

# Analysis and Research on seasonal Survey Data of Triangle Island in Pearl River Estuary

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## Abstract

The island ecosystem is unique and fragile, so the development of the island region needs to solve the conflict between development and ecological protection. In order to better develop and protect the island, this paper uses a high-precision three-dimensional model to conduct a series of data surveys on the typical uninhabited island triangle in Greater Bay Area. The results show that the measures to protect the ecosystem in the process of island development and utilization are more appropriate, as follows: (1) The triangle island has little impact on the coastline in 2022, and the natural coastline has hardly decreased. (2) The development and utilization area of the island has gradually increased, accounting for 46.14%-48.79% of the island area, and it is mainly for housing construction. (3) The island vegetation area is gradually increasing due to ecological restoration, accounting for 46.67%-48.36% of the whole island area, and the main increase area is artificial green space. The purpose of this study is to provide theoretical basis and practical experience for the subsequent survey and measurement in the process of island development and utilization.

## Keywords

Island; Development and utilization; Ecological protection; Monitoring.

## 1. Introduction

The basic platform for protecting the marine environment and maintaining marine ecological balance is the island. Scientific and reasonable island protection and management is critical for accelerating the development of the marine economy and promoting the pace of building a maritime power [1,2,3]. The basic survey of islands is the most fundamental work to promote good island management, and it includes surveying the island coastline and investigating the current state of environment and ecology, development and utilization, living environment, and social and economic conditions [1,4,5]. The triangle island was demarcated to strengthen the work foundation of the investigation on the current situation of the development and utilization of uninhabited islands left over from history.

This study conducted a data analysis of triangle island utilization based on the results of the field survey. A thorough analysis of the land use situation of island vegetation coverage, island topography, coastline length and type, island natural surface area, development and utilization activities, and so on is performed, and all types of resource data are summarized and formed. The seasonal survey data analysis report of triangle island is compiled based on the island status analysis results.

## 2. Methods

### 2.1. Study area

Triangle Island is located in the Lingdingyang area of Zhuhai City, in the Pearl River Estuary. The island is located at  $22^{\circ}08'38.201''\text{N}$ ,  $113^{\circ}43'01.813''\text{E}$ . Docks are located on the island's west and north sides, with the majority of them in various stages of development and utilization, and there are numerous construction sites, primarily for tourism and entertainment, temporary construction sites, and so on. In the south and east of the island, there are some mountainous areas covered by undeveloped forest land, and the majority of the islands are surrounded by natural coastlines.

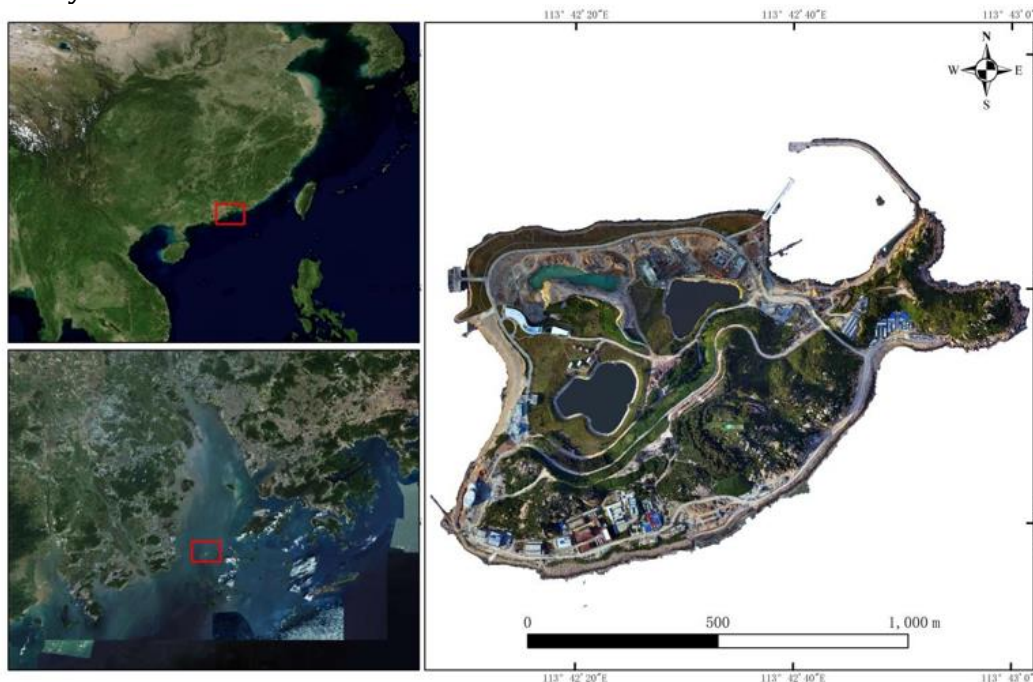


Figure 1 Geographical location of triangle island

### 2.2. Technical methods

Tilt photogrammetry is used to collect basic data in this study. The coastline survey is carried out using a three-dimensional model of the real scene and a digital image obtained by oblique photogrammetry, and the landform data, land use range data, coastline and coastline classification data, and coastline utilization type data are obtained [6,7,8]. The data of island development and utilization, vegetation coverage, and natural surface area of the island are obtained using topographic data.

## 3. Results and discussion

### 3.1. Shoreline Changes of Triangle Island in Four Seasons

The change of coastline in four seasons of Triangle Island is quantitatively calculated and analyzed based on the four-season model of Triangle Island, combined with the integration technology of geographic information system, and the change of coastline in four seasons of Triangle Island is analyzed from two perspectives: natural evolution conditions such as sea level rise and human engineering activities. The results show that the total coastline length of the triangle island in the first two seasons is 5049.72 m, 5046.58 m in the third season, and 5044.95 m in the fourth season. Natural conditions have little influence on coastline change, whereas human engineering activities have a large influence on coastline change. The main

reason for the decrease in coastline in the third season is that the flower garden above the Blues living room was demolished due to engineering construction needs, resulting in the change in coastline here. In the fourth season, there will be two areas of shoreline reduction. The road in the northeast corner of the first area was demolished due to the need for a reclamation project, which resulted in the demolition of the transportation coastline here and the transformation of it into the bedrock coastline. The second issue is that construction has altered the coastline in the southwest corner. Figure 2 depicts a comparison of the four seasons' coastlines, where the coastline was reduced due to terrain changes.

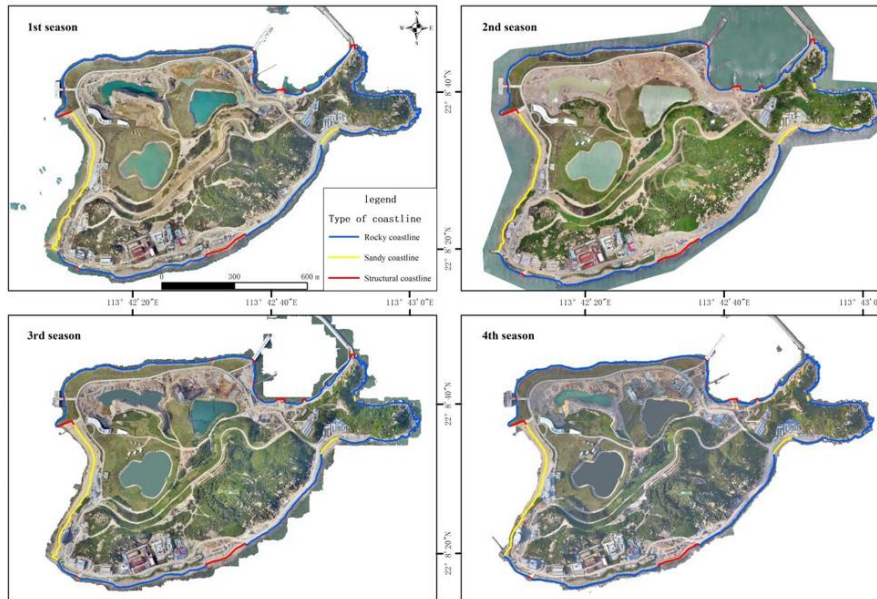


Fig. 2 Comparison of coastline changes of Triangle Island in four Seasons

### 3.2. Shoreline and shoreline classification

The island's coastline data is extracted using a three-dimensional model of the real scene and digital orthophoto map data, and the collection part is the high tide water level line, which is meticulously selected based on coastline features, water level traces, and shore deposits.

(1) Analysis of the first-class changes of the coastline of the triangle island.

The triangle island's first-class coastline consists of both artificial and natural coastline. The coastline has changed to some extent as a result of island construction issues and changes in tidal water level. Table 1 shows the proportion of first-class coastline, and Table 2 shows the seasonal change analysis of first-class coastline. The “QoQ” stands for quarter to quarter percentage.

Table 1 Analysis Table of Shoreline Length Proportion of Triangle Island in Four Seasons

Season	Shoreline length (m)				Total length of coastline
	Artificial shoreline	Proportion	Natural coastline	Proportion	
First season	413.76	8.19%	4635.96	91.81%	5049.72
Second season	428.74	8.49%	4620.98	91.51%	5049.72
Third season	429.20	8.50%	4617.39	91.50%	5046.58
Fourth season	391.08	7.75%	4653.87	92.25%	5044.95

Table 2 Analysis Table of Grade I Shoreline Changes of Triangle Island in Four Seasons

Season	Shoreline length (m)				Total	Quarter on quarter ratio
	Artificial shoreline	QoQ	Natural coastline	QoQ		
First season	413.76	0.00 %	4635.96	0.00 %	5049.72	0.00%
Second season	428.74	3.62 %	4620.98	0.32 %	5049.72	0.00%
Third season	429.20	0.11 %	4617.39	0.08 %	5046.58	-0.06%
Fourth season	391.08	8.88 %	4653.87	0.79 %	5044.95	-0.03%

(2) Analysis of the second-class changes of the triangle island coastline.

Triangle Island's second-class coastline consists of bedrock coastline, sandy coastline, and structure coastline. The coastline has changed to some extent as a result of island construction issues and changes in tidal water level. Table 3 shows the total length of second-class coastline occupied, and Table 4 shows a detailed analysis of second-class coastline changes in four seasons. Figure 3 depict Triangle Island's coastline utilization type distribution in four seasons.

Table 3 Proportion of Secondary Shoreline Class and Total Shoreline Length in Triangle Island in Four Seasons

Season	Shoreline length (m)						Total length of coastline
	Bedrock shoreline	Proportion to total coastline	Shoreline of structure	Proportion to total coastline	Sandy coastline	Proportion to total coastline	
First season	3858.86	76.42%	413.76	8.19%	777.10	15.39%	5049.72
Second season	3868.54	76.61%	428.74	8.49%	752.44	14.90%	5049.72
Third season	3839.75	76.09%	429.20	8.50%	777.63	15.41%	5046.58
Fourth season	3917.51	77.65%	391.08	7.75%	736.36	14.60%	5044.95

Table 4 Analysis Table of Secondary Changes of Shoreline in Triangle Island in Four Seasons

Season	Shoreline length (m)							
	Bedrock shoreline	QoQ	Shoreline of structure	QoQ	Sandy coastline	QoQ	Total length of coastline	QoQ
First season	3858.86	0.00%	413.76	0.00%	777.10	0.00%	5049.72	0.00%
Second season	3868.54	0.25%	428.74	3.62%	752.44	-3.17%	5049.72	0.00%
Third season	3839.75	-0.74%	429.20	0.11%	777.63	3.35%	5046.58	-0.06%
Fourth season	3917.51	2.03%	391.08	-8.88%	736.36	-5.31%	5044.95	-0.03%

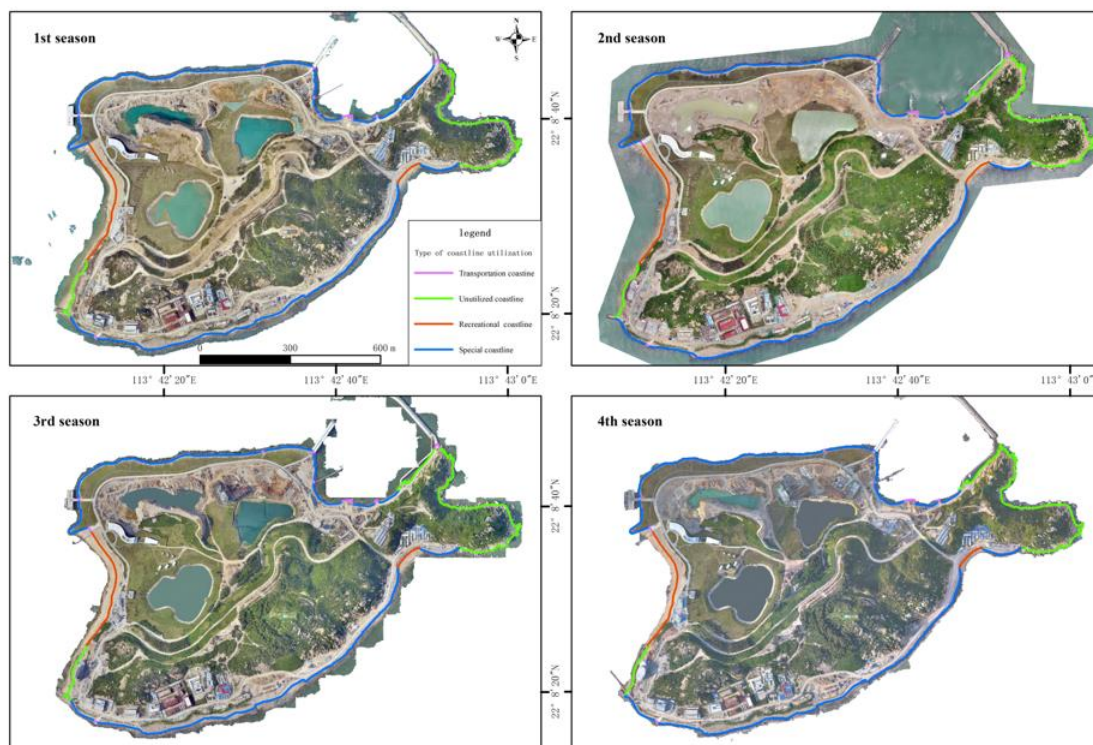


Fig. 3 Distribution Map of Shoreline Utilization Types of Triangle Island in Four Seasons

### 3.3. Shoreline utilization type data

Island shoreline data extracted based on real-life 3D model and digital orthophoto map data, the shoreline utilization type is filled in according to the shoreline secondary type and the field feature type, in accordance with the Technical Specification for Coastal Survey of Non-resident Islands in China (Trial).

Triangle Island has four types of shoreline utilization: transportation shoreline, special shoreline, unused shoreline, and recreational shoreline. The coastline has changed to some extent as a result of factors such as island construction issues and changes in tidal water level. Table 5 shows how the shoreline utilization types account for the total length of the coastline, and Table 6 shows a detailed analysis of the shoreline utilization types in four seasons.

Table 5 List of shoreline utilization types accounting for the total coastline length of Triangle Island in four seasons

Season	Shoreline length (m)								
	Traffic and transportation coastline	Proportion	Special coastline	Proportion	Unused coastline	Proportion	Recreational coastline	Proportion	Total length of coastline
First season	163.28	3.23%	3177.82	62.93%	1160.00	22.97%	548.63	10.86%	5049.72
Second season	171.93	3.40%	3005.44	59.52%	1338.71	26.51%	533.64	10.57%	5049.72
Third season	171.93	3.41%	2977.11	58.99%	1363.90	27.03%	533.64	10.57%	5046.58
Fourth season	134.27	2.66%	3008.82	59.64%	1368.22	27.12%	533.64	10.58%	5044.95

**Table 6 Analysis Table of Shoreline Utilization Types of Triangle Island in Four Seasons**

Season	Shoreline length (m)									
	Traffic and transportation coastline	QoQ	Special coastline	QoQ	Unused coastline	QoQ	Recreational coastline	QoQ	Total length of coastline	QoQ
First season	163.28	0.00%	3177.82	0.00%	1160	0.00%	548.63	0.00%	5049.72	0.00%
Second season	171.93	5.30%	3005.44	-5.42%	1338.71	15.41%	533.64	-2.73%	5049.72	0.00%
Third season	171.93	0.00%	2977.11	-0.94%	1363.90	1.88%	533.64	0.00%	5046.58	-0.06%
Fourth season	134.27	-21.90%	3008.82	1.07%	1368.22	0.32%	533.64	0.00%	5044.95	-0.03%

**3.4. Land Use Area**

The data of land use range in the four seasons of trigonometry are plotted based on the shoreline survey results. The ellipsoid area is calculated using the 2000 National Geodetic Coordinate System, the Gausskluger 3-degree belt projection, and 114 E as the central meridian. The surface area of natural form is calculated using topographic map elevation data combined with shoreline survey data, and the topographic map elevation datum is the 1985 national elevation datum. Table 7 contains statistics about the area.

**Table 7 Statistics of Island Land Area**

Season	Ellipsoid area (m <sup>2</sup> )	QoQ	Natural surface area (m <sup>2</sup> )	QoQ
First season	846532.70		920830.38	
Second season	846532.70	0.00%	916420.38	-0.48%
Third season	846687.28	0.02%	920928.24	0.49%
Fourth season	846464.72	-0.03%	923095.79	0.24%

**3.5. Island Vegetation Coverage Analysis**

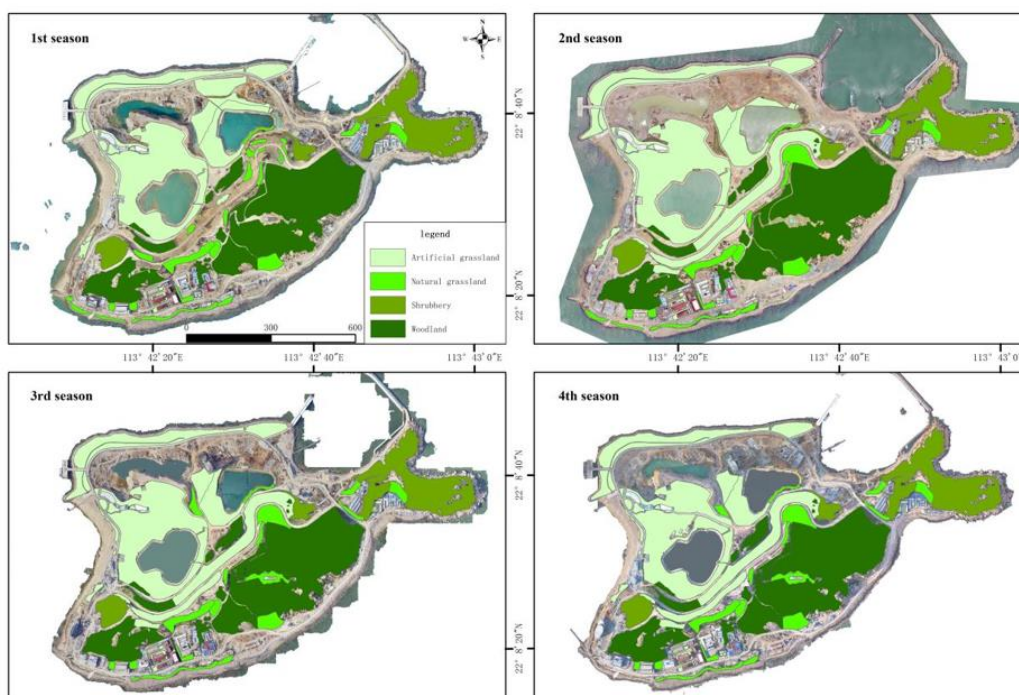
Triangle Island's vegetation coverage data in four seasons are derived from topographic and geomorphological data combined with orthophoto data. The island's vegetation surface changes dramatically in artificial green space as a result of construction sites, particularly those for tourism and recreation. At the same time, seasonal changes cause changes in the surface vegetation coverage. Table 8 shows the changes in the surface vegetation coverage area, and Table 9 and Figure 4 show the changes in the vegetation classification area.

**Table 8 Statistical Analysis Table of Vegetation Area of Triangle Island**

Season	Vegetation area (m)	Island area (m)	Percentage
First season	395047.83	846532.70	46.67%
Second season	413216.07	846532.70	48.81%
Third season	414530.96	846687.28	48.96%
Fourth season	409352.25	846464.72	48.36%

**Table 9 Statistical Analysis Table of Vegetation Coverage Classification Area of Triangle Island**

Season	Vegetation area (m <sup>2</sup> )									
	Artificial green space	QoQ	Native grassland	QoQ	Woodland	QoQ	Spinney	QoQ	Total vegetation area	QoQ
First season	145892.53		32061.68		153154.93		63938.69		395047.83	
Second season	163868.09	12.32 %	31311.73	- 2.34 %	154039.19	0.58 %	63997.06	0.09 %	413216.07	4.60 %
Third season	160801.51	- 1.87 %	36147.66	15.44 %	153416.54	- 0.40 %	64165.25	0.26 %	414530.96	0.32 %
Fourth season	156512.12	- 2.67 %	35258.36	- 2.46 %	153416.54	0.00 %	64165.25	0.00 %	409352.25	- 1.25 %



**Fig. 4 Vegetation Coverage of Triangle Island in Four Seasons**

**3.6. Island development and utilization status analysis**

Triangle Island's housing construction situation in four seasons is derived from topographic map data. Figure 5 shows that the triangle island is in the process of development and utilization, and several projects are underway on the island at the same time. The status of housing construction, development, and utilization all show an upward trend. The construction of tourism and recreation houses accounts for the majority of the total, and the overall changes in housing construction are shown in Tables 10, 11, 12, respectively.

**Table 10 Overall Changes of Development and Utilization Status**

Season	Current development and utilization area (m <sup>2</sup> )	Island area (m <sup>2</sup> )	Percentage of
First season	390558.68	846532.70	46.14%
Second season	398026.74	846532.70	47.02%
Third season	401296.73	846687.28	47.40%

Fourth season	413018.11	846464.72	48.79%
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Table 11 Overall Changes of Housing Construction

Season	Floor space of the house (m <sup>2</sup> )	Total area of development and utilization (m <sup>2</sup> )	Housing accounts for the total area of development and utilization.	Island area (m <sup>2</sup> )	Proportion of housing in island area
First season	21039.51	390558.68	5.39%	846532.70	2.49%
Second season	24992.83	398026.74	6.28%	846532.70	2.95%
Third season	29412.11	401296.73	7.33%	846687.28	3.47%
Fourth season	33488.80	413018.11	8.11%	846464.72	3.96%

Table 12 Analysis Table of Overall Changes in Housing Construction

Season	Floor space of the house (m)	Chain increase or decrease
First season	21039.51	
Second season	24992.83	18.79%
Third season	29412.11	17.68%
Fourth season	33488.80	13.86%

#### 4. Conclusion

The triangle island was measured for four seasons in 2022 in this study, and the corresponding three-dimensional model was established. Following data extraction and analysis, the following are the main conclusions:

(1) In 2022, the natural coastline accounted for more than 91% of the total in four seasons, while the artificial coastline increased in the second and third seasons but decreased in the fourth.

(2) The artificial coastline consists of transportation coastline and recreation coastline, the length of which increases and then decreases, while the recreation coastline remains stable after decreasing in the second season.

(3) The island's development and utilization area gradually increased, reaching its highest level in the fourth season, reaching 48.79%, with the main contributor being the housing construction of public service facilities.

(4) The island's vegetation area increased first, then decreased, peaking at 48.96% in the third season. The incremental contribution was primarily from artificial green space and shrub planting in the second season, but due to construction needs, the vegetation area decreased in the fourth season, with the exception of shrub.



Table 13 Classification of Development and Utilization Status Changes

Season	Current development and utilization area (m <sup>2</sup> )											
	Road square	QoQ	Housing construction	QoQ	Tourism recreation	QoQ	public services	QoQ	Landscape architecture	QoQ	Total area of development and utilization status	QoQ
First season	24077.19		31572.40		318406.64		16491.33		11.12		390558.68	
Second season	23667.08	-1.70%	35878.26	13.64%	320785.41	0.75%	17684.86	7.24%	11.12	0.00%	398026.74	1.91%
Third season	23607.08	-0.25%	39150.77	9.12%	320898.38	0.04%	17629.38	-0.31%	11.12	0.00%	401296.73	0.82%
Fourth season	23358.13	-1.05%	51212.99	30.81%	320898.38	0.00%	17537.49	-0.52%	11.12	0.00%	413018.11	2.92%

Table 14 Classification and Proportion of Development and Utilization Status

Season	Development and utilization of the current area ratio (m <sup>2</sup> )										
	Road square	Percentage of	Housing construction	Percentage of	Tourism recreation	Percentage of	public services	Percentage of	Landscape architecture	Percentage of	Total area of development and utilization status
First season	24077.19	6.16%	31572.40	8.08%	318406.64	81.53%	16491.33	4.22%	11.12	0.00%	390558.68
Second season	23667.08	5.95%	35878.26	9.01%	320785.41	80.59%	17684.86	4.44%	11.12	0.00%	398026.74
Third season	23607.08	5.88%	39150.77	9.76%	320898.38	79.97%	17629.38	4.39%	11.12	0.00%	401296.73
Fourth season	23358.13	5.66%	51212.99	12.40%	320898.38	77.70%	17537.49	4.25%	11.12	0.00%	413018.11

Table 15 Classification and Proportion of Development and Utilization Status

Season	Current building area of triangle island (m <sup>2</sup> )													
	Concrete house	Chain increase or decrease	brick house	Chain increase or decrease	Mixed room	Chain increase or decrease	Simple board house	Chain increase or decrease	Shed house	Chain increase or decrease	House under construction	Chain increase or decrease	Total building area of the house	Chain increase or decrease
First season	19163.84		11.73		1046.21		7838.44		183.11		3213.25		31456.58	

Second season	18087.24	-5.62%	25.55	117.79%	1056.85	1.02%	8792.35	12.17%	336.26	83.64%	6035.06	87.82%	34333.31	9.15%
Third season	24877.13	37.54%	242.58	849.53%	1072.25	1.46%	10143.65	15.37%	539.05	60.31%	6116.20	1.34%	42990.85	25.22%
Fourth season	29532.15	18.71%	239.25	-1.37%	1063.33	-0.83%	10388.57	2.41%	539.03	0.00%	6746.95	10.31%	48509.28	12.84%

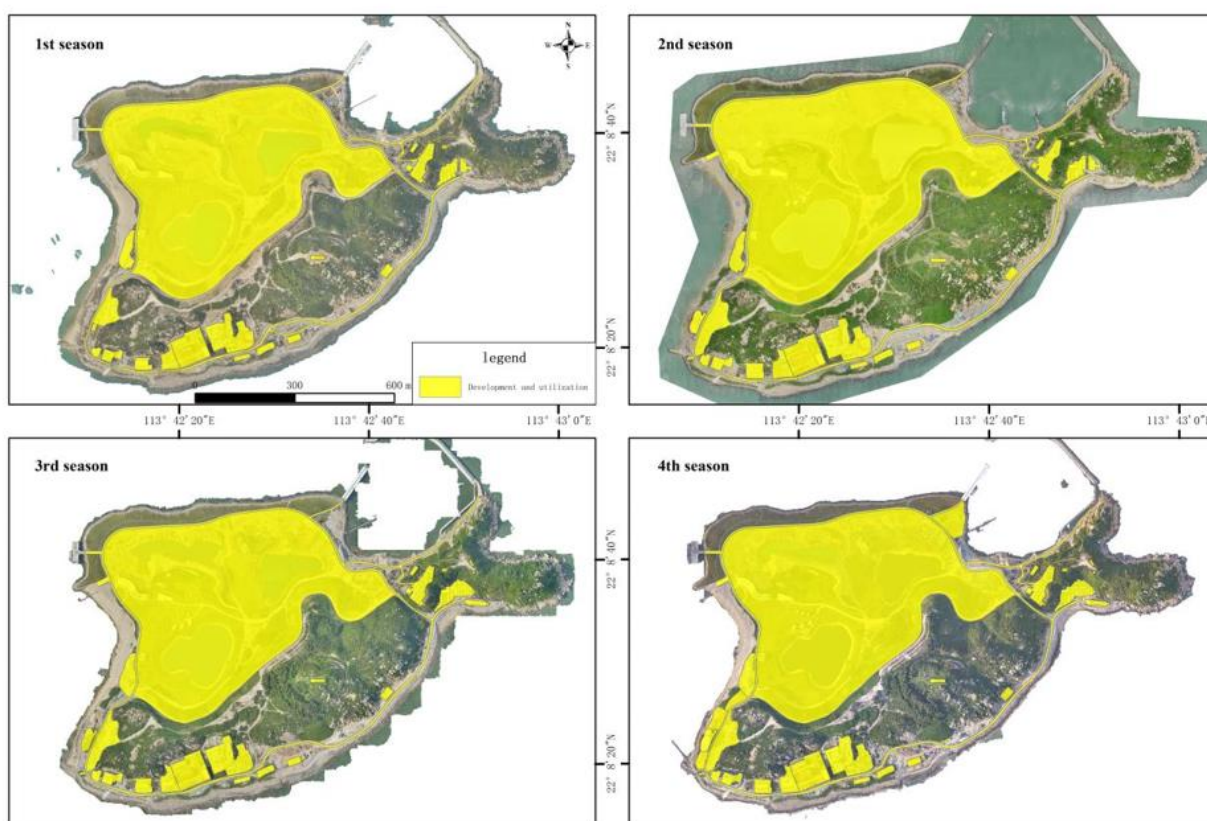


Fig. 5 Development and Utilization Status of Triangle Island in four seasons

### Acknowledgements

This research was funded by Marine resources management and utilization of the special fund for the Guangdong Province (44000022000000018938), and Science and Technology fund of Guangdong Provincial Department of Natural Resources (GDZRZYKJ2022008).

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