest

The authors declare that there is no conflict of interests regarding the publication of this manuscript.

Declaration of Artificial Intelligence (AI)

The author(s) affirm that no artificial intelligence (AI) tools, services, or technologies were employed in the creation, editing, or refinement of this manuscript. All content presented is the result of the independent intellectual efforts of the author(s), ensuring originality and integrity.

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