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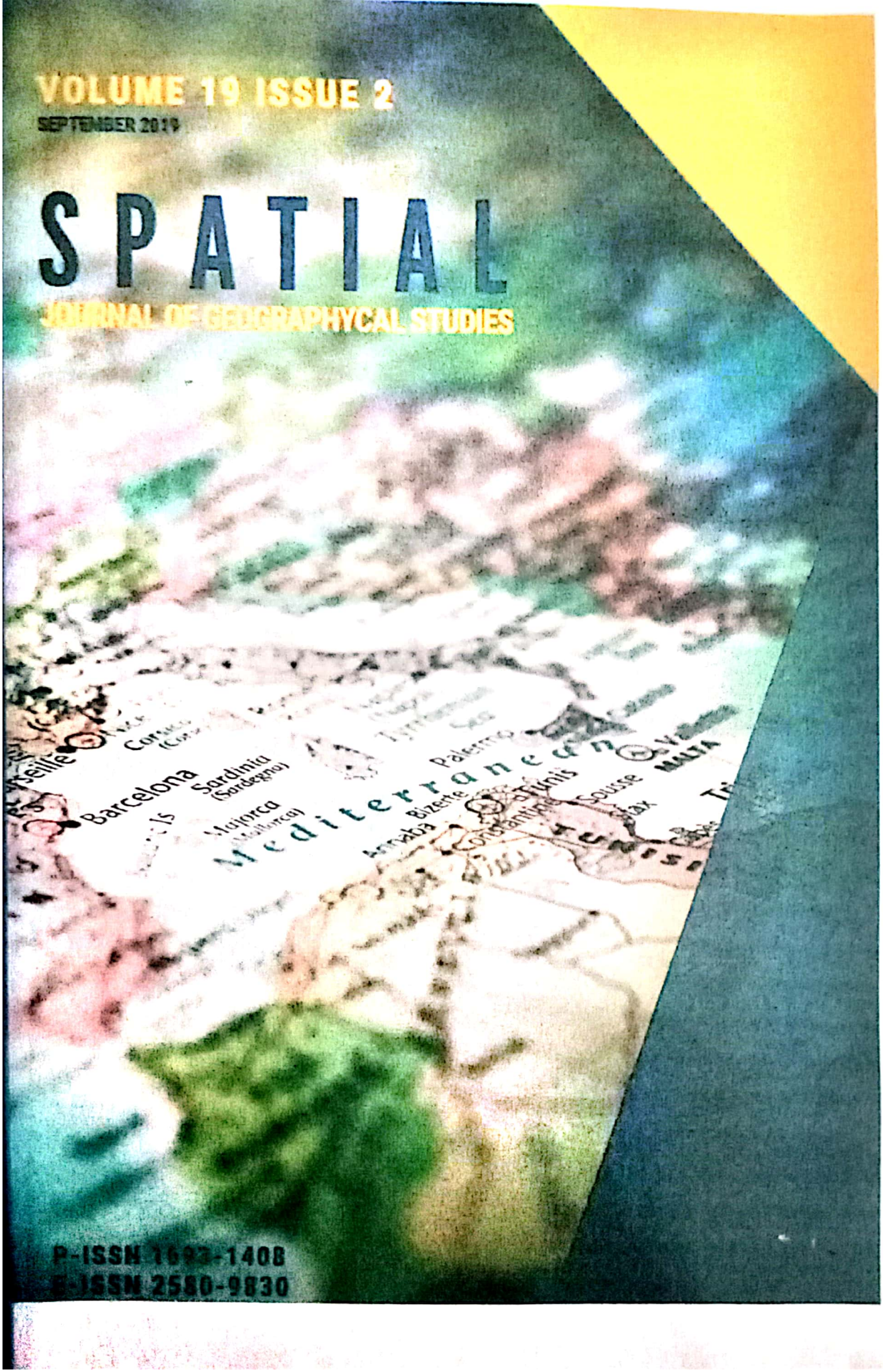

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Design and Implementation of WebGIS Marine Ecotourism Area, Tegal Island, Lampung Province

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A B S T R A K

Pulau Tegal memiliki potensi dan keanekaragaman wisata bahari yang menjadi daya tarik bagi wisatawan. Namun, belum tersedia informasi yang dapat membantu wisatawan dalam mengetahui objek dan kawasan wisata yang terdapat di Pulau Tegal. Penelitian ini menyajikan informasi wisata yang ada di Pulau Tegal ke dalam bentuk peta Sistem Informasi Geografis. Metode pemetaan yang dilakukan menggunakan perangkat lunak Quantum GIS dengan bantuan plugin QuickMapServices (QMS) untuk menampilkan citra Google Earth dan plugin qgis2web untuk mengkonversi file QGIS (.qgz) menjadi peta web (WebGIS) serta adanya input indeks wisata. Hasil pemetaan didapatkan digitasi dari setiap objek dan fasilitas wisata di Pulau Tegal ke dalam bentuk shapefile (.shp) serta informasi ditampilkan pada attribute table layer. WebGIS digunakan sebagai media penyaji peta SIG yang mudah diakses dan disesuaikan tampilannya dengan library JavaScript Leaflet (open source). Peta Sistem Informasi Geografis memberikan kemudahan bagi masyarakat dalam menyampaikan dan mencari informasi wisata di Pulau Tegal.

Keywords:
Ecotourism
Tourism Suitability Index
Regional Carrying Capacity
Geographic Information System
Tegal Island

A B S T R A C T

Tegal Island has the potential and diversity of marine tourism which is an attraction for tourists. However, information is not yet available that can help tourists in knowing the objects and tourist areas contained in Tegal Island. This research presents tourism information in Tegal Island in the form of a Geographic Information System map. The mapping method is done using Quantum GIS software with the help of the QuickMapServices (QMS) plugin to display Google Earth imagery and the qgis2web plugin to convert QGIS files (.qgz) into web maps (WebGIS) and the presence of tourist index input. The mapping results obtained digitization of each tourist object and facility on Tegal Island in the form of shapefiles (.shp) as well as information displayed on the attribute table layer. WebGIS is used as a media for GIS map renderers that is easily accessed and adjusted according to the JavaScript Leaflet library (open source). Map of Geographic Information Systems makes it easy for people to convey and search for tourist information on Tegal Island.

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Introduction

Indonesia is an archipelagic country that has the potential to utilize coastal areas as a marine ecotourism area (Koroy, Kismanto, Fredinan Yulianda, 2017). Indonesia has large and small islands that number ± 17,504 islands and occupies the second-longest coastline after Canada, which is 95,161 km (Lasabuda, n.d.) so that Indonesia has several areas that can utilize as marine ecotourism areas along the existing coastline area.

One of the marine ecotourism areas located in Lampung Province is Tegal Island. Tegal Island located in Gebang Village, Padang Cermin District, Pesawaran Regency, Lampung Province. Tourists use a motorboat with a travel time of ± 15 minutes from Sari Ruding Beach to access the island (Titaheluw, Syahnul Sardi, 2012). The island was covering an area of ± 140 Ha inhabited by around 20 family heads(Anggraini, Desti Rizki, Abdullah Aman Damai, 2018). Tegal

Island is an area suitable to be developed into ecotourism.

Ecotourism defined as any form of nature-based tourism, where tourists can observe and appreciate nature and the traditional culture contained in it (World Tourism Organization, 2018). Ecotourism must contain elements of education, interpretation of natural areas, and aims to minimize the negative impacts on nature and the socio-cultural nature of tourism activities(Ruhanen, 2019). Ecotourism development is expected to support the maintenance of natural areas, generate economic benefits for the manager, provide alternative employment, and increase awareness of nature for local people and tourists.

Ecotourism activities must apply the following principles: 1. Reduce the physical environmental and cultural impacts of the community; 2. Develop awareness and appreciation of the environment and culture of the community; 3. Provide a positive experience for visitors and managers; 4. Generate financial benefits for conservation; 5. Generate economic profits for the local community and managers; 6. Offering a memorable interpretive experience for visitors; 7. Design, build, and operate low-impact facilities; 8. Accept the customs and spiritual beliefs of the local population and work together to make empowerment (The International Ecotourism Society 2015).

This principle is in line with the concept of sustainable ecotourism development (Haryanto, 2016) so that the ecotourism area managed as a source of sustainable community income, as well as an effort to preserve the culture of the community and the potential of local natural resources.

One of the natural ecotourism that has a diversity of tourist objects and activities is marine ecotourism (Abdillah, 2016). Marine ecotourism is a tourist attraction and purpose that comes from the potential seascape and coastal landscape. Tourism originating from seascape potential is tourism activities that prioritize the wealth of marine resources and seawater dynamics, while coastal landscape tourism is tourism activities that based on resources in coastal areas and the culture of surrounding communities (Yulianda, 2007). Events that often offered in marine ecotou rism are beach recreation, outdoor activities, and biota observations that interact in coastal ecosystems.

One of the weaknesses in the development of ecotourism areas is the lack of information about existing tourist attractions, and this makes it difficult for tourists to obtain information that indirectly impacts the number of visitors. The provision of ecotourism information often ignored, especially areas that are still managed by the local community. Information on tourist objects generally obtained orally or through other media that are less informative (Soyusiawaty, Dewi, Rusydi Umar, 2007).

The development of ecotourism areas is inseparable from the promotion of attractions related to increasing tourist attraction. Advertising is carried out to provide an overview and information about an object or tourist area. This information is used by tourists to adjust tourism needs with tourist destinations (Rahmayanti, Yunita Dwi, 2013).

Problems regarding the need for information related to attractions on Tegal Island cause the need for a media about that information. The purpose of this study is to present tourist information on Tegal Island in the form of a Geographic Information System map. Maps are a natural means of indexing and presenting tourism related information (Jovanović & Njeguš, 2008). The information presented is related to the tourism suitability index (IKW) and regional carrying capacity (DDK). The benefits of this research are providing information related to the marine ecotourism area on Tegal Island in the form of a website that can be accessed by the wider community easily.

Methode

1. Research sites

The research location located in Tegal Island, Gebang Village, Padang Cermin District, Pesawaran Regency, Lampung Province. Geographically the island is located at coordinates 05 ° 34 '00 "LS and 105 ° 16 '29" BT (Oriana, Nindita, Isni Nurruhwati, Indah Riyantini, 2017).

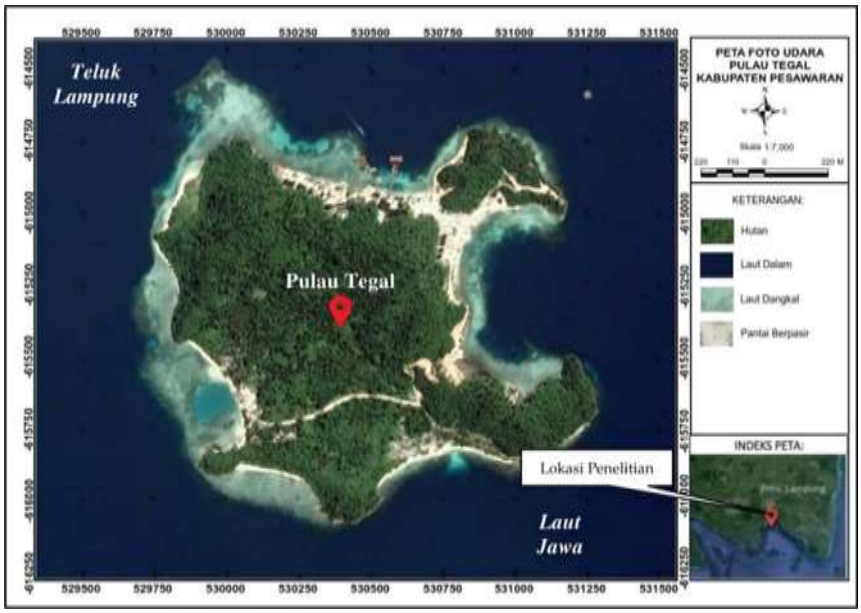

Figure 1. Map of Aerial Photos of Tegal Island

2. Equipment

The equipment used to retrieve data in this study showed in Table 1.

Table 1. Peralatan Penelitian

No	Peralatan	Fungsi
1	GPS (*Global Positioning System*)	Carrying out coordinates of a point (waypoint) or route (track) of a particular research object.
2	Camera	Take documentation of research data, in the form of images or videos.
3	Laptop	Compile data that has been obtained and processed using the Quantum GIS program.
4	Drone Aircraft	Obtain documentation of a research object from a certain height.
5	Roll meter	Measuring length and height.
6	Secchi disk	Measures the level of water brightness.
7	50 × 50 cm squares	Calculate the seagrass cover using the quadratic transect method.
8	Bottle Buoy and Stopwatch	Calculate the current speed.
9	Wooden Sticks and Water Pass Hose	Measure the beach slope.
10	Wooden Peg	Gives a tidal boundary mark.
11	Snorkel Glasses	Help observations made underwater.

3. Potential Attractions

Analysis of the potential of attractions is needed to determine the suitability of a tourist area as a whole. Parameters arranged based on their importance in the conformity matrix, while the weighting of each parameter obtained from the scoring method. The settings used to refer to(Pusat Studi Pariwisata Universitas Gadjah Mada (PUSPAR UGM), 2005), while the equation in counting refers to (Yulianda, 2007). The categories of potential tourism object classes showed in Table 2.

Table 2. Potential Attraction Class Category

No.	Score	Information
1	≥77 - 100%	Suitable
2	≥55 - 76%	Quite Suitable
3	<55%	Not Suitable

4. Travel Conformance Index

In a tourist area, there is more than one tourist attraction. Each suitability level can be calculated based on the suitability matrix (Yulianda, 2007) so that the development of attractions adjusted to the potential of resources and allocation. The final result is the number of multiplications between the weights and scores of each parameter, which is then divided by the maximum score. Suitability of objects and tourist areas seen from the suitability percentage obtained through the equation (Yulianda, 2007).

The Tourism Conformity Index (IKW) uses a suitability matrix arranged based on the level of importance of each parameter (Domo, Attur Mudzy, Zulkarnaini, 2017). The equation used in calculating tourism suitability refers to Yulianda (2007), namely:

$$IKW = \sum \left(\frac{Ni}{N_{maks}} \right) \times 100\%$$

Information:

IKW: Tourism Suitability Index

Ni: Value of the i parameter (score × weight)

Nmax: The maximum value of all compliance parameters

The results obtained through the conformity matrix categorized in 4 categories, namely:

S1: Very suitable (75-100%)

S2: Appropriate (50-74%)

S3: Conditionally conditional (25-49%)

N: Not proper (<25%)

1) IKW Beach Recreation Category

The tourism suitability matrix for the beach recreation category has ten parameters in it with a Nmax value of all 84 parameters. Quantitative data measurements carried out three times. The depth of the beach measured at a distance of 10 m from the coastline (Yulisa, Eka Noerma, Yar Johan, 2016). Beach width measured from the last vegetation boundary up to the shoreline. The type of beach, seabed material, coastal land cover, and hazardous biota obtained through direct observation at the research station (Ramadhan, Syahru, Pindi Patana, 2014). The tourism suitability matrix for the beach recreation category shown in Table 3.

Table 3. IKW Matrix in the Coastal Recreation Category

No	Parameters	Weight	Category S1	Score	Category S2	Score	Category S3	Score	Category N	Score
1	The Dept of the Beach (m)	5	0-3	3	>3-6	2	>6-10	1	>10	0
2	Beach Type	5	white sand	3	white sand, a pinch of clam	2	Black sand, craggy, little steep	1	dirth, stony, steep	0

No	Parameters	Weight	Category S1	Score	Category S2	Score	Category S3	Score	Category N	Score
3	Wide Beach (m)	5	>15	3	10-15	2	3-<10	1	<3	0
4	Aquatics Material	3	Sand	3	Sandy Reefs	2	Sand Muddy	1	Mud	0
5	Current Speed (m/s)	3	0-0.17	3	0.17-0.34	2	0.34-0.51	1	>0.51	0
6	Beach Tilt (°)	3	<10	3	10-25	2	>25-45	1	>45	0
7	The Brightness of the waters (%)	1	100	3	50-<100	2	30-<50	1	<30	0
8	Coastal landclosing	1	coconut, bare ground	3	bush, shrub, lowliness, savana	2	high shrub	1	mangrove, settlement, port	0
9	Dangerous Biotic	1	none	3	Sea-urchin	2	sea-surchin, ray	1	sea-urchin, ray, lepu, shark	0
10	Availabilty of fresh water (km)	1	<0.5	3	>0.5-1	2	>1-2	1	>2	0

Source: Yulianda, 2007

2) IKW Mangrove Tourism Category

The tourism suitability matrix for the mangrove tourism category has five parameters in it with a Nmax value of all 39 parameters. The thickness of the mangrove measured from the outline of the mangrove (towards the land) to the coastline. Mangrove density is calculated based on the number of mangrove individuals in an area of 100 m^2 (Dharmawan, I Wayan Eka, 2014). Mangrove species and biota objects obtained through direct observation of mangrove areas. The tourism suitability matrix for the mangrove tourism category shown in Table 4.

Table 4. IKW Matrix Mangrove Tour Category

No	Parameter	Weight	Category S1	Score	Category S2	Score	Category s3	Score	Category N	Score
1	Mangrove Thickness (m)	5	>500	3	>200-500	2	50-200	1	<50	0
2	Mangrove Density (100 m^2)	3	>15-20	3	>10-15, >20	2	5-10	1	<5	0

3	Mangrove Types	3	>5	3	3-5	2	1-2	1	0	0
4	Low Tides (m)	1	0-1	3	>1-2	2	>2-5	1	>5	0
5	Biotic Object	1	fish, shrimp, crab, mollusc, reptile, bird.	3	fish, shrimp, crab, mollusc,	2	fish, mollusc	1	ne of the water biotic	0

Source: Yulianda, 2007

3) IKW Seagrass Tourism Category

The tourism suitability matrix for the seagrass tourism category has seven parameters in it with a Nmax value of all parameters of 51. Seagrass cover is calculated using the quadratic transect method perpendicular to the coastline(Rahmawati, Susi, Andri Irawan, Indarto Happy Supriyadi, 2014). The depth of the seagrass measured at the starting point of seagrass vegetation found from the shoreline. Seagrass species and substrate types were obtained by direct observation at the study site. Fish species at the study site obtained from the Department of Fisheries and Maritime Affairs of Lampung Province. The tourism suitability matrix for seagrass tourism categories shown in Table 5.

Table 5. IKW Matrix Seagrass Tourism Category

No	Parameters	Weight	Category S1	Score	Category S2	Score	Category S3	Score	Category N	Score
1	Segrass Cover (%)	5	>75	3	>50-75	2	25-50	1	<25	0
2	Wter Brightness (%)	3	>75	3	>50-75	2	25-50	1	<25	0
3	Fish Types	3	>10	3	6-10	2	3-5	1	<3	0
4	Seagrass Types	3	Cymodocea Halodule Halophila	3	Syringodium Thalassodendron	2	Thallasia	1	Enhalus	0
5	Substrate Types	1	Pasir berkarang	3	Pasir	2	Pasir berlumpur	1	Berlumpur	0
6	Current Speed (cm/s)	1	0-15	3	15-30	2	30-50	1	>50	0
7	The Deepth of Seagrass (m)	1	1-3	3	>3-6	2	>6-10	1	>10, <1	0

Source: Yulianda, 2007

4) IKW Diving Tourism Category

The diving tourism suitability matrix has six parameters with a Nmax value of 54. Coral community cover is calculated using the LIT (Line Intercept Transect) method with a transect line along 50 m parallel to the coastline (Giyanto, Manuputty Anna EW, Abrar Muhammad, Siringoringo Rikoh M, Suharti Sasanti R, Wibowo Kunto, Edrus Isa Nagib, 2014). The depth of the coral reef measured at the starting point of finding coral communities from the shoreline. Lifeform types were obtained from local developers, while reef fish species collected from the Lampung Province Office of Maritime Affairs and Fisheries. The tourism suitability matrix for the diving category shown in Table 6.

Table 6. IKW Matrix of Diving Tourism

No	Parameters	Weight	Category S1	Score	Category S2	Score	Category S3	Score	Category N	Score
1	Water Brigthness (%)	5	>80	3	50-80	2	20-<50	1	<20	0
2	Coral Community Cover (%)	5	>75	3	>50-75	2	25-50	1	<25	0
3	Lifeform Types	3	>12	3	<7-12	2	4-7	1	<4	0
4	Reef Fish Types	3	>100	3	50-100	2	20-<50	1	<20	0
5	Current Speed (cm/s)	1	0-15	3	>15-30	2	>30-50	1	>50	0
6	The Depth of The Coral Reef (m)	1	6-15	3	>15-20 3-<6	2	>20-30	1	>30 <3	0

Source: Yulianda, 2007

5) IKW Snorkeling Tourism Category

The snorkel tourism suitability matrix has seven parameters with a Nmax value of 57. The width of the reef stretch is the distance perpendicular to the coastline, starting from the point where coral reefs found to the point where coral reefs found. The suitability matrix of the snorkeling tourism category shown in Table 7.

Table 7. Matriks IKW Kategori Wisata *Snorkeling*

No	Parameter	Bobot	Kategori S1	Skor	Kategori S2	Skor	Kategori S3	Skor	Kategori N	Skor
1	Kecerahan perairan (%)	5	>80	3	50-80	2	20-<50	1	<20	0
2	Tutupan komunitas karang (%)	5	>75	3	>50-75	2	25-50	1	<25	0
3	Jenis *lifeform*	3	>12	3	<7-12	2	4-7	1	<4	0
4	Jenis ikan karang	3	>50	3	30-50	2	10-<30	1	<10	0
5	Kecepatan arus (cm/s)	1	0-15	3	>15-30	2	>30-50	1	>50	0
6	Kedalaman terumbu karang (m)	1	1-3	3	>3-6	2	>6-10	1	>10; <1	0
7	Lebar hamparan datar karang (m)	1	>500	3	>100-500	2	20-100	1	<20	0

Source: Yulianda, 2007

6) Regional Carrying Capacity

The calculation of the carrying capacity of the area, is used to determine the maximum size of tourists who can accommodate at any given time without disrupting nature or humans (Domo, Zulkarnaini, and Yoswaty 2017). In this study, the equation of the carrying capacity of a tourist area refers to (Yulianda, 2007), namely:

$$DDK = K \times \frac{Lp}{Lt} \times \frac{Wt}{Wp}$$

Information:
DDK: Regional carrying capacity
K: Ecological potential of visitors
LP: Area or length of the area used
Lt: Area of unit area for a tourism activity
Wt: Time provided by the area per day
Wp: Time needed by visitors in tourism activities

Result and Discusion

Tegal Island has an ecotourism attraction with its natural wealth. This island divided into four regions, namely north, east, south, and west. The northern part is the main focus of developers in the provision of facilities and attractions. The development of facilities and tourist attractions on this island continues to do to provide a magnet for tourists.

1. Calculation of Potential Attractions

The data collected is then adjusted to the matrix of potential tourist attractions. Data obtained through observation, analysis, and relevant agencies. After that, the score of each parameter is summed and calculated using the equation (Yulianda, 2007), so that the suitability category of potential tourism objects obtained on Tegal Island. Table 8 shows that the total score received was 35 out of 39 total scores. The suitability category of marine ecotourism areas is obtained at 89.74% and falls into the Appropriate (S2) category.

Table 8. Potential Objects of Tourist Attraction

No.	Potential Assessment Factors	Variable	Criteria	Score	Result
1	Quality of Tourism Object	a. Keunikan objek wisata dan fungsi sebagai kawasan lindung The Uniqueness of tourism object and functions as protected area	• If the object found elsewhere • If the object found elsewhere and have protective function • If the object rarely found elsewhere and have protective function	1 2 3	✔
		b. Diversity of supporting attractions	• Don't have attractions yet • Has 1-2 supporting attractions • Has> 2 supporting attractions	1 2 3	✔
2	Attraction condition	c. The cleanliness of the tourism object and the availability of land for development	• The tourism object is less clean and has no land for development • Attractions are decent but do not have area for development, or vice versa • Tourism objects are clean and have development land	1 2 3	✔
3	The economic competitiveness	d. The number of tourists	• Number of tourists is low • Moderate tourist numbers	1 2	

No.	Potential Assessment Factors	Variable	Criteria	Score	Result
	of tourism objects		• High tourist numbers	3	✔
		e. Ticket prices	• Ticket prices are expensive	1	
			• Ticket prices are moderate	2	✔
			• Cheap ticket prices	3	
4	Accessibility	f. Road infrastructure to the location of attractions	• Available motor and car road infrastructure	1	✔
			• Available road infrastructure that can be passed by motorbikes and cars, there are alternative roads that can develop, in poor condition	2	
			• Available motorbike and car road infrastructure, there are alternative roads that can be designed, in good condition	3	
		g. Travel time for tourists to a tourist attraction from the capital	• Travel time> 2 hours from the capital	1	
			• Travel time is 1-2 hours from the capital	2	
			• Travel time <2 hours from the capital city	3	✔
		h. Availability of public transportation to get to the location of attractions	• Public transit is not available	1	
			• Public transport is possible, not regular	2	
			• Public transportation is available, regular	3	✔
5	Support the development of attractions	i. Object development support	• No manager	1	
			• Only managed	2	
			• Tourism objects are regulated by the government and the community / private sector professionally	3	✔
		j. Development and promotion of tourism object	• Tourism objects have not yet been developed or published	1	
			• Tourism objects have been designed but not yet published	2	
			• Tourism objects developed and published	3	✔
6	Supporting tourist attraction facilities	k. Availability of facilities to meet residents' physical and social needs	• Not available	1	
			• 1-2 types of simple facilities are available	2	
			• Available> 2 types of private	3	✔

No.	Potential Assessment Factors	Variable	Criteria	Score	Result
			facilities		
7	Complimentary facilities	l. Availability of complementary facilities (parking lots, toilets / WC, information centre)	• Tidak tersedia • Not available • 1-2 types of facilities are available • Available> 2 types of facilities m.	1 2 3	✔
8	Safety and comfort	m. Security of the area around the tourist attraction	• Crimes often occur around the area of the tourist attraction • Rarely occurs crime around the tourist area attraction • There has never been a crime in the area around the tourist attraction	1 2 3	✔
		Total Score (Ni)		**35**	
		Score Maxsimum (N_{maks})		**39**	
		Persentage ($(Ni/N_{maks})\times100\%$)		**89.74%**	
		Category of Tourism Object Potency Class		**Suitable**	

Source: PUSPAR UGM, 2005

2. IKW Calculation of the Beach Recreation Category

Tegal Island has a coastline around the island. The primary beach material in the form of white sand and open land cover with coconut trees add to the natural beauty on Tegal Island. The condition of a gentle slope of the beach makes the beach area on Tegal Island safe as a recreational object.

Table 9. Travel Conformance Index Beach Recreation Category

No	Parameters	Weight	Category S1 Score (3)	Category S2 Score (2)	Category S3 Score (1)	Category N Score (0)
1	Beach depth (m)	5	0-3	-	-	-
2	Beach type	5	White Sand	-	-	-
3	Beach Width (m)	5	-	-	3-<10	-
4	Underwater material	3	Sand	-	-	-
5	Current Speed (m / s)	3	-	0.17-0.34	-	-
6	Beach slope (°)	3	<10	-	-	-
7	Waters Brightness (%)	1	100	-	-	-
8	Coastal land cover	1	Coconut, Bare Ground	-	-	-
9	Biota is dangerous	1	None	-	-	-
10	Availability of freshwater	1	<0.5	-	-	-

No	Parameters	Weight	Category S1 Score (3)	Category S2 Score (2)	Category S3 Score (1)	Category N Score (0)
	(km)					
	Amount	**28**	**60**	**6**	**5**	**0**
	N_{total}			**71**		
	N_{maks}			**84**		
	IKW ((N_{total}/N_{maks})×100%)			**84.52%**		
	Category			**Very Suitable (S1)**		

Table 9 shows that the total value obtained was 71 from the maximum amount of 84. The percentage of the tourism suitability index for the beach recreation category on Tegal Island was 84.52% and included in the very appropriate category (S1).

3. IKW Calculation for Mangrove Tourism Category

Based on direct observations, the number of mangrove individuals found on Tegal Island is relatively small. The lack of individual mangroves influenced by several things, such as the condition of the substrate on Tegal Island in the form of white sand and a little mud deposit.

In contrast, mangroves generally live in muddy areas. There are three mangrove forests, each in the east and west. Types of mangroves found at the study site were Avicennia and Rhizophora. Rhizophora dominates mangrove species on Tegal Island.

Table 10. Travel Conformance Index Mangrove Tourism Category

No	Parameters	Weight	Category S1 Score (3)	Category S2 Score (2)	Category S3 Score (1)	Category N Score (0)
1	Mangrove thickness (m)	5	-	-	-	<50
2	Mangrove density (100 m^2)	3	-	-	-	<5
3	Mangrove type	3	-	-	1-2	-
4	Tidal (m)	1	0-1	-	-	-
5	Biotic Object	1	Fish, Shrimp, Crab, mollusc, reptile, bird.	-	-	-
	Amount	**13**	**6**	**0**	**3**	**0**
	N_{total}			**9**		
	N_{maks}			**39**		
	IKW ((N_{total}/N_{maks})×100%)			**23.08%**		
	Category			**Not Suitable (N)**		

Table 10 shows that the total value obtained was 9 out of a maximum amount of 39. The percentage of the tourism suitability index for the beach recreation category on Tegal Island was 23.08% and included in the inappropriate category (N).

4. IKW Calculation for Seagrass Tourism Category

Seagrasses grow and live around Tegal Island. Seagrass is a plant that lives at the bottom of the water and needs sunlight for photosynthesis. The level of water brightness influences the amount of sun that can reach the bottom of the water. The type of sand substrate

on Tegal Island is very suitable for seagrass habitat because it does not affect the level of water brightness. The kinds of seagrass found on Tegal Island, namely Enhalus, Halodule, and Thalassia. Halodule is a type of seagrass that dominates on Tegal Island. Many aquatic biotas live in seagrass beds, such as small fish, mollusks, and crustaceans.

Table 11. Travel Conformance Index Seagrass Tourism Category

No	Parameters	Weight	Category S1 Score (3)	Category S2 Score (2)	Category S3 Score (1)	Category N Score (0)
1	Seagrass cover (%)	5	-	>50-75	-	-
2	Waters Brightness (%)	3	>75	-	-	-
3	Fish species	3	>10	-	-	-
4	Seagrass type	3	*Enhalus, Halodule, Thalassia*	-	-	-
5	Substrate type	1	-	Pasir	-	-
6	Current Speed (cm / s)	1	-	15-30	-	-
7	Seagrass depth (m)	1	1-3	-	-	-
	Jumlah	**17**	**30**	**14**	**0**	**0**
	N_{total}			**44**		
	N_{maks}			**51**		
	IKW ((N_{total}/N_{maks})×100%)			**86.27%**		
	Category			**Very Suitable (S1)**		

Table 11 shows that the total value was 44 from the maximum amount of 51. The percentage of the tourism suitability index for the seagrass category in Tegal Island was 86.27% and included in the very appropriate category (S1).

5. IKW Calculation for Diving Tourism Category

Tegal Island can attract tourists to observe the beauty of the vast expanse of coral reefs and the diversity of reef fish species. Coral reefs found at a depth of ± 3 m around Tegal Island. Based on Tegal Mas Island Developer data, there are 12 types of life forms of living coral on Tegal Island. Coral reef ecosystems have many unusual aquatic biotas to be observed, such as reef fish, starfish, and anemones, which are home to several types of small fish. Some endangered biota also found around coral reefs, such as sea urchins, sea cucumbers, and jellyfish.

Table 12. Suitability Index of the Dive Tourism Category

No	Parameters	Weight	Category S1 Score (3)	Category S2 Score (2)	Category S3 Score (1)	Category N Score (0)
1	Waters Brightness (%)	5	>80	-	-	-
2	Coral community cover (%)	5	>75	-	-	-
3	Type of life form	3	-	<7-12	-	-
4	Types of reef fish	3	-	-	20-<50	-
5	Kecepatan arus (cm/s)	1	-	>15-30	-	-
6	Coral reef depth (m)	1	-	3-<6	-	-

Jumlah	**18**	**30**	**10**	**3**	**0**
N_{total}			**43**		
N_{maks}			**54**		
IKW ((N_{total}/N_{maks})×100%)			**79.63%**		
Category			**Very Suitable (S1)**		

Table 12 shows that the total value obtained was 43 out of a maximum amount of 54. The percentage of the tourism suitability index for the beach recreation category on Tegal Island was 79.63% and included in the very appropriate category (S1).

6. IKW Calculation for Snorkeling Tourism Category

Snorkeling has done in the same area as diving tourism, which is on a stretch of coral reef. This tour is conducted to observe the beauty of coral reefs and aquatic biota contained in it. Snorkeling has done on the surface of the water, so tourists do not need to have special abilities in terms of diving.

Seven parameters can determine the suitability index of snorkeling tourism on Tegal Island. The settings available are similar to the IKW matrix in the diving tourism category. Still, there are additional parameters that focus on the width of a flat reef as a snorkeling tour.

Table 13. Travel Conformance Index Snorkeling Tourism Category

No	Parameters	Weight	Category S1 Score (3)	Category S2 Score (2)	Category S3 Score (1)	Category N Score (0)
1	Waters Brightness (%)	5	>80	-	-	-
2	Coral community cover (%)	5	>75			
3	Type of life form	3	-	<7-12	-	-
4	Types of reef fish	3	-	30-50	-	-
5	Current Speed (cm / s)	1	-	>15-30	-	-
6	Coral reef depth (m)	1	-	>3-6	-	-
7	Flat reef stretch (m)	1	-	>100-500	-	-
Amount		**19**	**30**	**18**	**0**	**0**
N_{total}				**48**		
N_{maks}				**57**		
IKW ((N_{total}/N_{maks})×100%)				**84.1%**		
Category				**Very Suitable (S1)**		

Table 13 shows that the total value obtained was 48 out of the maximum amount of 57. The percentage of the tourism suitability index for the beach recreation category on Tegal Island was 84.21% and included in the very appropriate category (S1).

7. Calculation of Regional Carrying Capacity

The calculation of the carrying capacity of the area is carried out to determine the maximum size of visitors that can accommodate at a particular time without causing disturbance to nature or humans. The carrying capacity of the area for beach recreation, mangrove tourism, seagrass tourism, diving, and snorkeling obtained through the calculation of the carrying capacity of the region.

Table 14. Calculation of Carrying Capacity of Tourism Object Areas

No	Objek Wisata	K	Lp	Lt	Wt	Wp	DDK
1	Beach recreation	1	795.77 m	50 m	6	3	31
2	Mangrove tourism	1	110.17 m	50 m	8	2	8
3	Seagrass tourism	1	3884.87 m^2	250 m^2	4	2	31
4	Dive	2	5327.9 m^2	2000 m^2	8	2	21
5	Snorkeling	1	5327.9 m^2	500 m^2	6	3	21
		Total DDK (person/day)					**112**

Table 14 shows that the carrying capacity of the area was 31 visitors/day for beach recreation, eight people/day for mangrove tourism, 31 people/day for seagrass tours, 21 people/day for diving tours, and 21 people/day for snorkeling.

8. Mapping Based on Geographic Information Systems

After collecting and analyzing data related to marine ecotourism objects and areas on Tegal Island. GIS can be used in tourism as a decision supporting tool for sustainable tourism planning, impact assessment, visitor flow management, and tourism site selection (Rahman, 2010). Furthermore, the data will inform in a digital map through Quantum GIS software. Quantum GIS is software used to create digital maps of regions and display information in the form of text and images. Tourists can access a map of the area, find out tourist information, and see an overview of the region through a GIS map. Mapping using GIS-based software is quite efficient and straightforward in the data input process. The steps taken in mapping using Quantum GIS software are as follows:

1) They are digitizing the area that will use as a map object. Digitization can be in the form of territorial boundaries, access roads, and streams. If scanning is not possible, a map of the area's shapefiles can use. The plan of regional shapefiles that commonly used is a map of the province.
2) Creating a new layer of a particular object following existing data points or coordinates. The steps taken are to click Layer → Create Layer → New Shapefile Layer or press on the keyboard Ctrl + Shift + N.
3) In the New, Shapefile Layer menu, select the options that are tailored to the needs of the layer to be created, namely: 1. Select polygon type for the sheet in the form of the polygon; 2. EPSG map format: 32748-WGS 84 / UTM Zone 48S; and 3. Fields adjusted according to layer requirements.
4) Each layer can display information related to the results of digitizing an area. The attributes in the form of tourist information posted by right-clicking on the layer used open Attribute Tables and New Field and fill in the characteristics following of knowledge has obtained, such as location coordinates, availability of facilities, and infrastructure, as well as the results of regional documentation.
5) Digitize each object by clicking Toggle Editing → Add Feature. Digitizing the object is adjusted to the location and coordinates obtained from the GPS.
6) Input information on the Attribute Table from the results of data analysis that has achieved.
7) Adjust the appearance of each digitization of tourist attractions by right-clicking Layer → Properties → Style → Color. The thickness of

the lines, shading, and transparency of the layer adjusted through the menu.

8) Repeating step 2 to step 7 until all attractions have digitized, the information inputted, and the appearance changed to the entire digital map.

In the development of geographic information system technology, digital GIS maps are not only accessed through Quantum GIS software but can also access via the website. The website has chosen as media accessed through electronic devices connected to the internet.

Some plugins needed in building WebGIS maps and these plugins are available in the Quantum GIS software plugin directory. The steps taken are: click on the Plugins Tab → Manage and install plugins → search for plugins → Install plugins. The QuickMapServices (QMS) plugin is used to display Google Earth imagery, so digital maps with aerial visuals obtained. The qgis2web plugin is used to process a QGIS (.qgs) file consisting of several shapefile (.shp) data into a website database file (.html). The steps taken are:

1) Press the Create web map icon on the Plugin Toolbar.
2) After the "Export to web map" window opens, then make adjustments to the Layers and Groups menu.
3) Change the entire label layer that will display information into inline labels (subject and information in one line) or header labels (issue and knowledge in different lines) that tailored to the needs of information display.
4) Select JavaScript Leaflet on the menu available at the bottom.
5) Export the QGIS file by clicking the "Export" menu.
6) When finished, the digital map will automatically open in the browser software used. Re-check the completeness of the layer and the information displayed.

The converted Quantum GIS file uploaded into the hosting website that prepared. Choose a domain name that matches the designed GIS map. The use of a memorable domain name can make it easier for users to access websites, such as place names or mapping areas. The steps taken are:

1) It is setting up a domain and website hosting. This study uses a domain provider and website hosting site https://id.000webhost.com/.
2) Register for a new account and follow the steps given to determine the domain name for the new website. The domain name used must be available and developing the contents of WebGIS.
3) After the domain name is approved, the website settings will then appear. To upload a website database file, the steps taken are: a. Select menu: Tools → File manager → Upload File. b. The page automatically redirects to web hosting. The next step is: select menu public_html → Upload Files → Select Files (website data in .zip format) Upload. c. Extract files that have uploaded into the public_html folder. WebGIS file successfully saved into web hosting.
4) Re-checking WebGIS (complete layers and information from each layer). The website of the geographic information system map of the marine ecotourism area of Tegal Island accessed via the URL https://tegalmas.000webhostapp.com/.

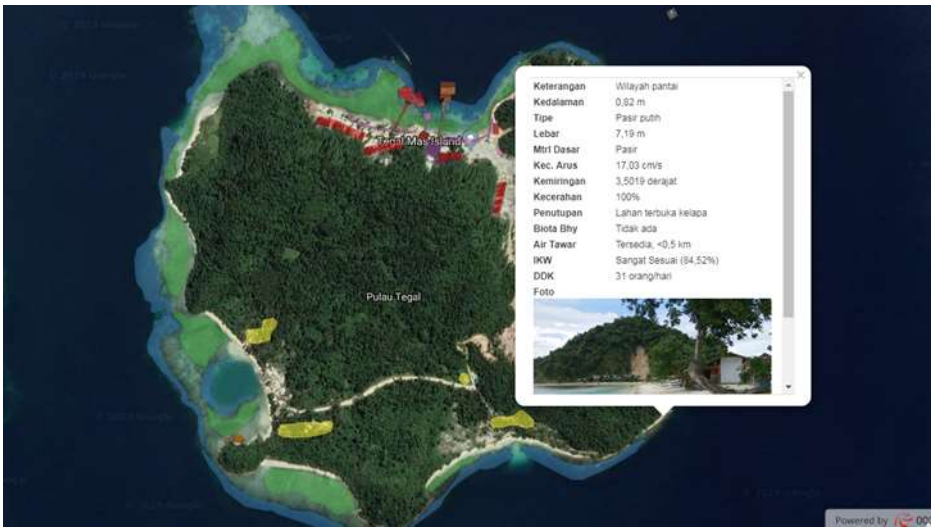

Figure 2. Display of GIS Map on Website

Conclusion

The conclusion is that the mapping of tourist objects and areas in Tegal Island was successfully carried out using Quantum GIS software, which accessed through the website. GIS Mapping helps the community in finding and knowing tourist information on Tegal Island.

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