Research on the Vitality of Urban Coastal Space Based on Multi-Source Data

Taking Shapowei Huangcuo Section of Huandao Road in Xiamen as an Example

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Abstract. Taking Shapowei Huangcuo section of Huandao Road in Xiamen as the object of study, this paper explores spatio-temporal variation rules of coastal spatial vitality of Huandao Road and analyzes the relationship between environmental factors and spatial vitality; The multi-source data such as Baidu thermodynamic chart data, POI data and OSM data crawled from the network are imported into Arc GIS10.8 for quantification, and SPSS was used for multiple linear regression analysis. The research results indicated that the location centrality, land mix, plant coverage, road network density, cultural service facility density, catering service facility density and medical service facility density have remarkable influence on the vitality of coastal space. Propose design strategies for improving the vitality of urban coastal space based on the influence of various factors.

Keywords: multi-source data; Urban coastal space; Space vitality; Environmental impact factors

1 Introduction

Located in the transitional zone between sea area and land area, urban coastal area owns unconditional location advantages and resource advantages. It is the primary place for citizens, tourists to have fun, leisure and other activities, and has unique research value. The enhancement of the vitality of the coastal space can help urban construction and economic development to a high quality [1]. The construction of vitality space is the starting point of today's urban design. The construction of vitality space plays an significant role in the construction of urban public space, but there is no unified criteria for determining the factors affecting the vitality of coastal space. All the time, we use traditional subjective feelings to judge the vitality of a region, but the traditional methods are so subjective that they lack of theoretical basis and data support. In recent years,

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with the rapid development of information technology, especially the popularity of location-based service technology and corresponding products, it has provided technical support for extensive and in-depth mining of crowd activities and their spatio-temporal characteristics of distribution Baidu thermal map data, POI data, remote sensing images and other multi-source data provide new ideas and technical means for planning and design, effectively remedy the limitations of traditional research data on urban vitality, and provide support for the scientific research on coastal space vitality.

The article takes the Shapowei Huangcuo section of Huandao Road in Xiamen as the research area to study the correlation between various vitality influencing factors and the spatial and temporal distribution characteristics of coastal space vitality; On the basis of multivariate linear regression analysis of the quantitative indicators of coastal space vitality and the quantitative indicators of influencing factors, practical strategies to enhance the vitality of coastal space are proposed.

2 Preliminary Study

In terms of coastal space, the scholars own a relatively narrower scope of study. Since 1890, they have mainly studied from the perspectives of sociology and phenomenology, and analyzed some social phenomena from among. There are more and more successful construction cases of coastal space. For example, Zhang Qu finds different influencing factors according to the characteristics of different coastal areas [2].

In terms of urban vitality, Domestic research on urban vitality mostly focuses on urban design, urban planning and other aspects. For example, Ye Yu and others proposed that good street accessibility, appropriate construction intensity and architectural form, and sufficient function mixing are the spatial form basis for promoting urban vitality by summing up many classical urban design theories of urban vitality construction [3]; Zhang Chengyuan and others utilized the advantages of data to set up a research method of urban space vitality based on space use intensity [4].

3 Research Object and Research Method

3.1 General Situation of Research Object

As the research area in this particle is at the edge of an island, the Shapowei Huangcuo section is a special geographical environment near sea and hill. In order to conduct quantitative analysis on the vitality index and influencing factor index of coastal space, the study area is divided into a study block with an area of about 12km2 by shifting 1200m inward along the coastline within the study area, and its map is introduced into Arc GIS10.8 to establish a 100 * 100m fishing net space, forming 1229 "small space units" with an area of 1hm2 for specific research. (Figure 1).

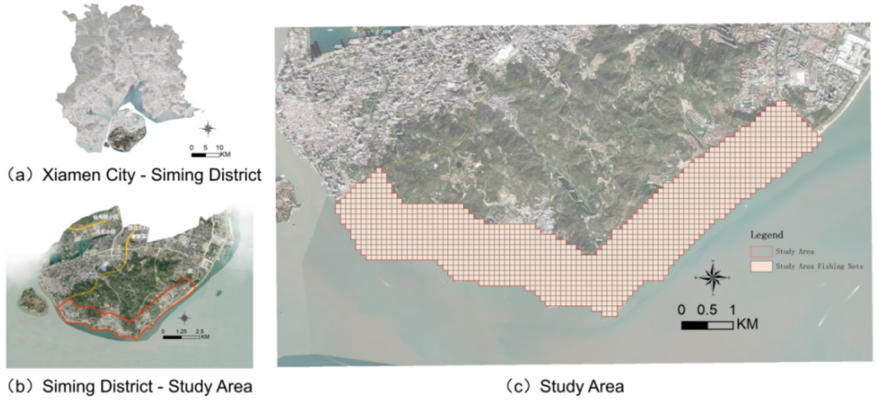


Fig. 1. Study Area of the Section of the Traffic Circle Road from Sha Po Wei to Huang Cuo. Photo source: Self drawn by the author.

3.2 Data Source

3.2.1 Vitality Characterization Data.

This study adopt the "Baidu Heat Map" data as the basic data for calculating the vitality characterization of coastal space. "Baidu heat Map" has the characteristic of dynamic, continuous and easy to identify, which can objectively and comprehensively express the space-time characteristics of crowd activities, and is extensively used in the study of urban vitality [5].

In this study, we used the web crawler program to collect Baidu heat data from September 17 to October 3, 2022. The collection time is from 7: 00 a.m. to 22: 00 p.m., and the collection frequency is once an hour. In order to ensure the reliability of the data and exclude the days that are not suitable for going out due to the weather, two rest days (Saturday and Sunday) and two working days (Monday and Tuesday) from September 17 to 20, plus two holidays on October 1 and 3 (during the National Day), were finally selected. A total of 96 thermal maps were collected in six days, and the thermal data collected were imported into Arc GIS10.8 for reclassification and raster processing. Use the mask extraction tool to intersect and connect the thermograph data with the research scope, filter out the data outside the research scope, and finally divide the thermal distribution into seven grades by color, and assign values of 1~7 to each grade. The higher the value is, the denser the population is and the higher the vitality level is. On the contrary, the lower the vitality level is.

3.2.2 Characterization Data of Environmental Impact Factors.

The data representing the environmental impact factors of coastal space mainly come from POI data, NDVI data, OSM road network data and global 30M land use data. Point of Interest (POI for short) of POI data in the study can accurately reflect the laws of human social activities and the spatial distribution characteristics of geographical objects [6]. It comes from the Gaode Map Open Platform. After screening, 5334 point

data covering the entire research scope are finally selected. The attribute table of each data point contains longitude and latitude, name, address, category, etc. Refer to the classification on the official website of Gaode (As shown in Table 1).

Table 1. POI Data Classification and Quantity

POI Category	Subclass	Quantity
Catering services	Chinese restaurant, foreign restaurant, fast food restaurant, coffee shop, tea house, dessert shop, etc	1764
Shopping services	Shopping malls, supermarkets, flower, bird, fish and insect markets, cultural goods stores, clothing, shoes, hats, leather goods stores, etc	1187
Science, education and culture	Museums, exhibition halls, art galleries, libraries, science and technology museums, archives, schools, etc	405
Medical services	General hospitals, specialized hospitals, clinics, disease prevention institutions, animal medical places, etc	91
Accommodation services	Hotels, guesthouses, residential areas, etc	1253
Sports and leisure	Sports venues, golf related places, entertainment places, holiday resorts, cinemas, etc	212
Scenic spots	Park squares, animal and botanical gardens, city squares, beaches, memorial halls, scenic spots, etc	134
Transportation services	Bus stops, parking lots, subway stations, waiting booths, etc	288
total		5334

Data Source: The author refers to the official website of Gaode for sorting.

NDVI data originates from the official website of Institute of Geographic Science and Resources, Chinese Academy of Sciences; The OSM road network data originates from the OpenStreetMap official website; Global 30M land use data originates from GlobeLand30 official website; Import various acquired data into Arc GIS10.8 for quantitative processing, and connect the processed data with the layer of the study area to filter out the data that does not belong to the study area.

3.3 Measurement of Vitality of Coastal Space and Quantification of Influencing Factor

3.3.1 Measurement of Vitality of Coastal Space.

The vitality of coastal space refers to the current crowd density of coastal space activities. From the perspective of users, the vitality of coastal space has three characteristics: aggregation, stability and diversity [7]. Due to the lack of crowd attribute and activity type information in the data currently obtained, it is difficult to accurately describe the diversity characteristics of vitality, so this study adopts vitality intensity characterization, that is, the activity crowd aggregation density in unit space; Characterized

by activity stability, that is, the stability degree of continuous activity of active population in unit time.

1) Quantitative method of vitality intensity. Vitality Strength Index refers to the gathering density of the activity crowd in the coastal space at a certain time. But in this study, it refers to the relative number of people obtained by multiplying the thermal value H of each grade at a certain time (the relative value obtained by Baidu after a series of operations) and its area Sh (unit: hm2²) in each small coastal space, and then compared with the total area S of the small coastal space (as shown in Formula 1-2):

$$VSIn(ij) = \frac{\sum_i^j Vn}{S \times (j-i)} \tag{1}$$

$$Vn = \sum_i^j Sh \times H \tag{2}$$

In this formula, VSIn (ij) is the vitality intensity of coastal space unit n from i to j; Vn is the sum of the relative number of people in the coastal space unit n from time i to time j; The greater the value of VSIn (ij), the higher the vitality intensity of coastal space.

2) Quantitative method of vitality stability. Vitality Stability Index is able to effectively reflect the degree of dynamic change of population activity density in a period of time. In this study, the standard deviation of crowd activity density values of each coastal space unit in each time period is used for quantification (Formula 3), and aims at no tempering treatment for reverse index (Formula 4):

$$\sigma = \sqrt{\frac{\sum_i^j (Tn-\mu)^2}{j-i}} \tag{3}$$

$$VVIn(ij) = \frac{\sigma_{MAX} - \sigma}{\sigma_{MAX} - \sigma_{MIN}} \tag{4}$$

In this formula, σ Is the standard deviation of crowd density at the moment from i to j of coastal space unit n, VVIn (ij) is the vitality stability of each coastal space unit n from i to j, and Tn represents the relative population density of coastal space n at each time from i to j, μ It represents the average population density of coastal space n at all times from i to j, σ^{min} and σ^{max} They respectively are the minimum and maximum of the original data of the standard deviation of population density. The larger the value of VVIN (ij) is, the more stable the vitality of coastal space unit n is from i to j.

3.3.2 Establishment and Quantification of Vitality Impact Factor Evaluation System.

Through the study of relevant literature on influencing factors of waterfront and coastal space vitality, it is concluded that the environmental influencing factors affecting the vitality of coastal space mainly include four first level indicators, namely location, transportation, facilities and spatial characteristics, and 12 elements as the indicator system of influencing factors of coastal space vitality (see Table 2).

Table 2. Indicators and Quantification of the Factors Affecting the Vitality of the Coastal Space.

Level I indicator	level II indicator	annotation	method to obtain
Location	Location centrality	It represents the degree of connection between the urban coastal space unit and the urban center	BigeMap GIS Office Ranging
facilities	Density of medical service facilities	The ratio of the number of POI of medical service facilities in the service area of the coastal space unit to the unit area	By crawling the POI data of medical service facilities
	Residential density	The ratio of the number of residential POIs in the service area of the coastal space unit to the unit area	By crawling residential POI data
	Density of commercial service facilities	The ratio of the number of commercial POIs in the coastal space unit service area to the unit area	By crawling commercial POI data.
	Density of sports service facilities	The ratio of the number of POI of sports service facilities in the coastal space unit service area to the unit area	By crawling the POI data of sports service facilities
	Density of cultural service facilities	The ratio of the number of POIs of schools, science and technology museums, memorial halls, etc. in the coastal space unit to the unit area	By crawling the POI data of cultural facilities
	Density of catering facilities	The ratio of the number of POI of restaurants, cafes and other catering buildings in the coastal space unit to the unit area	By crawling catering POI data
traffic	Rate of bus stop coverage	The ratio of the bus stop service point in the coastal space unit service area to the area of the research unit	By crawling the POI data of bus stops
	Road network density	The ratio of the total length of the road network within the coastal space unit to the area of the research unit	Calculation based on OSM road data
spatial feature	Land use mixing degree	Reflect the ability of coastal space to meet the diverse needs of use	Through planning drawings and current situation investigation
	Density of scenic spots	The ratio of the number of scenic spots POI in the coastal space unit to the area of the research unit	By crawling the POI data of scenic spots
	Rate of plant coverage	To measure the greening level of coastal space units	By crawling the information of Institute of Geographic Sciences and Natural Resources Research

Data Source: The author collates according to the literature

4 Analysis of the Spatio-Temporal Characteristics of the Vitality of the Coastal Space on Xiamen Island Ring Road

4.1 Analysis of Vitality Intensity

4.1.1 Daily Fluctuation Characteristics of Vitality Intensity.

Because the change rules of the same typical dates are similar, September 17, 2022 (Saturday) is the representative day of a day off, September 19 (Monday) is the representative day of the working day, and October 1 (National Day) is the representative day of the holiday. For the research on the fluctuation characteristics of daily vitality intensity of typical representatives, firstly, the thermal values of each time period of the day are introduced into Arc GIS10.8, which are divided into seven levels by natural discontinuity method, and areas with 6-7 grade intervals are defined as high heat zones, and areas with 4-5 grade intervals are defined as sub heat zones. The high heat area and the sub heat area respectively represent the areas where people are highly concentrated and the areas where people are relatively concentrated in the urban coastal space. And to some extent, it can reflect the track of crowd activities, and compare the area statistics of high and sub hot areas on rest days, working days and holidays with the thermal fluctuations of three typical days (as shown in Figure 2).

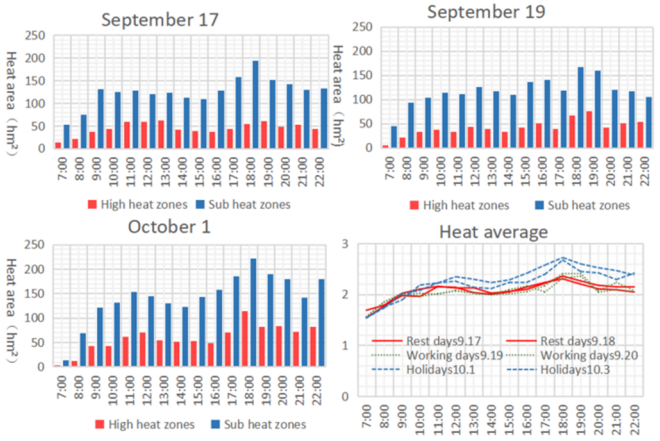


Fig. 2. Comparison of Area Change and Thermal Fluctuation of Typical Daily High Heat Zone and Sub-Heat Zone in Coastal Space.

As shown in Figure 2, the area of the high heat zone in the coastal space on the rest day (September 17) grew rapidly from 7 a.m. to 9 a.m., and then slowly increased to 13 a.m. to reach the peak. It may be that people go out successively for activities in the morning. The hot weather in Xiamen in the afternoon led to the gradual reduction of the thermal area to 16 o'clock, forming a trough. Affected by the evening peak and night activities, the second and third peaks appeared at 19: 00 and 21: 00 respectively, and the coastal space high heat zone was still in a high state at 22: 00. The overall value of

the area of the sub-heat zone is relatively high, with the first peak at 9 a.m. and slight fluctuation at 15 p.m., and then it rapidly increases to 18 p.m. to form the second peak, and then the population gradually disperses.

On a working day (September 19), the area of the high heat zone in the coastal space has the first peak at 10 o'clock during the morning rush hour of commuting, and the second peak at 12 o'clock as people gather in the outdoor activity area during the lunch break. Influenced by the evening peak and night activities, a small peak appeared at 16: 00, and reached the highest peak in the whole day at 19: 00. Then the crowd gradually dispersed, and there was still an upward trend at 22: 00. The sub-heat zone tends to be stable at 8 o'clock, and the change is relatively stable. It has experienced three ups and downs on the whole, with peaks at 12: 00, 16: 00 and 18: 00 respectively.

On holidays (October 1), the area of the hot area in the coastal space fluctuated sharply from 8: 00 a.m. to 9: 00 a.m., and then increased slowly. After reaching the peak at 12: 00 a.m., it tended to be stable. At 16: 00, the crowd gradually gathered, and the highest peak appeared at 18: 00 p.m., which was significantly higher than other typical dates. Due to the large number of tourists gathered in the coastal space during the National Day holiday, it may be that some performance activities were held in the area during this period, which suddenly decreased by 19: 00, and then tend to became stable and high.

It can be seen from the comparison chart of typical date fluctuations that there is little difference between the thermal mean value of working days and rest days, while the overall level of the thermal mean value of holidays is significantly higher than that of other typical days, which indicates that there are more tourists coming to this activity with a high crowd density in coastal space on holidays. The peak value of the rest day shifted slightly backward compared with other typical days, and the overall fluctuation trend was similar. The trend was upward from 7: 00 to 12: 00, stabilized at 16: 00, and gradually dispersed after the peak value appeared at 18: 00.

4.1.2 Temporal and Spatial Distribution Characteristics of Vitality Intensity.

In order to study the temporal and spatial dynamic changes of vitality intensity of three typical dates, the vitality intensity was normalized and divided into seven grades according to the natural gap method (as shown in Figure 3). The regions with high relative vitality intensity index (red patches) are concentrated in the east of Xiagang Street, Shapowei in the west of Binhai Street, Overseas Chinese Museum, Xiamen University, Baicheng Beach, Zengcuo'an, Huangcuo and other famous tourist attractions with earlier development and their surrounding areas. On the contrary, areas with low relative population vitality intensity index (yellow patches) are mainly distributed in Huangcuo Community, Zengcuo'an Community and other areas with relatively late development and low degree of development, such as Botanical Garden, Zengshan, Caokeng Mountain and other areas with low concentration of forest green space people. On the difference of different typical dates, the average vitality intensity of Zengcuo'an, Baicheng Beach and other areas shows the relationship of holidays>rest days>working days. The number of units with high vitality intensity on rest days is slightly higher than that on working days, but less than holidays. It can be inferred that people like to have leisure time in Baicheng Beach, Zengcuo'an and other places around on holidays or rest

days. Maybe people want to go out to relieve the pressure of work or life with the help of daily rest time.

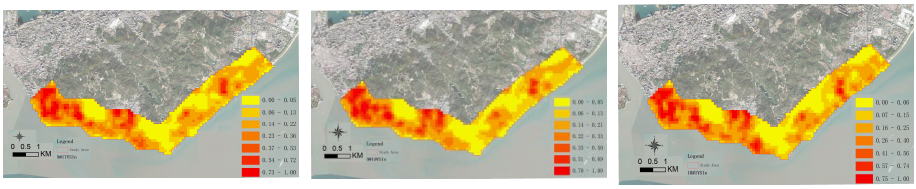


Fig. 3. Vigor Strength Distribution Chart Painting source: (author's own drawing).

4.2 Vitality Stability Analysis

With the same processing method as the vitality intensity, the vitality stability indicators of rest days, working days and holidays are also normalized, and the natural discontinuity method is used to divide 7 levels (Figure 4). The areas with high vitality and stability are mainly distributed in the east of Zengcuo'an Community and the west of Huangcuo Community, including Lion Rock Park, Botanical Garden, Zengcuo'an and other scenic spots. The areas with high vitality stability on weekdays mainly include residential areas, optimistic exhibition halls and some parks and green spaces. The vitality stability distribution on rest days and holidays is roughly the same as that on weekdays.

4.3 Analysis of Synergy Situation Between Vitality Intensity and Stability

With vitality intensity as the ordinate and vitality stability as the abscissa, the vitality intensity and vitality stability of 1229 small coastal space units are divided into high and low categories according to the principle of equality, forming four different combinations (as shown in Figure 5), and obtaining four groups of spatial distribution maps of coastal space vitality areas (as shown in Figure 6).

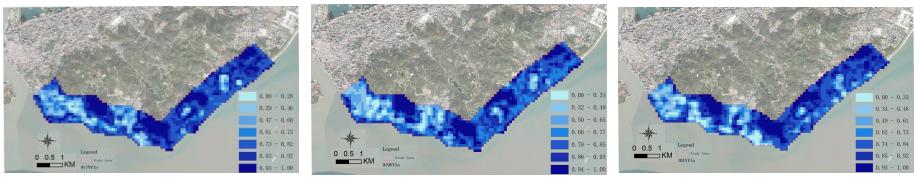


Fig. 4. Vitality Volatility Distribution Chart Painting source: (author's own drawing).

4.3.1 High Strength-High Stability Area.

This type of region is the most dynamic region because of its high vitality and stability, which can attract more people. It can be seen from Figure 6 that the cluster distribution of this type of area on each typical date is relatively scattered, and relatively

scattered points are distributed in small communities and shopping malls, such as farmers' markets, supermarkets and convenience stores; In addition, it also includes some campus areas, such as kindergartens, primary schools, middle schools, universities and vocational schools. The vitality distribution structure of this type of coastal space is roughly similar in the three typical days, with the number of rest days slightly more than holidays slightly more than working days.

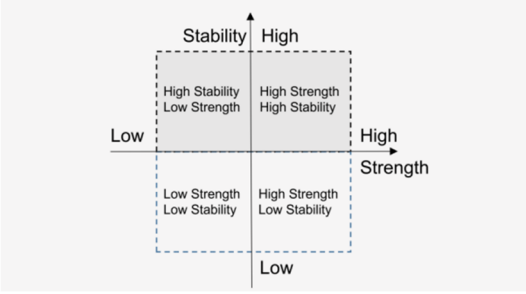
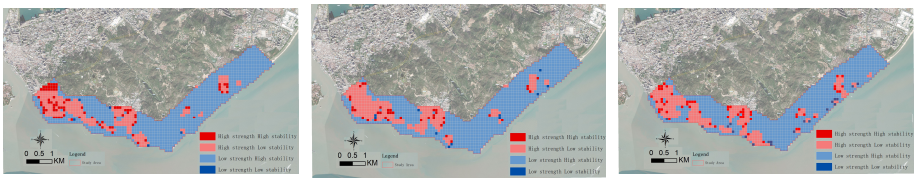


Fig. 5. Four Types of Vitality Painting source: (author's own drawing)



RestDays Working Days Holidays

Fig. 6. Distribution of Four Vitality Types on a Typical Date

4.3.2 High Strength Low Stability Area.

This type of area has a relatively high vitality intensity at some specific time, which can attract more people to gather here, but the daily average utilization rate is not high, the daily flow fluctuates greatly, but the regional distribution is relatively concentrated. Relatively densely distributed in areas with high mobility, including commercial streets, education and transportation, such as historical blocks, various campuses and public transport stations.

4.3.3 Low Strength High Stability Area.

This type of area has special functions, usually to serve specific people, resulting in low vitality intensity. However, this type of coastal space has strong vitality and stability. The distribution of the three typical dates is roughly the same. It mainly distributes some coastal open green space and various parks and other spaces with special functions, such as Lion Rock Park, Botanical Garden and Zengcuo'an scenic spots.

4.3.4 Low Strength Low Stability Area.

The vitality and stability of this type of area are not high, and the attraction of this type of area is the weakest. In addition to incomplete construction and some special land, as long as open temples, reservoirs and plantations are distributed, such as Nanputuo Temple, Xiada Reservoir, Yunding Strawberry Garden and other surrounding areas. The road network density and population density around such coastal space units are low.

5 The Influence of Environmental Factors on the Vitality of Coastal Space

In order to study the impact of environmental elements of coastal space on the vitality of coastal space, and identify the differences and weights arising from them, first, the original data of 12 environmental impact elements obtained from various collection methods will be imported into Arc GIS10.8 for data quantification, exported to Excel software for normalization, and then imported into Arc GIS10.8 to establish fishing net connection, so as to obtain the indicators of vitality impact elements. Finally, SPSS26 software was utilized to conduct multiple linear regression analysis and Pearson correlation analysis on the indexes of the influencing factors of vitality and the indicators of vitality characterization.

5.1 Relationship Between Environmental Factors and Vitality Intensity

Multivariate linear regression analysis was carried out on the independent variable vitality influencing factor index and the dependent variable average vitality intensity to obtain the vitality intensity regression standardized residual error distribution diagram (as shown in Figure 7) and the multivariate linear regression model coefficient table (as shown in Table 3). It can be seen in Figure 7 that the distribution frequency of the standardized residual error histogram of vitality intensity has a high degree of fit with the normal distribution curve, which indicates that the regression model built has a good integrity. Secondly, the actual cumulative probability in the normal distribution P-P diagram of standardized residual error of vitality intensity is basically consistent with the expected cumulative probability, indicating that the establishment of this regression model is highly feasible and can be well combined with the reality. From the model coefficient Table 3, we can see that the value of each variance inflation factor (VIF) is less than 5 (VIF is used to evaluate whether there is a collinearity between factors. Generally speaking, if VIF<10, it is considered that there is no serious collinearity between independent variables, and vice versa), indicating that there is no significant problem of multiple collinearity between independent variables, so the model is effective.

In the vitality intensity model, it can be found that the P values of the independent variable location centrality, land mix, plant coverage, road network density, cultural service facility density, catering service facility density and medical service facility

density are all less than 0.01 (P represents the correlation coefficient between the variables. It is generally considered that P<0.01 is extremely significant, P<0.05 is significant, P>0.05 is not significant), so there is a very significant correlation between these independent variables and vitality intensity. It can be seen from the standardized coefficient Bete value that the density of catering service facilities has the largest impact on the vitality intensity among the independent variables. At the same time, it can be seen that the adjusted $R^2 = 0.563$, indicating that the vitality intensity of coastal space is affected by 56.3% of the vitality of environmental impact factors.

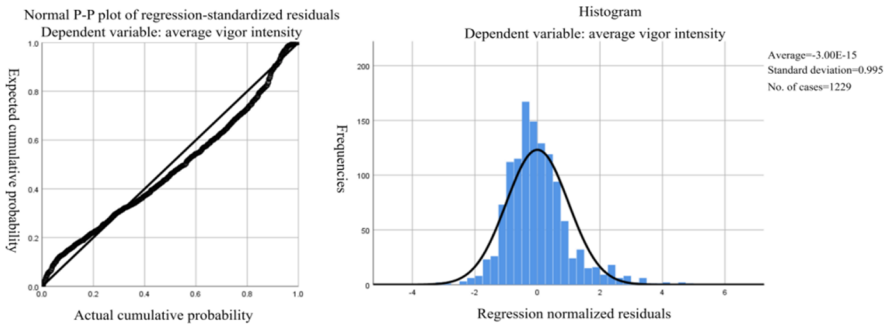


Fig. 7. Multiple Linear Regression Standardized Residual Distribution of Vitality Strength. Painting source: (author's own drawing)

The Pearson correlation analysis results (as shown in Table 4) based on the independent variable environmental impact element indicators and the vitality intensity of each typical date of the dependent variable show that the road network density and the density of catering facilities have a positive effect on the vitality intensity, of which the road network density has the largest impact and is most obvious on rest days; The density of catering service facilities has the weakest impact on working days; However, location centrality, land mix, the rate of plant coverage, density of cultural service facilities and density of medical service facilities have certain inhibitory effects on vitality intensity. Among them, the location centrality has the largest inhibitory effect on the vitality intensity in holidays, and the inhibiting effect of land use mixing degree is the weakest in working days.

Table 3. Coefficient Table of Multiple Linear Regression Model of Vitality Strength

Type	Independent variable	Non standardized coefficient		Standardization coefficient	t	Significance	Collinearity statistics	
		B	Standard error	Beta			tolerance	VIF
/	(Constant)	.458	.016		29.106	.000		
Location	Location centrality	-.299	.017	-.365	-17.730	.000	.839	1.192
Spatial character-	Land mix	-.092	.011	-.168	-8.610	.000	.932	1.073
istic	The rate of plant coverage	-.227	.021	-.222	-10.997	.000	.872	1.147

Traffic	Scenic spot density	.094	.052	.034	1.810	.071	.987	1.013
	Road network density	.130	.018	.137	7.090	.000	.948	1.055
	The rate of bus stop coverage	.052	.036	.027	1.433	.152	.995	1.005
	Residential density	-.070	.053	-.033	-1.332	.183	.575	1.741
Facility	Density of sports service facilities	.029	.089	.007	.323	.746	.761	1.314
	Density of cultural service facilities	.148	.036	.086	4.111	.000	.813	1.230
	Density of commercial service facilities	.075	.076	.034	.986	.324	.302	3.309
	Density of catering facilities	.489	.060	.298	8.142	.000	.266	3.764
	Density of medical service facilities	.209	.035	.127	6.035	.000	.806	1.240

a. Dependent variable: average activity intensity; Adjusted R^2=0.563

Table 4. Analysis Table of Typical Daily Vitality Strength and Environmental Influence Factors

Type	Independent variable	Rest day vitality intensity		Workday vitality intensity		Holiday vitality intensity	
		Pearson correlation	Sig (Double tail)	Pearson correlation	Sig (Double tail)	Pearson correlation	Sig (Double tail)
Location	Location centrality	-.037	.197	-.032	.269	-.066*	.021
Spatial characteristics	Land mix	-.026	.365	-.019	.503	-.031	.274
	The rate of plant coverage	-.051	.071	-.050	.078	-.041	.151
Traffic	Scenic spot density	.099**	.001	.085**	.003	.096**	.001
	Road network density	.254**	.000	.243**	.000	.234**	.000
	The rate of bus stop coverage	.035	.216	.033	.252	.036	.207
	Residential density	.111**	.000	.118**	.000	.095**	.001
Facilities	Density of sports service facilities	.049	.089	.043	.133	.053	.064
	Density of cultural service facilities	-.049	.089	-.053	.062	-.044	.125
	Density of commercial service facilities	.052	.068	.057*	.045	.037	.201
	Density of catering facilities	.083**	.004	.089**	.002	.064*	.025
	Density of medical service facilities	-.039	.167	-.037	.193	-.038	.186

Number of cases: 1229

**. At 0.01 level (double tail), the correlation is significant; * At 0.05 level (double tail), the correlation is significant.

5.2 Relationship Between Environmental Factors and Vitality Stability

The multivariate linear regression analysis was carried out between the independent variable vitality influencing factor index and the dependent variable average vitality stability, and the standardized residual error distribution diagram of vitality intensity regression (as shown in Figure 8) and the coefficient table of the multivariate linear regression model (as shown in Table 5) were obtained. It is found in Figure 8 that the distribution frequency of the standardized residual error histogram of the vitality stability is also highly consistent with the normal distribution curve, which indicates that

the regression model built has good integrity. Secondly, the actual cumulative probability in the normal distribution P-P diagram of the standardized residual error of the vitality stability is basically consistent with the expected cumulative probability, indicating that the establishment of this regression model is highly feasible and can be well combined with the reality. From Table 5 of the coefficients of the vitality stability model, we can see that the values of each variance expansion coefficient are less than 5, which indicates that there is no significant multicollinearity problem between the independent variables, so an effective vitality stability regression model is obtained.

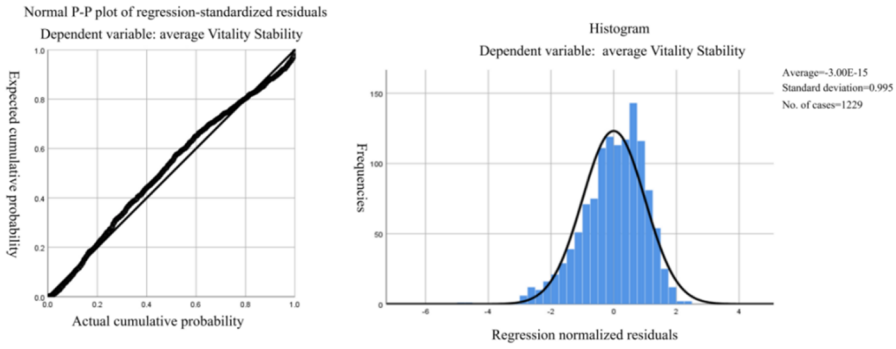


Fig. 8. Multiple Linear Regression Standardized Residual Distribution of Vitality Volatility. Painting source: (author's own drawing)

In the vitality stability model, it can be found that the P values of the independent variables such as location centrality, land mix, the rate of plant coverage, the rate of bus station coverage, residential density, cultural service facility density and catering service facility density are all less than 0.05, indicating that there is a very significant correlation between these independent variables and vitality stability. It can be seen from the standardized coefficient Bete value that the location centrality has the greatest impact on the vitality stability among the independent variables. At the same time, it can be seen that the adjusted $R^2 = 0.427$, indicating that the environmental impact factor index of coastal space has 42.7% impact on the vitality stability.

The Pearson correlation analysis results (as shown in Table 6) based on the independent variable environmental impact element indicators and the vitality stability of each typical date of the dependent variable can be seen that, except for the location centrality, land mix, the rate of plant coverage and cultural service facility density, all other elements have a certain inhibitory effect on the vitality stability. Among them, the location centrality plays the most important role in promoting the vitality stability on holidays, while the road network density plays the most important role in inhibiting the vitality stability on holidays; The promotion of plant coverage on rest days is the weakest, and the inhibition of medical service facility density on holidays is the weakest.

Table 5. Coefficient Table of Multiple Linear Regression Model of Vitality Volatility

Type	Independent variable	Non standardized coefficient		Standardization coefficient	t	Significance	Collinearity statistics	
		B	Standard error	Beta			Tolerance	VIF
/	(Constant)	.546	.017		32.265	.000		
Location	Location centrality	.228	.018	.297	12.601	.000	.839	1.192
Spatial character-istics	Land mix	.086	.012	.167	7.477	.000	.932	1.073
	The rate of plant coverage	.225	.022	.234	10.135	.000	.872	1.147
	Scenic spot density	-.089	.056	-.035	-1.595	.111	.987	1.013
Traffic	Road network density	-.232	.020	-.261	-11.760	.000	.948	1.055
	The rate of bus stop coverage	-.086	.039	-.048	-2.204	.028	.995	1.005
	Residential density	-.142	.057	-.072	-2.515	.012	.575	1.741
Facilities	Density of sports service facilities	.022	.096	.006	.226	.822	.761	1.314
	Density of cultural service facilities	-.183	.039	-.113	-4.739	.000	.813	1.230
	Density of commercial service facilities	.033	.081	.016	.406	.685	.302	3.309
	Density of catering facilities	-.324	.065	-.210	-5.024	.000	.266	3.764
	Density of medical service facilities	-.072	.037	-.046	-1.931	.054	.806	1.240

a. Dependent variable: average activity is stable; Adjusted R^2= 0.427

Table 6. Analysis of Vitality Fluctuations and Environmental Impact Elements on Typical Dates

Type	Independent variable	Rest day vitality intensity		Workday vitality intensity		Holiday vitality intensity	
		Pearson correlation	Sig (Double tail)	Pearson correlation	Sig (Double tail)	Pearson correlation	Sig (Double tail)
Location	Location centrality	.105**	.000	.087**	.002	.143**	.000
Spatial char-acteristics	Land mix	.029	.308	.037	.196	.044	.125
	The rate of plant coverage	.001	.975	.002	.954	.005	.870
	Scenic spot density	-.088**	.002	-.064*	.025	-.079**	.006
Traffic	Road network density	-.171**	.000	-.166**	.000	-.181**	.000
	The rate of bus stop coverage	-.072*	.011	-.048	.096	-.047	.099
	Residential density	-.094**	.001	-.112**	.000	-.074**	.009
Facilities	Density of sports service facili-ties	-.027	.347	-.018	.532	-.057*	.046

Density of cultural service facilities	.024	.406	.054	.057	.028	.328
Density of commercial service facilities	-.032	.269	-.032	.262	-.022	.448
Density of catering facilities	-.056*	.049	-.068*	.018	-.041	.148
Density of medical service facilities	.057*	.046	.044	.123	.035	.225
Number of cases: 1229						

**. At 0.01 level (double tail), the correlation is significant; * At 0.05 level (double tail), the correlation is significant.

6 Conclusion

This particle is mainly based on multi-source data, taking Shapowei Huangcuo Section of Huandao Road in Xiamen as the research object, and studying the spatio-temporal variation law of vitality intensity and vitality stability of each coastal space unit within the scope of study, as well as the impact of environmental impact factors on its vitality. The following conclusions are reached:

First, in terms of temporal and spatial distribution characteristics, the vitality intensity of the eastern part of Xiagang Street and the western part of Binhai Street in the coastal space of Xiamen Huandao Road is significantly higher and more concentrated, which is most significant during holidays, while the regions with higher vitality stability are mainly distributed in Zengcuo'an Community and Huangcuo Community, and the vitality stability value on rest days is higher than other typical days; From the perspective of single day, people prefer to gather in the coastal space in the evening to carry out outdoor activities, and the longer the rest time, the more people gather and the longer the duration, especially in holidays;

Second, in terms of vitality distribution characteristics, the coastal space areas with high vitality intensity and high vitality stability are often the most developed and have complete service facilities; The coastal space in areas with high vitality intensity and low vitality stability is mainly distributed in areas with high mobility such as commercial streets, education and transportation; The areas with low vitality intensity and high vitality stability are mainly distributed in some coastal open green space and various parks and other spaces with special functions; The areas with low vitality intensity and low vitality stability are mainly open temples, reservoirs and plantations, and the traffic system in this area needs to be improved;

Third, the results of multiple linear regression analysis between the environmental impact factor index of coastal space and the vitality intensity and vitality stability indicate that the independent variables of the environmental impact factor index with $P<0.05$ include location centrality, land mix, the rate of plant coverage, road network density, cultural service facility density and catering service facility density, which indicates that these factors have significant effects on the vitality intensity and vitality stability, Other environmental impact factors have no significant impact on the vitality of coastal space. Pearson correlation analysis shows that road network density (0.254) and catering service facilities (0.089) have positive effects on vitality intensity; The

location centrality (-0.066), land mix (-0.031), the rate of plant coverage (-0.051), and cultural service facility density (-0.053) have a certain inhibitory effect on the vitality intensity; The influence on the vitality and stability of coastal space is opposite.

Reference

1. Liu Song, Lai Siqi. Research on the Factors Affecting the Vitality of Urban Public Space Based on Multi source Data -- Taking the Huangpu River Coastal Area in Shanghai as an Example [J]. Landscape Architecture, 2021,28 (03): 75-81. DOI: 10.14085/j.fjyl.2021.03.0075.07
2. Zhang Qu Integration of seawater, sand beach, green belt and sunshine [D]. Chongqing University, 2008
3. Ye Yu, Zhuang Yu, Zhang Lingzhu, etc Morphological exploration of vitality creation in urban design -- based on quantitative analysis of urban spatial morphological characteristics and test of residents' activities [J] International Urban Planning, 2016, 31 (1): 8
4. Zhang Chengyuan, Zhang Gan, Zhou Haiyao Research on spatial analysis and impact mechanism of urban vitality based on multiple big data -- taking Hangzhou central city as an example [J] Architecture and Culture, 2017 (9): 5
5. Wang Shifu, Qin Xiaoling, Deng Zhaohua. Research on the coordination degree of urban waterfront space vitality from the perspective of environmental behavior [J]. Tropical Geography, 2021,41 (05): 1009-1022. DOI: 10.13284/j.cnki.rddl.003393.
6. Fu Dongwen, Han Yin, Wang Xinyu. Research on the vitality of urban rail transit stations based on POI data [J]. Transportation Research, 2021,7 (06): 69-78. DOI: 10.16503/j.cnki.2095-9931.2021.06.008.
7. Liu Song, Lai Siqi. Research on the vitality measurement of urban public space supported by big data [J]. Landscape Architecture, 2019, 26 (05): 24-28. DOI: 10.14085/j.fjyl.2019.05.0024.05.