The impact of vegetation change and climate in coastal cities on public sports: the impact of urban heat island

Zhen Zeng

Received: 12 March 2021 / Accepted: 28 April 2021 / Published online: 17 May 2021
© Saudi Society for Geosciences 2021

Abstract

The process of urbanization is the most important human activity since the twentieth century. Due to the unique environmental problems brought about by urbanization, urban heat islands not only affect regional economic development and regional climate but also bring comfort to urban residents and energy consumption. The negative impact is obvious, so the study of urban heat island effect is very important to monitor regional and even global climate change and guide urban development plans. First of all, this paper takes the coastal megacities along the Belt and Road as the research object, based on MODIS surface temperature products and Landsat land use classification data, and uses urban heat island intensity as an indicator to analyze the heat islands of 10 megacities from an interannual and seasonal perspective from 2004 to 2020. The effect of the spatio-temporal pattern changes; then, taking a city as an example, based on Landsat land use classification data, RS and GIS technology is used to analyze the land cover change and urban expansion of a city in the past 30 years; finally, according to Landsat surface temperature data and land using classified data, the impact of land use and cover characteristics on urban heat islands in a city was investigated. Outdoor sports organizations and operators in SD coastal cities found that the outdoor sports organizations and operators in SD coastal cities did not make full use of the geographical environment, economic development, and cultural environment of coastal cities and fully analyzed the comprehensive and systematic problems in the organization and management of outdoor sports, so that outdoor sports organizations and operators in SD coastal cities can give full play to their advantages. Through this research, we will promote a more comprehensive understanding of the healthy and sustainable development of outdoor sports and promote the organization and development of outdoor sports. Management research provides a theoretical basis.

Keywords Coastal cities · Vegetation change · Urban heat island · Sports

Introduction

Urbanization is the most significant human activity process since the twentieth century. According to United Nations statistics, the proportion of the global urban population increased from less than 30% in 1950 to 54% in 2014, and it is predicted that this proportion will reach 66% by 2050. Currently, there are about 7.8 billion people living in urban areas within 200 km from the coastline, and the total population may double by 2025. The rapid and continuous urbanization of coastal cities has promoted the improvement of local transportation facilities and the development of tourism and trade. At the same time, the huge transformation of natural types to artificial construction land such as asphalt and reinforced concrete in the process of urbanization has given local natural resources and ecology. The environment has caused great pressure. The urban heat island effect refers to a local climatic phenomenon in which the temperature in the urban area is higher than that in the surrounding villages. It is a unique environmental problem in the process of urbanization (Zeng 2016). The urban heat island effect can produce a series of negative effects such as increased pollution, increased energy consumption, and increased residents’ health risks. In recent years, the temporal and spatial evolution characteristics of the urban heat island effect and the impact of land use cover changes have attracted widespread attention from domestic and foreign scholars (Zeng 2017).
Reasons for the impact of coastal climate on sports

The climate environment has always been an important influencing factor of outdoor sports, and physical education is basically outdoor sports, so the effect of physical education often fluctuates due to local climate changes. The main reason why the coastal climate environment has a huge impact on physical education is that the coastal climate has the characteristics of high humidity, frequent sea breeze and high wind, more sand in the wind, and more rainy seasons. These characteristics will cause different degrees of different sports (Aird 2018). The impact of this thus affects the normal progress of physical education. On the whole, the coastal climate environment will play a major role in human body functions, changing sports conditions, changing sports rules, and even affecting people’s emotions and psychology, which will affect sports in many ways. From the perspective of human body function, the coastal climate has many rainy seasons, frequent sea breeze, and strong wind, which will greatly affect the physical function of athletes, which will affect the performance of athletes. Basically, all athletes are difficult to fully perform in a relatively harsh climate environment (Cabrera-Miranda and Paik 2019).

The type of impact of coastal climate environment on sports

Different coastal climates have different impacts on sports, not only in the level of impact but also in the degree of impact. Taking football teaching sports as an example, precipitation, strong wind, humidity, temperature, smog, etc. will all have different effects on it, as follows:

The impact of precipitation on sports is obvious. As rainfall affects the visibility of athletes, at the same time, it can also cause the site to become more slippery, which often leads to a significant increase in sports risks, especially for sports such as football with a large amount of exercise and more intense sports, which are more prone to safety accidents on rainy days. Although football can also be carried out in the case of low precipitation, due to the presence of water on the ground and the slippery field, athletes are prone to accidents when running fast. At the same time, the ball will float on the water, and the precipitation will interfere with the sight of the athletes. It is easier to consume physical strength in football, and it is difficult to effectively play sports skills and tactics, which severely restricts the development of sports.

Coastal areas have a maritime monsoon climate, with frequent sea breeze throughout the year and strong winds, especially when the season changes in spring, summer, autumn, and winter, and windy weather is extremely common. The impact of windy weather on sports is reflected in many aspects. The first is the heat dissipation of athletes. The wind helps the athlete’s body to dissipate heat, thereby keeping the athlete in a relatively good competitive state for a long time, which is conducive to the development of sports. However, this is limited to the suitable wind speed range. When the wind speed is too high, it will have a certain negative impact on the athlete’s physical function and interfere with the movement; the second is the wind. Wind will produce athletes and sports equipment (Chang et al. 2019).

Force, usually manifested as resistance or thrust, thereby affects movement. When the wind is small, the impact on sports is small. At the same time, higher requirements are placed on the professional ability and competitive level of athletes. It is necessary for athletes to adapt to the wind direction and wind force and try to eliminate the impact on sports (Chapman 2004).

The humidity in the seaside area will be greater under the action of the maritime monsoon climate, which will affect the indoor decoration and computer equipment in the seaside area, and will also have an indirect impact on sports. This is because under different humidity conditions, athletes’ perspiration, body heat emission, and water and salt metabolism will be different, which will affect the athlete’s physical function and affect the development of sports. When the humidity is too low, the athlete’s body will dissipate heat faster, and at the same time, the amount of sweat will be large, which will make the athlete feel dry and cracked. At the same time, it is easy to feel dry throat, and the respiratory defense function will be further reduced during exercise (Chen et al. 2018).

Research design

Data source

Remote sensing data

The remote sensing data used in this paper are mainly MODIS night surface temperature products MOD11A2 and Landsat series data. The main purposes of each data are as follows: MOD11A2 is used to study and analyze the temporal and spatial change characteristics of the heat island effect of the megacities in the Belt and Road region; Landsat data is used to extract the land use and cover information of each city for the determination of the urban and rural boundaries and land use cover. The research is changed. In addition, Landsat data is also used to invert the surface temperature data of a certain city and to study the impact of land use and cover characteristics on the urban heat island effect (Clausen and D’Souza 2001).

Landsat series data is not only one of the main data sources for the study of regional land use and cover changes but also often used in the study of local urban heat island effects. In order to study the impact of huge changes in land use types caused by rapid urbanization on the urban heat island effect,
this paper takes a city in a typical coastal megacity in the Belt and Road region as an example and collects Landsat series covering a certain city area in 1990, 2000, 2010, and 2019. The images are used to study the characteristics of land use cover changes and coastline changes caused by urban expansion in a city in the past 30 years and to analyze the impact of land use cover changes on the heat island effect of a megacity. The detailed information is shown in Table 1. The data set is freely available from the official website of the US Geological Survey (Connaire et al. 2015).

Other auxiliary data

Other auxiliary data used in this paper include the boundary vector data of the study area and Google Earth high-resolution images. The vector data is mainly used for cropping the image data of the study area, and the Google Earth images are mainly used for the accuracy evaluation of land use classification data in the same period (Dai and Zhou 2018).

Data preprocessing

In order to ensure the efficiency of remote sensing image information extraction, the original data must be preprocessed. The data preprocessing is mainly to reduce the related errors of the image, thereby improving the accuracy and reliability of the research results. The preprocessing of MODIS surface temperature products mainly includes image stitching, projection, format conversion, and cropping. Since Landsat4-5 and Landsat8 satellite images have undergone preliminary geometric correction of the system, and the preprocessing of Landsat images in this paper mainly includes radiation correction and cropping (Datta and Mashaly 1990).

MODIS data preprocessing

Using MODIS data geometric correction and resampling tool MRT can preprocess LST data in HDF format, including image stitching, projection, and format conversion. Due to the wide range of research involved in this article, the long research time limit, and the large workload of MODIS data preprocessing, this article uses MRT tools to complete the batch preprocessing of MODIS surface temperature data in the Window console environment. Because the unit of MODIS surface temperature product is Kelvin (K), Eq. 1 is used to convert the unit of LST data to degree Celsius.

\[
LST = DN \times 0.02 - 273.15
\]

In the formula, LST is the surface temperature value (unit: °C), and DN is the gray value of the pixel.

According to the vector boundaries of 10 megacities, the interactive programming environment IDL8.5 provided by ENVI5.3 was used to realize batch cropping of images in the study area, and the surface temperature data of each city from 2007 to 2020 was obtained. The MATLAB environment was used to calculate the annual average, summer and winter average of each city’s surface temperature from 2007 to 2020, because 10 cities are located in the northern hemisphere except Jakarta, which is located in the low latitude area of the southern hemisphere (5.91–6.50°S), the data from June to August of each year are selected to calculate the summer average LST, and the data is from December to February of the following year. Calculate the average winter LST.

Landsat data preprocessing

Radiation correction refers to the process of system random radiation distortion or external factors, distortion correction caused by the data collection and transmission system, and the process of removing or correcting image distortion caused by radiation errors. Radiation correction includes radiation correction and atmospheric correction.

The vector data of the survey area is used as the ROI of the target area, and the irregular image reduction function based on the external vector data provided by ENVI5.3 is used to reduce the geographic location image of the survey area and provide subsequent land data support, such as extraction of use and coverage information, quantification of urban heat island intensity, analysis of land use and coverage changes.

| Table 1 List of Landsat image parameters in a certain city |
|----------------------------------------------------------|
| Get the day before | Sensor | Row number | Resolution (m) | Projection and coordinate system | With number | Cloud coverage |
|-------------------|--------|------------|----------------|---------------------------------|-------------|---------------|
| 1990.02.01        | Landsat 5/TM | 152/043 | 30              | UTM/WGS84                      | 42          | 1%            |
| 2000.0213         | Landsat 5/TM | 152/043 | 30              | UTM/WGS84                      | 42          | 0%            |
| 2010.04.29        | Landsat 5/TM | 152/043 | 30              | UTM/WGS84                      | 42          | 0%            |
| 2019.02.01        | Landsat 8/TIRS | 152/043 | 30              | UTM/WGS84                      | 42          | 0.45%         |
Land use classification and accuracy verification

In this paper, the overall classification accuracy in the hybrid matrix is used as the evaluation index of classification accuracy. The overall classification accuracy refers to the percentage of correctly classified pixels in the total number of pixels participating in the classification. The larger the value, the higher the classification effect and the higher the classification accuracy. Kappa coefficient is an integrated test method proposed by Cohen in 1960 to evaluate the classification results of remote sensing images. The Kappa coefficient is used to measure the consistency between two images. It can verify the classification accuracy more accurately, and it is the main evaluation index of remote sensing image classification accuracy. The evaluation criteria of Kappa coefficient (Table 2) have been widely used in image classification accuracy evaluation.

For the land use classification data of each period, this paper uses the Google Earth images of the same period to generate a confusion matrix for the accuracy evaluation of the classification results by randomly collecting verification samples through visual interpretation, ensuring that the overall accuracy and Kappa coefficient of all classification results reach 85% the above.

Calculation of urban heat island effect

Surface Urban Heat Island Intensity (SUHII) is generally measured by the temperature difference between urban and rural areas, expressed by Eq. (2):

\[
SUHII = T_{urban} - T_{rural}
\]

(2)

In the formula, SUHII represents the intensity of urban heat island on the surface, \( T_{urban} \) represents the average temperature of urban areas, and \( T_{rural} \) represents the average temperature of rural areas. Based on the year-by-year average heat island intensity (SUHII) data of the study area from 2004 to 2020 calculated by formula (2), and using formula (3) to average the SUHII data (excluding outliers), the spatial distribution of the multi-year average heat island intensity among cities is obtained.

\[
SUHII_{cij} = \frac{\sum_{i=2001}^{2017} SUHII_{ci}}{17}
\]

(3)

Table 2 Kappa coefficient accuracy evaluation standard

| Kappa coefficient | Consistency   |
|-------------------|---------------|
| < 0.0             | Very bad      |
| 0.0–0.2           | Bad           |
| 0.2–0.4           | general       |
| 0.4–0.6           | Medium        |
| 0.6–0.8           | Great         |
| 0.8–1.0           | Well          |

In the formula, SUHII_{ci} represents the average value of SUHII on pixel \( i \) for city \( c \) from 2004 to 2020; \( j \) represents the year (\( j = 2001, 2002, ..., 2017 \)).

According to the multi-year average heat island intensity value, the study area is divided into different grades, as shown in Table 3. A pixel with SUHII \( \leq 0 \) °C is defined as a level 0 heat island, a pixel with \( 0 \) °C < SUHII \( \leq 1 \) °C is defined as a level 1 heat island, a pixel with \( 1 \) °C < SUHII \( \leq 2 \) °C is defined as a level 2 heat island, 2 °C < SUHII \( \leq 3 \) °C is defined as a level 3 heat island, and SUHII > 3 °C is defined as a level 4 heat island.

Mask the corresponding SUHII data according to the boundary of the core urban area, calculate the average annual SUHII data of the urban area (excluding waters) using formula (4), and obtain the annual average SUHII value of each city, that is, the urban annual average heat island intensity. Then use the linear regression method to analyze the annual average SUHII change trend of each city, and analyze the significance of the trend.

\[
SUHII_{cj} = \frac{\sum_{i=2001}^{2017} SUHII_{ci}}{17}
\]

(4)

In the formula, SUHII_{cj} represents the average value of SUHII in city \( c \) in year \( j \); \( i \) represents the \( i \)th pixel.

The impact of vegetation coverage on urban climate and environment

The normalized building index (NDBI) is an index that represents urban construction land. The larger the land area of the building and the higher the building density, the greater the NDBI value. Otherwise, the NDBI value becomes smaller. The calculation of the formula is as follows:

\[
NDBI = \frac{\rho_{MIR} - \rho_{NIR}}{\rho_{MIR} + \rho_{NIR}}
\]

(5)

In the formula, \( \rho_{MIR} \) and \( \rho_{NIR} \) are the mid-infrared and near-infrared bands of the multispectral image after atmospheric correction. The normalized vegetation index (NDVI) is often used to characterize the state of land vegetation. The growth state of vegetation is good, and the higher the coverage rate, the larger the corresponding NDVI value, the better the growth state of vegetation, and the greater the coverage rate. The calculation is as follows:

\[
NDVI = \frac{\rho_{NIR} - \rho_{R}}{\rho_{NIR} + \rho_{R}}
\]

(6)
In the formula, $\rho_{NIR}$ and $\rho_{R}$ are the near-infrared and infrared bands of the multispectral image after atmospheric correction.

**Research on coastal public sports**

According to research needs, the full-text database of Chinese journals, the full-text database of Chinese doctors’ papers, the full-text database of Chinese outstanding master’s theses, and foreign language databases, including “sports” and “geography,” “sports geography/competitive sports,” and “sports” and “/geography,” I read other aspects of literature and the library of Nanjing’s general university. Through careful reading and classification and analysis of the collected data, a systematic understanding of the research situation of this topic will lay a certain theoretical foundation for the research of this paper.

This article uses mathematical statistics to deal with the number of medals won by provinces and regions in the last national competition, find favorable sports in each region, and establish a true strategic pivot. According to the results of the survey and data statistical processing, carefully compare the contents of the relevant data obtained, summarize and analyze, and combine logical knowledge and methods to clarify and summarize the research viewpoints of this topic (Drag 2017).

**Research results**

**Analysis of temporal and spatial characteristics of heat islands in coastal cities**

Based on the results of Landsat land use classification in the study area, this paper extracts the continuous area of the built-up area where the construction land density is greater than 50% as the urban core area.

Table 4 shows the expansion speed of the core urban areas of each megacity from 2005 to 2020, indicating that the urban core areas of 10 cities have expanded to a certain extent during the period 2003–2020. According to statistics, Shanghai, Shenzhen, Tianjin, and Guangzhou are the cities with large urban expansion. The urban core areas around 2020 have increased by 83.73%, 39.70%, 35.66%, and 27.67% respectively compared with 2005. The period of rapid urban expansion in 7 cities was between 2005 and 2010, after which the expansion rate has slowed down. Around 2020, the urban area of Shanghai expanded by 47.05% compared to 2005. The expansion rate dropped to 13.39% from 2010 to 2015. In 2020, the urban expansion rate slowed down to 10.19% compared with 2015.

Figure 1 shows the spatial distribution characteristics of the urban core area of the megacities from 2016 to 2020 and the multi-year average heat island intensity from 2004 to 2020. Heat islands (SUHII > 0 °C) are mainly distributed in the core urban areas of cities. Especially high-intensity heat islands are basically distributed in the urban core areas with dense population activities, indicating that urban heat island effects generally occur in cities where the urban temperature is higher than the rural temperature. The average heat island intensity level of each city varies greatly for many years. Except for the weaker heat island intensity of Jakarta, the highest level of heat island intensity of other cities is mainly between 3 and 4. In particular, the heat island effect in a certain city and Tianjin is more significant, the intensity of the heat island is as high as 5 to 6 °C, and the area of the strong heat island (SUHII > 3 °C) area is significantly larger than other cities. Figure 2 shows the interannual variation of the average annual SUHII in 10 cities, and the intensity of the heat island in each city fluctuates. The cities with relatively gentle changes in urban heat island intensity are Tianjin and Istanbul. The average annual SUHII value of Tianjin for many years is basically between 2.0 and 2.5 °C, with the minimum value in 2015 (1.91 °C). The average annual SUHII value of Istanbul for many years is between 1.5 and 2.0 °C, and the maximum value appeared in 2014 (2.09 °C). Before 2010, the fluctuation range of Mumbai’s urban heat island intensity was relatively small, and the average annual SUHII value was basically between 1.3 and 1.8 °C.

**Table 3** Classification of heat island intensity levels

| Heat island intensity level | SUHII range  |
|----------------------------|--------------|
| Grade 0 heat island        | SUHII ≤ 0 °C |
| Level 1 heat island        | 0 °C < SUHII ≤ 1 °C |
| Level 2 heat island        | 1 °C < SUHII ≤ 2 °C |
| Level 3 heat island        | 2 °C < SUHII ≤ 3 °C |
| Level 4 heat island        | SUHII > 3 °C |

**Table 4** Expansion rate of core urban areas of megacities from 2005 to 2020 (%)

| Period      | Guangzhou | Chennai | Certain city | Manila | Mumbai | Shanghai | Shenzhen | Tianjin | Jakarta | Istanbul |
|-------------|-----------|---------|-------------|--------|--------|----------|----------|---------|---------|----------|
| 2005–2010   | 16.15     | 5.45    | 0.32        | 3.93   | 0.32   | 47.05    | 11.68    | 8.97    | 2.27    | 3.98     |
| 2011–2015   | 4.57      | 1.36    | 0.28        | 1.71   | 0.03   | 13.39    | 12.87    | 16.60   | 1.48    | 2.43     |
| 2016–2020   | 5.10      | 1.20    | 1.28        | 2.31   | 0.10   | 10.19    | 10.83    | 6.77    | 0.93    | 0.79     |
According to the changes in the average annual SUHII value for many years (Table 5), the city with the most significant urban heat island effect is a city, with the annual average SUHII value as high as 3.02 °C for many years, followed by Tianjin and Guangzhou, with the average SUHII being 2.31 and 2.14 °C, respectively. The cities where the multi-year average of SUHII exceeds 1 °C are Istanbul, Shenzhen, Mumbai, Manila, and Chennai, with 1.82, 1.81, 1.59, 1.42, and 1.33 °C respectively. According to trend analysis, the city with the most significant increase in annual urban heat island intensity is Chennai. Its annual average SUHII value increases by about 0.07 °C (∑ < 0.1) per year. The heat island intensity of other cities has no significant change trend.

According to Fig. 3 and Table 6, the city with the highest heat island intensity in summer is Istanbul. Its SUHII value has been stable at 2.5–3 °C for many years, and the average SUHII value is 2.88 °C. The second is Guangzhou (2.31 °C). The cities where the average SUHII in summer exceeds 1 °C are Tianjin (1.80 °C), Shenzhen (1.75 °C), Mumbai (1.44 °C), and a certain city (1.36 °C). The city with the most significant heat island intensity in winter is a city whose SUHII value is almost 4 °C or more every year, and the average SUHII is as
According to the analysis of the seasonal change trend of heat island intensity (Table 6), the cities with significant changes in urban heat island intensity in summer are Chennai and Istanbul. Chennai increases significantly at a rate of 0.25 °C/year ($P < 0.05$). On the contrary, in Istanbul, the heat island intensity in summer showed a significant downward trend ($-0.04 °C/year$, $P < 0.05$). The cities with significant changes in heat island intensity in winter are Chennai, Mumbai, and Shanghai, and the heat island intensity has a significant upward trend, with rates of 0.07, 0.02, and 0.05 °C/year, respectively ($P < 0.05$). The seasonal change trend of heat island intensity in other cities is not significant.

### Analysis of land use cover change and urban expansion

#### Land use and cover changes

Figure 4 shows the land use classification results of a city in 1990, 2000, 2010, and 2019. The land use types are divided into 6 categories: water area, construction land, land vegetation, mangrove, beach/sand land, and bare land/bare rock. From Fig. 4, it can be found that the density and scope of construction land in a certain city have increased and expanded significantly during the period 1990–2019. On the contrary, the area of bare land/bare rock has declined, while the change of land vegetation has not changed much.

According to the results of the fourth phase of land use classification, using statistical methods to analyze the change trends of various types of land use and cover in a city from 1990 to 2019 (Fig. 5), it can be found that the surface types of a city are mainly bare land/bare rock. The four phases all account for about 50% of the total area of the study area, but their area shows a trend of continuous decrease ($-72.89 \text{ km}^2/\text{a}$, $P = 0.054$) and a total decrease of about 240.13 km$^2$ from 1990 to 2019, while in the construction land area, there is a continuing upward trend ($76.71 \text{ km}^2/\text{a}$, $P = 0.057$), with a total increase of about 254.50 km$^2$ in the past 30 years, and the land vegetation area has not changed much. Although the change trend of waters and tidal flats/sandy land is not obvious, the coverage of mangroves has a significant expansion trend ($38.58 \text{ km}^2/\text{year}$, $P = 0.034$).

Table 7 shows a city’s land use transfer matrix in 1990–2000 and 2010–2019. The total transfer rates of land use types in the two periods are 12.92% and 13.12%, respectively. The structure of land use change in the two phases is similar. The types with the largest land use transfer rate are terrestrial vegetation, accounting for 58.62% and 58.74% of the total land vegetation area in each phase. From 1990 to 2000, about 56.38 km$^2$ of land vegetation was transferred to bare land/
bare rock, accounting for 49.59% of the total land vegetation area in 1990, during which about 63.45 km² of land/bare rock was transferred to land vegetation.

Table 8 shows the relevant indicators for the expansion of urban construction land in a city during 1990–2019. It can be found that during 1990–2019, the area of construction land expansion in a city totaled about 254.50 km², and the expansion of construction land mainly occurred in 1990–2000 and 2010. In the two time periods in 2019, the expansion area was 151.00 km² and 109.92 km², accounting for about 98.60% of the total expansion area. The fastest period of urban expansion occurred during 1990–2000. The construction land increased by an average of about 15.10 km² per year, and the expansion accounted for about 7.46% of the total construction land. During the period 2010–2019, the urban expansion speed was 11.10 km²/a, and the expansion dynamics accounted for
approximately 3.11%. The expansion degree of urban construction land in the three stages is less than 10% and mainly shows a downward trend.

The construction land of a city is mainly concentrated in the southern coastal area, which is also the location of the core urban area of a city. Through overlay analysis (Fig. 6), it is found that the urban expansion of a certain city from 1990 to 2019 is very significant, and construction land mainly includes three types of expansion: sprawl, infill, and leaping.

Coastal land expansion

The coastline is affected by the topography and landform of the local coastal zone and the degree of human development.

The origin, material composition, and human use of the coastline are shown in Fig. 7.

According to the remote sensing interpretation signs of different coastlines (Table 9), the four coastlines of 1990, 2000, 2010, and 2019 in the study area were extracted using GIS vectorization technology based on image data to analyze the change characteristics of the coastline of a city in the past 30 years. Most of the coastlines extracted by visual interpretation based on remote sensing images are the instantaneous water edges taken at the moment of satellite transit. Generally, water boundary position of the coastline is greatly affected by factors such as tide fluctuations, but the coastline of the rock plate and the artificial coastline will not be affected too much. According to the survey, the coastline types of a certain city are mainly Bedrick coastlines and artificial coastlines.

| Table 7 | Land use transfer matrix (km²) of a city in 1990–2000 and 2010–2019 |
|---------|------------------|-----|-----|-----|-----|-----|-----------|-----|
|         | 1    | 2    | 3    | 4    | 5    | 6    | Total  | P (%) |
| 1990    | 1 158.96 | 7.47 | 154.50 | 0.36 | 63.45 | 1.90 | 1814.64 | 12.55 |
|         | 7.37 | 255.43 | 2.51 | 30.21 | 0.40 | 10.29 | 306.20 | 16.58 |
|         | 10.68 | 3.18 | 186.28 | 0.04 | 2.22 | 0.13 | 202.55 | 8.03 |
|         | 3.21 | 14.37 | 0.44 | 95.65 | 0.79 | 1.72 | 116.17 | 17.66 |
|         | 56.38 | 0.06 | 10.10 | 0.04 | 47.04 | 0.08 | 113.69 | 58.62 |
|         | 3.30 | 23.28 | 0.52 | 0.53 | 0.20 | 589.45 | 617.29 | 4.51 |
| Total   | 1667.89 | 303.79 | 354.35 | 126.83 | 114.10 | 603.57 | 3170.53 | 12.92 |
| 2010–2019 | 1 1472.19 | 6.89 | 121.58 | 0.55 | 59.68 | 0.69 | 1161.58 | 11.40 |
|         | 3.23 | 43.81 | 1.47 | 15.57 | 0.04 | 0.97 | 65.08 | 32.68 |
|         | 27.20 | 2.04 | 325.45 | 0.00 | 2.76 | 0.06 | 357.50 | 8.97 |
|         | 1.12 | 5.85 | 0.21 | 185.26 | 0.61 | 1.51 | 194.56 | 4.78 |
|         | 63.78 | 0.21 | 6.25 | 0.25 | 49.58 | 0.09 | 120.15 | 58.74 |
|         | 6.50 | 61.54 | 2.78 | 22.11 | 0.32 | 678.33 | 771.59 | 12.09 |
| Total   | 1574.01 | 120.34 | 457.74 | 223.76 | 112.99 | 681.64 | 3170.47 | 13.12 |
while coastlines of other types of coastlines account for a small proportion. In addition, the dates of obtaining the images of the four stages are almost the same. Therefore, in this article, we basically think that the extracted water boundary is the coastline of the survey area.

This article uses the end point rate of change (EPR) and linear regression rate (LRR) as indicators to evaluate the characteristics of a city’s coastline change. EPR is calculated by dividing the net coastline movement NSM (the length of the cross-section line between the initial coastline and the final coastline) by the time interval between the initial and final coastlines (Fig. 8).

The main advantage of the EPR indicator is that it is easy to calculate, but the disadvantage is that when more data is available, additional information may be ignored. LRR refers to the use of least squares method to fit the intersection of the cross-sectional line and the coastline to calculate the rate of change of the coastline (Fig. 9). The slope of the regression line is the LRR value. The linear regression method has the following characteristics: (1) All data are used regardless of the change in the trend or accuracy of the original data; (2) the method is purely computational; (3) the calculation is based on recognized statistical concepts; (4) this method is easy to use. However, this method is easily affected by outliers and tends to underestimate the rate of change compared to other statistical data (such as EPR). Therefore, the combination of EPR and LRR can more scientifically and accurately simulate the rate of change of coastline in time and space.

According to statistical analysis, the coastline length of a certain city increased by 26.08 km from 1990 to 2019, and the total coastline length has a significant growth trend (9.51 km/a, \( P < 0.05 \)) (Fig. 10).

It can be seen from Fig. 11 that the proportion of cross-sectional lines with erosion phenomena is relatively small, and a larger part of the coastline shows a change of expansion toward the sea. The average values of the end point rate of change and linear regression rate of a city’s coastline are 4.97 m/a and 4.63 m/a, respectively; the maximum end point rate of change is 61.45 m/a, and the maximum linear regression rate is 47.74 m/a. This shows that from 1990 to 2019, the coastline of certain parts of a certain city has undergone a relatively drastic expansion toward the sea.

### Coastal land accretion

It can be seen from Fig. 12 that the expansion and change of the coastline to the seaside mainly occur in the middle and east coastlines of the study area, which are located in areas such as large sea mouths, ports, and docks with dense human

---

**Table 8** Average annual urban construction land expansion indicators of a city

| Period    | Expansion area (km²) | Expansion speed (km²/a) | Expansion dynamics (%) |
|-----------|----------------------|-------------------------|------------------------|
| 1990–2000 | 151.00               | 15.10                   | 7.46                   |
| 2000–2010 | 3.58                 | 0.36                    | 0.10                   |
| 2010–2019 | 99.92                | 11.10                   | 3.11                   |
activities and rich resources (Gao and Wu 2006). The coastline types are mainly artificial shorelines. The significant reason for the significant land accretion in the coastal zone of the study area is mainly due to a series of development and construction of some seaports, ports, and docks, which caused the coastline to extend to the seaside (Fig. 13).

Table 10 shows the average value and standard deviation of surface temperature of different land use types (except water area) in a city from 2000 to 2019. It can be found from

![Five coastline samples](image)

**The impact of vegetation changes in coastal cities on the climate and environment**

Table 10 shows the average value and standard deviation of surface temperature of different land use types (except water area) in a city from 2000 to 2019. It can be found from
Table 10 that the average LST of various types of land use and cover in 2019 is generally less than that in 2000 and 2010. This is mainly because the bare land/bare rock that contributes the most to the surface temperature has been significantly reduced during 2000–2019. Mainly converted to construction land, this change has affected the urban surface temperature pattern and reduced the difference in surface temperature between land use types (Hosseini Kordkheili et al. 2011).

Figure 14 shows the distribution of the scattered points of the land surface temperature (LST) and the NDBI in the third phase of a city. It can be concluded that there is a significant positive correlation between LST and NDBI in a certain city. Therefore, in future urban construction and planning, the layout of large-area, high-density buildings should be avoided as much as possible, and the urban architectural pattern should be planned reasonably.

It can also be found from Fig. 15 that in 2019, a city’s LST and NDVI showed a weak negative correlation, which indicates that urban green land has a certain regulatory effect on the surface temperature of a city. Therefore, increasing urban vegetation coverage and optimizing urban greening indicators can effectively alleviate the urban heat island effect of a city in the future.

Analysis of advantageous projects of public sports in coastal areas

According to Table 11, the northern coastal region has won 490 medals, including 180 gold medals, 147 silver medals, and 163 bronze medals, accounting for 22.65% of the total number of medals, which is 1.85 times the national average. Among them, the largest proportion is continuous activity 45.5 medals, accounting for 29% of the total medal activity. The second is the precision event, which won 34.5 medals, accounting for 27% of the total. The third is endurance and activities in the competition, with 129.5 and 28.5 medals, respectively, accounting for 25% of the total number of medals (Ju et al. 2014). The fifth place is speed, with 38.5 medals, accounting for 23% of the total. The sixth medal was 99.5 in the battle, accounting for 22% of the total number of medals. The seventh is the speed and intensity of 40
medals. The total number of medals in this group is 21%. The eighth is in 74 American events, and this team accounted for 17% of the total number of medals.

Table 12 shows that the eastern coastal region has won 522.5 medals, including 169.5 gold medals, 177 silver medals, and 176 bronze medals, accounting for 24.15% of the total number of medals, which is 1.97 times the national average (Kim et al. 2018). Speed events accounted for the largest proportion of 58 medals, accounting for 34% of the total number of medals. The second is 33 medals in the same competition, accounting for 29% of all medals. The third is the precision event, which won 33 medals. This accounts for 26% of all medals. The fourth is fighting, with 109 medals accounted for 24% of the total. The fifth place is the fighting activities of the United States and the Internet, with 103 medals and 35.5 medals, respectively, accounting for 23% of the total medals of these activities (Lei et al. 2014). The seventh is the durable event 110 medals, which accounts for 22% of the total medals. The eighth is speed and intensity, with 41 medals accounted for 21% of all medals.

Table 13 shows that the southern coastal region has won a total of 297 medals, including 98 gold medals, 96 silver medals, and 103 bronze medals, accounting for 13.73% of the national average of 1.12 times. Among them, the largest proportion of shameful incidents in the United States is 90 medals, accounting for 20% of the group’s total medals. This is the 31st full-speed medal. The third is a network event, with 23 medals accounted for 15% of all medals. The fourth is speed, strength, and endurance. There are 24 and 68 medals, respectively. Both medals account for 13% of the total number of medals. The fifth is the 14 medals of the same competition, accounting for 12% of all medals (Li et al. 2010). The seventh is a precision event, with 11 medals accounting for 9% of all medals. The eighth is a battle event, with 36 medals, accounting for 8% of all medals in this category.

Discussion and analysis

Mitigation measures and suggestions for the heat island effect in coastal cities

Reasonable planning of urban structure and spatial layout

The urban surface temperature of a city has a significant positive correlation with the normalized building index, indicating that the construction land of a city has a significant contribution to the urban heat island. Therefore, in future urban...
construction and planning, try to avoid the construction of high-density, continuous, and large-scale high-rise building land, and reasonable planning of urban structure and layout can effectively alleviate the urban heat island effect of a city (Li et al. 2017).

Increase urban vegetation coverage and improve urban greening indicators

In a city, land vegetation is scarce and green conditions are poor, so impervious surfaces and other artificial surfaces (such as construction land, roads, bridges, etc.) have played a control role in the impact of urban heat islands and weakened the impact of green vegetation and other natural surfaces on urban heat islands. Therefore, measures such as increasing urban vegetation coverage, increasing vegetation coverage, and optimizing urban greening indicators can strengthen the regulation effect of green vegetation on urban heat islands and promote healthy and sustainable urban development (Li et al. 2019a, 2019b).

Control urban population density and optimize urban environmental quality

Man-made heat release is one of the main causes of urban heat island effect. Appropriate control of urban population and population density, and continuous improvement of the urban environmental governance system, can effectively control
urban ecological environmental problems and urban climate problems caused by human activities (Li et al. 2019a, 2019b).

**Improve urban traffic conditions**

Vehicle exhaust emissions are the main component of man-made heat release. Therefore, through reasonable control of urban traffic, such as optimizing transportation infrastructure, researching and developing or introducing new energy transportation technologies, encouraging public transportation, implementing vehicle restriction systems, and restricting emission indicators, it can effectively improve urban congestion and excessive exhaust emissions. Urban traffic problems, thereby alleviating urban climate problems.

**Countermeasures for the coastal climate environment to interfere with sports**

In-depth study of the local coastal climate environment and formulation of response plans

Meteorological climate usually has certain laws, except for a few special cases and extreme weather conditions, local coastal climate environments generally have laws to follow. Schools in coastal areas should collect, analyze, and process local meteorological information from previous years, focus on research and summary of local climate characteristics, and formulate appropriate physical education plans based on the actual local climate. For example, football sports are greatly affected by precipitation, strong winds, humidity,

**Table 10** Average and standard deviation of land surface temperature for different land use types in a city from 2000 to 2019

| Land use type             | 2000s Mean LST | 2000s Standard deviation | 2010s Mean LST | 2010s Standard deviation | 2019s Mean LST | 2019s Standard deviation |
|--------------------------|----------------|--------------------------|----------------|--------------------------|----------------|--------------------------|
| Bare ground/bare rock    | 25.62          | 1.27                     | 32.21          | 1.88                     | 22.61          | 1.97                     |
| Construction land        | 24.11          | 1.30                     | 29.81          | 1.30                     | 22.34          | 1.00                     |
| Land vegetation          | 23.76          | 1.51                     | 29.17          | 2.23                     | 21.19          | 1.28                     |
| Beach/sand               | 20.07          | 2.14                     | 26.92          | 2.71                     | 20.49          | 1.03                     |
| Mangrove forest          | 19.58          | 0.52                     | 24.88          | 0.73                     | 19.49          | 0.47                     |

**Fig. 14** Scatter plot of LST and NDBI in a city from 2000 to 2019
temperature, smog, etc. Based on the results obtained from the analysis and summary of climate data in previous years, the school tries to arrange football teaching with less precipitation, less wind, humidity and temperature, and smog. The season is not serious, so as to minimize the negative impact of the climate environment on football.

**Actively explore the practical application of sports meteorology**

The current research directions of sports meteorology are mainly concentrated in two aspects: one is to study the time, place, and weather protection of large-scale sports events, and the other is to study the influence of meteorological elements on sports performance, personnel, and equipment. Therefore, it is necessary for schools to pay attention to this, actively carry out theoretical research and practical exploration around sports meteorology, and provide support and guarantee for physical education and sports with scientific methods (Low and Cheung 2012).

**The organization and management strategy of public sports in coastal cities**

In terms of management, “organization” has two meanings. One is used as a noun, and the other is used as a verb. The organized outdoor sports activities are to ensure the safety of outdoor sports activities. According to the purpose of outdoor sports and rules, with the mobilization of outdoor sports leaders, coaches, participants, and other personnel, the composition and adjustment process of activity funds, equipment, other resources and materials are guided in an orderly and

**Table 1** Number of medals in various groups in the northern coastal area (unit: pieces)

|                    | Speed power | Speed | Endurance | Difficult beauty | Accuracy | Confrontation Network confrontation | Fighting confrontation |
|--------------------|-------------|-------|-----------|------------------|----------|--------------------------------------|------------------------|
| Number of gold medals | 16          | 12.5  | 46        | 31               | 8.5      | 13.5                                 | 15                     | 37.5                   |
| Number of silver medals | 13.5        | 13.5  | 41        | 23               | 12       | 7                                    | 12.5                   | 24.5                   |
| Number of bronze medals | 10.5        | 12.5  | 42.5      | 20               | 14       | 8                                    | 18                     | 37.5                   |
| Total              | 40          | 38.5  | 129.5     | 74               | 34.5     | 28.5                                 | 45.5                   | 99.5                   |
smooth way. Outdoor sports as a result of unique characteristics are connected with risky outdoor activities. Therefore, in order to better manage outdoor activities, organized outdoor activities are particularly important. The general process of organizing outdoor sports activities is pre-event preparation, mid-term management, and later management, and management is implemented through the entire outdoor activities (Ma et al. 2019).

**Conclusion**

The characteristics of the coastal climate environment make it have a huge impact on sports, ranging from affecting the normal performance of athletes’ competitive level, and increasing the risk of sports. Therefore, when teaching physical education in coastal areas, schools and teachers should fully grasp the reasons and performance of the impact of climate on sports, and on this basis, optimize teaching arrangements, formulate emergency curriculum plans, actively build indoor gymnasiums or wind and rain playgrounds, and use existing in terms of technological innovation and expansion of physical education models, and the impact of even coastal climates on sports will be reduced overall.

In the coastal cities of SD Province, there are still great possibilities for the development of outdoor sports. For the development of outdoor sports, QD cities showed the characteristics of early start and rapid development, while some other coastal cities in SD Province showed the characteristics of late start and rapid development. Outdoor sports organizations lack safety work and lack mature management mechanisms. The safety awareness of people participating in outdoor sports needs to be improved. The number of individual spontaneous organizations and outdoor sports clubs seems to have increased significantly. The corresponding market order is not strictly managed by government departments. At present, the only government organization department responsible for outdoor sports management in the coastal cities of SD Province is the Mountaineering Association. Outdoor sports are mixed with other sports, and there is no clear department to promote the popularization of outdoor sports. The rules and systems related to outdoor sports are single, and mountaineering and rock climbing are mainly related to outdoor sports. In the coastal cities of SD Province, there are almost no geographical restrictions and systems for outdoor sports. Establishing a cooperative relationship on the premise that government departments and non-profit groups are independent of each other, realize resource sharing and common risks, and maximize mutual benefits. In the outdoor sports organization and operation of coastal cities in SD Province, it is possible to cultivate the cooperative partnership between the Sports Bureau, the Outdoor Sports Association, and the Outdoor Sports Club and give full play to their respective advantages to achieve complementarity and a win-win situation. Half of the management labor can achieve twice the result.

| Speed power | Speed Endurance Difficult beauty | Accuracy Confrontation | Network confrontation | Fighting confrontation |
|-------------|---------------------------------|------------------------|----------------------|----------------------|
| Number of gold medals | 10 | 18 | 36.5 | 32 | 12 | 9 | 20.5 | 31.5 |
| Number of silver medals | 16 | 22 | 40.5 | 32.5 | 7 | 14 | 8 | 37 |
| Number of bronze medals | 15 | 18 | 33 | 38.5 | 14 | 10 | 7 | 40.5 |

| Speed power | Speed Endurance Difficult beauty | Accuracy Confrontation | Network confrontation | Fighting confrontation |
|-------------|---------------------------------|------------------------|----------------------|----------------------|
| Number of gold medals | 4 | 12 | 27 | 32 | 4 | 6 | 6 | 7 |
| Number of silver medals | 12 | 6 | 18 | 30 | 4 | 4 | 10 | 12 |
| Number of bronze medals | 8 | 13 | 23 | 28 | 3 | 4 | 7 | 17 |

| Speed power | Speed Endurance Difficult beauty | Accuracy Confrontation | Network confrontation | Fighting confrontation |
|-------------|---------------------------------|------------------------|----------------------|----------------------|
| Number of gold medals | 24 | 31 | 68 | 90 | 11 | 14 | 23 | 36 |
Open access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution, and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made. The images or other third party material in this article are included in the article’s Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the article’s Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this license, visit http://creativecommons.org/licenses/by/4.0/.

Declarations

Conflict of interest The authors declare that they have no competing interests.

References

Aird P (2018). Deepwater drilling: well planning, design, engineering, operations, and technology application. Gulf Professional Publishing.

Cabrera-Miranda JM, Paik JK (2019) Two-phase flow induced vibrations in a marine riser conveying a fluid with rectangular pulse train mass. Ocean Eng 174(15):71–83

Chang Y, Wu X, Zhang C, Chen G, Liu X, Li J, Xu L (2019) Dynamic Bayesian networks based approach for risk analysis of subsea wellhead fatigue failure during service life. Reliab Eng Syst Saf 174:454–462

Chapman C (2004). Fundamentals of seismic wave propagation. Cambridge university press.

Chen L, Arzaghi E, Abaei MM, Garaniya V, Abbassi R (2018) Condition monitoring of subsea pipelines considering stress observations and structural deterioration. J Loss Prev Process Ind 51:175–185

Clausen T, D’Souza R (2001) Dynamic risers key components for deepwater drilling, floating production. Offshore (Gulfroo. 2001, 61(5): 89–93

Connaire A, O’Brien P, Harte A, O’Connor A (2015) Advancements in subsea riser analysis using quasi-rotations and the Newton–Raphson method. International Journal of Non-Linear Mechanics 70:47–62

Dai Y, Zhou J (2018) Experimental investigations on seismic response of riser in touchdown zone. International Journal of Naval Architecture and Ocean Engineering 10(3):348–359

Datta TK, Mashaly EA (1990) Transverse response of offshore risers to random ground motion. Earthq Eng Struct Dyn 19(2):217–228

Drag L (2017) Application of dynamic optimisation to stabilise bending moments and top tension forces in risers. Nonlinear Dynamics 89(3):2225–2239

Gao FP, Wu YX (2006) Non-linear wave-induced transient response of soil around a trenched riser. Ocean Eng 33(3-4):311–330

Hosseini Kordkheili SA, Bahai H, Mirtaheri M (2011) An updated Lagrangian finite element formulation for large displacement dynamic analysis of three-dimensional flexible riser structure. Ocean Eng 38(5-6):793–803

Ju X, Fang W, Yin H, Jiang Y (2014) Stress analysis of the subsea dynamic riser base process piping. J Mar Sci Appl 13(3):327–332

Kim DK, Incecek A, Choi HS, Wong EWC, Yu SY, Park KS (2018) A simplified method to predict fatigue damage of offshore riser subjected to vortex-induced vibration by adopting current index concept. Ocean Eng 157(1):40–49

Lei S, Zhang WS, Lin JH, Yue QJ, Kennedy D, Williams FW (2014) Frequency domain responses of a parametrically excited riser under random wave forces. J Sound Vib 333(2):485–498

Li X, Guo H, Meng Y (2010) Stress analysis of top tensioned riser under random wave and vessel motions. J Ocean Univ China 9(3):251–256

Li X, Chen G, Zhu H, Zhang R (2017) Quantitative risk assessment of subsea pipeline instability. J Loss Prev Process Ind 45:108–115

Li X, Chen G, Bu C, Xu C (2019a) Dynamic risk assessment of subsea pipeline leak using precursor data. Ocean Eng 178:156–169

Li X, Yang M, Chen G (2019b) An integrated framework for subsea pipelines safety analysis considering causation dependencies. Ocean Eng:175–186

Li YM, Cheung SH (2012) On the long-term fatigue assessment of mooring and riser systems. Ocean Eng 53:60–71

Ma KT, Luo Y, Kwan CTT, Wu Y (2019). Mooring system engineering for offshore structures. Gulf Professional Publishing.

Zeng Z (2016) A novel model for enterprise technological innovation capability evaluation with 2-tuple linguistic information. J Intell Fuzzy Syst 31(1):541–546

Zeng Z (2017) Model for evaluating the technological innovation capability in high-tech enterprises with fuzzy number intuitionistic fuzzy information. J Intell Fuzzy Syst 33(4):2085–2094