A model of economic loss of environmental carrying capacity caused by flood disasters in urban tourism areas

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Abstract
In the research on the economic loss of the carrying capacity of the tourism industry caused by flood disasters, some domestic and foreign scholars have conducted many years of research and have achieved certain results. The most commonly used model at present is mainly based on the historical data of the local urban tourism industry and calculates the economic loss of the environmental carrying capacity of the urban tourism area based on aquatic elements, submersion time, etc. However, although the model can provide some help, it still has shortcomings. The economic loss predicted by the model is quite different from the actual loss. In view of this situation, a model of the economic loss of the environmental carrying capacity of urban tourism areas due to flooding is designed to provide technical support for the assessment of the economic loss of the environmental carrying capacity of urban tourist areas. In this context, this article combines early warning theory, sustainable development theory, urban biology theory, urban environmental theory, and urban function and design planning theory into the economic loss model of environmental carrying capacity based on the research of relevant experts. Experts at home and abroad have used system dynamics simulation methods to establish environmental carrying capacity economic loss models based on the research results of domestic and foreign tourism environmental carrying capacity to study the environmental carrying capacity of coastal areas in our country. Based on the research results, it puts forward relevant suggestions to improve the environmental carrying capacity of coastal cities in our country, optimizes the early warning system of coastal cities’ environmental carrying capacity, and relieves the environmental pressure of coastal scenic spots, thereby promoting the tourism development, economic development, urban planning and environmental protection for coastal scenic spots.

Keywords Flood disaster · Urban tourism · Environmental carrying capacity · Early warning theory

Introduction
In recent years, our country’s tourism industry has developed rapidly, which has brought huge economic benefits to various tourist areas and also caused serious environmental pollution. Because many tourist area developers and management agencies put the promotion of local economic development in the first place, therefore, when constructing tourist areas and making profits through tourist areas, they ignore the carrying capacity of the local environment and lead to environmental problems. The pollution problem is getting worse and the local ecological balance has been severely damaged. At the same time, our country has always been a country with a high rate of natural disasters since ancient times (Casper 2010). Many regions have been devastated by mountain floods, droughts, floods, mudslides, landslides, earthquakes, and storms all year round. This is harmful to people’s lives, property, and social economy and has a huge impact. Estimating the urban tourism environmental carrying capacity can not only promote the development, planning, and management of local scenic spots but also can be used as an important criterion for measuring the local tourism development and environmental protection. Therefore, the environmental carrying capacity of urban tourist areas can be estimated and evaluated (Adamia et al. 2011). Improving the significance is very significant. For natural disasters with a high rate of emergence in these areas, how to conduct fast and effective collection and loss assessment is a problem that the tourism industry needs to solve urgently. This is due to the economic loss assessment of
the environmental carrying capacity of urban tourist areas that can take preventive measures in a targeted manner and reduce the economic losses caused by natural disasters to local residents under the conditions within our ability.

In the research on the economic loss of the carrying capacity of the tourism industry caused by flood disasters, some domestic and foreign scholars have conducted many years of research and have achieved certain results (Li et al. 2016). The most commonly used model at present is mainly based on the historical data of the local urban tourism industry and calculates the economic loss of the environmental carrying capacity of the urban tourism area based on aquatic elements, submersion time, etc. However, although the model can provide some help, it still has shortcomings (Berberian and King 1981). The economic loss predicted by the model is quite different from the actual loss. In view of this situation, a model of the economic loss of the environmental carrying capacity of the urban tourism area due to flooding is designed to provide important decision support for the evaluation of the economic loss of the environmental carrying capacity of the urban tourist area.

With the development of the times and economic progress, people’s ideas and economic concepts have been greatly improved. In the early stages of social and economic development, people are more concerned about how to make full use of environmental resources to obtain greater economic benefits (Motiei 1993). Today, the concept of sustainable development has gradually become the mainstream development concept of all countries in the world. The people, while pursuing economic gains, pay attention to the sustainable use of environmental resources, the protection of the ecological environment, and the maintenance of the balance of the ecosystem. As an ancient cultural country with a vast territory, abundant products, and outstanding customs and culture, China has always been a more important part of our country’s economic development, and the development of tourist attractions in coastal areas has the best prospects for economic development in our country’s tourist areas, regions with the greatest development potential and fastest development speed (Omidvar et al. 2016). The development of tourist areas in coastal cities can not only promote urban construction in these places and increase the economic income of local residents but also promote the development of local terrestrial and marine resources and promote the process of land-sea integration. However, due to the excessive development and utilization of natural resources in coastal areas, the development of scenic spots has also brought a serious blow to the ecology of these places. Therefore, many coastal city tourist areas have problems such as serious environmental pollution, excessive environmental load, and ecological system imbalance. Therefore, if you want to continue to promote the economic development and ecological civilization construction of coastal areas, it is necessary to estimate the maximum environmental carrying capacity of coastal city scenic spots, rationally develop and utilize natural resources in coastal areas, and solve the problems caused by overload and weak load of scenic spots (Nabavi 1976): the imbalance of ecological development. In this context, based on previous studies, this article integrates early warning theory, sustainable development theory, urban biology theory, urban environmental theory, urban function and design planning theory, and other related theories in the economic loss model of environmental carrying capacity based on previous studies. Combining the research results of domestic and foreign experts on the environmental carrying capacity of tourism at home and abroad, the method of system dynamics simulation was used to establish an economic loss model of environmental carrying capacity to study the environmental carrying capacity of coastal areas in our country (Agard et al. 2005). Based on the research results, it puts forward relevant suggestions to improve the environmental carrying capacity of coastal cities in our country, optimizes the early warning system of coastal cities’ environmental carrying capacity, and relieves the environmental pressure of coastal scenic spots, thereby promoting the development and economic development of coastal scenic spots. Development, urban planning, and environmental protection.

**Materials and methods**

**Data source**

This experiment takes a certain urban tourist area as the experimental object. Taking into account the relevant information in 2019, the information is collected from the official website, the public reports issued by the local tourism bureau and the urban planning area, and the information collected from the local People’s Daily (Omidvar et al. 2018). Relevant local information is collected and the city’s loss cost from January to October 2019 is calculated. Tourism economic indicators are shown in Table 1. Table 1 shows the environmental conditions of the city affected by floods in 2019, causing different losses every month. Based on the experimental data, the evaluation errors of the two models are compared.

**Table 1** Experimental data

| Environmental indicators                              | Standard | 2019 |
|-------------------------------------------------------|----------|------|
| Greening/%                                            | 40       | 21   |
| Infrastructure/%                                      | 50       | 36   |
| Water quality compliance rate/%                       | 100      | 80   |
| Waste treatment rate/%                                | 90       | 88   |
| Air pollution/%                                       | 80       | 72   |
| Concentrated sewage treatment rate/%                  | 90       | 41   |
| Tourism revenue/100 million US dollars                | 10       | 5.96 |
Research methods

The economic loss model of environmental carrying capacity in tourist areas scientifically determines whether the evaluation result has practical value (Oskui 1994). Therefore, considering the specific conditions of China’s urban tourism industry, the method of combining flood loss rate and pre-disaster value is used to calculate the economic loss model framework of urban environmental carrying capacity. As shown in Fig. 1, the economic loss model of environmental carrying capacity in urban tourist areas is divided into four parts. The first layer is the target layer, which is the final evaluation object of the economic loss of environmental carrying capacity in urban tourist areas; the second layer is the field in which each target in this layer includes different fields (Bina et al. 1986). The indicators in each field are supported by lower-level indicators. Due to the impact of floods, the economic loss model needs to be constructed based on the maximum carrying capacity of the local ecological environment and the maximum carrying capacity of biomass. Economic carrying capacity indicators and social carrying capacity indicators are the main basis; the third layer is the element layer; the number and types of indicators contained in this layer are the same as the second layer, and the only difference is that this layer has higher requirements for each indicator. These more demanding indicators constitute all the elements of indicators in various fields. The fourth layer is the indicator layer, which is the most basic level of the model and which meets and reflects the requirements of the element layer and judges whether the evaluation purpose is achieved.

The environmental carrying capacity of the urban tourist area before the flood disaster is calculated, and the theoretical support for the assessment of the loss caused by the flood disaster (Agard et al. 2011) is provided. The assessment of the environmental carrying capacity of the urban tourism area before the occurrence of floods is made from the aspects: tourism resource integration, ecological capacity, and tourism economic capacity. The formula for calculating the limit daily capacity of urban tourism area resources before the flood disaster is as follows:

\[ T_i = \frac{a}{l_0} \times k \]  
(1)

The capacity of the tourist destination to deal with tourism pollutants through the purification and absorption capacity of the urban tourism ecological environment is calculated. The calculation formula is as follows:

\[ T_j = \sum_{i=1}^{s} \frac{a}{l_0} + Aa \]  
(2)

Tourist facilities, accommodation, entertainment facilities, etc. will be affected by externalities when they are affected by floods. The urban tourism economic capacity is calculated,
and the calculation process is as follows:

\[ T_e = \sum \frac{D}{E_u} \]  

(3)

Combining the above calculations, the calculation of the environmental carrying capacity of tourist areas when the city is not affected by floods is completed.

The surface water content of the studied urban tourism area is not only related to rainfall but also related to the vegetation type, vegetation distribution, soil permeability, river distribution and flow direction, groundwater distribution and flow direction, and human social activities in the area (Chen and Tian 2005). Therefore, it is necessary to fully consider these factors when studying the surface runoff of urban tourism areas when flooding disasters occur. The expression of surface runoff obtained under the background of fully considering these factors is as follows:

\[ h(k) = \frac{n}{a} / f_x \]  

(4)

Results

Because the research on the convergence process of surface runoff in the underground is troublesome, and the research results are generally not very accurate, this paper ignores the specific process of surface runoff confluence in the underground when calculating the distribution of surface runoff in tourist attractions (Piryaei et al. 2010). By studying the convergence characteristics of surface runoff in tourist attractions on the ground and the topographic distribution and topographical distribution characteristics that go into the water flow and surface runoff distribution in each area of the tourist area are simulated. The specific calculation formula obtained according to the simulation results is as follows:

\[ W = \frac{F(s)}{\bar{A}} \]  

(5)

In the formula, \( W \) represents the surface runoff in the tourist area, \( F(s) \) is the submerged area after the flood disaster occurs, and \( \bar{A} \) represents the actual surface height of the area.

Based on the calculation of environmental carrying capacity, net surface flow, and submergence depth estimation in the urban tourism area, the loss rate of flood disasters is determined (Darabi et al. 2017). The foundation strength of urban tourist areas to further reflect the stability of the foundation in the area after the occurrence of floods is calculated. Taking into account the large area of urban tourism, the geological distribution map is combined with remote sensing image processing. Firstly, the types of sediments in the tourist area are determined, then the geological map is used for interpretation, and finally the foundation bearing capacity of the urban tourist area is evaluated. The specific process is shown in Fig. 2.

The BP neural network is used to calculate the loss rate of flood disasters; several influencing factors that have a greater impact on the damage caused by flood disasters are set as independent variables, and the specific losses caused by flood disasters in each area are set as dependent variables for calculation. The process is as follows:

\[ p = \frac{a}{f} \times n^a \]  

In the formula, \( p \) represents the disaster-causing loss of the flood disaster, \( a \) and \( f \) represent the disaster-bearing body factor of the flood disaster, and \( n^a \) represents the disaster-pregnant environmental factor of the flood disaster (PPZ 2013). In a specific implementation, the corresponding data in the database is called out according to the BP neural network. The process is shown in Fig. 3.

On this basis, the evaluation of the economic loss of the environmental carrying capacity of the urban tourism area was completed (Fig. 4), and the flood loss rate was obtained by the method of process stacking.

Fig. 2 Specific flow chart
Research results of flood disasters on the economic loss of environmental carrying capacity in urban tourism areas

Experimental platform

Due to the large amount of data involved in the experiment process, manual calculations are prone to errors, so an experimental platform is established to calculate the experimental results. The experimental platform is shown in Fig. 5.

The total loss cost of the city from January to October of 2019 is known. First, the data is entered into the experimental database, and then two models are used to evaluate the loss cost of the city’s tourist areas (Premoli Silva and Verga 2004). Finally, to make the experimental results more intuitive, the actual loss cost is compared with the evaluation results of the design model and the control model.

Analysis of experimental results

The evaluation results of the two models are shown in Table 2. After statistical calculations, it is concluded that the maximum difference between the loss prediction result of the control model and the actual cost loss is 24,500 yuan, and the minimum difference is 3500 yuan (Elamri et al. 2016). The maximum difference between the model evaluation result of this design and the actual loss cost is 2500 yuan, and the minimum difference is 200 yuan. Comparing the maximum difference and the minimum difference cost of the two evaluation models, it can be seen that the maximum error of the design model is 22,000 yuan less than the maximum error of the control model, which proves that the designed flood disaster has a better effect on the economic loss of the environmental carrying capacity of the urban tourism area (Razmjoei et al. 2018). The error of the comparison model evaluation is small. This is because the model designed this time can effectively calculate the carrying capacity of the urban tourist area (Fig. 6) before the flood disaster and calculate the overall loss to the...
Therefore, the above experiments can prove the effectiveness of the economic loss model of environmental carrying capacity of urban tourism areas caused by flood disaster and provide some help for the calculation of economic loss of environmental carrying capacity of urban areas, so as to provide the basis for preventing the loss caused by flood disaster (Shuttleworth 2008) (Fig. 7).

### Time series analysis of early warning index of tourism environmental carrying capacity in coastal areas

Through the constructed dynamic model, the maximum environmental carrying capacity of some coastal cities in recent years and in the next few years is simulated and calculated to obtain the maximum environmental carrying capacity index of coastal city scenic spots and drawn according to the maximum environmental carrying capacity index of each year. The curve distribution diagram is shown, and the detailed diagram is shown in Fig. 1. By analyzing the curves in the figure, we can roughly summarize the development characteristics of the maximum environmental carrying capacity of coastal scenic spots (Stöcklin and Setudehnia 1971). At the same time, in order to record the changes in the detailed carrying capacity index of coastal city scenic spots in each year, the relevant personnel will take the maximum carrying capacity index of the natural environment, the maximum carrying capacity index of the social environment, and the maximum carrying capacity index of the economic environment of the coastal city scenic spot (Elamri et al. 2014), as a warning zone to judge the total carrying capacity of coastal city scenic spots (Fig. 8). The detailed maximum carrying capacity index of each type of scenic spot is shown in Table 3.

Through the analysis of the data in Table 4, we can know that the tourism resources and natural resources of coastal city scenic spots have the most obvious impact on the resource and environmental carrying capacity of the scenic spots (Su and Zhou 2020). Compared with natural resources, the impact of tourism resources is more obvious. Not only the total amount of tourism resources will affect the resource and environmental carrying capacity of scenic spots in coastal cities but also the spatial distribution and temporal change characteristics of tourism resources will also affect the resource and environmental carrying capacity of scenic spots along the river (Willm et al. 1961). The types of tourism resources are very rich, of which the most significant impact on the

### Table 2 Experimental comparison results

| Month | Actual loss cost/yuan | Evaluation result against model/yuan | The design model evaluation result/yuan |
|-------|----------------------|-------------------------------------|----------------------------------------|
| 1     | 34,500               | 10,000                              | 32,000                                 |
| 2     | 24,000               | 35,000                              | 23,500                                 |
| 3     | 15,000               | 25,000                              | 14,000                                 |
| 4     | 20,000               | 16,500                              | 18,900                                 |
| 5     | 53,222               | 45,000                              | 52,000                                 |
| 6     | 59,000               | 49,000                              | 57,500                                 |
| 7     | 70,000               | 62,000                              | 67,800                                 |
| 8     | 82,000               | 68,000                              | 80,000                                 |
| 9     | 40,000               | 35,000                              | 39,000                                 |
| 10    | 37,000               | 25,000                              | 36,800                                 |

Fig. 6 Study area administrative division
environmental carrying capacity is water resources. By sorting out the data in Table 4, we find that the distribution of water resources in coastal cities and scenic spots has a very obvious jump in recent years, and the total amount of distribution has neither shown a significant upward or downward trend, nor has an accurate development law. In other words, therefore, we can judge that the increase in the environmental carrying capacity of natural resources in coastal cities and scenic spots has no direct connection with the changes in local water resources. However, the staff summarized the distribution of water resources in a few years and found that the changes in water resources in coastal cities and scenic spots will stabilize in the next few years, which will also greatly promote the environmental carrying capacity of the scenic spots (Vincent Fig. 7 Fuzzy comprehensive evaluation result of vulnerability to flood disaster in a certain area

Fig. 8 Early warning simulation results of tourism environmental carrying capacity in coastal areas from 2004 to 2025
et al. 2005). With the advancing of time, the per-capita land resource occupation of coastal cities has shown a trend of declining year by year, which also greatly limits the increase in the environmental resource carrying capacity of coastal city scenic spots. Researchers believe that the main reasons for this situation are two: One is the population growth of coastal cities. With economic development and social progress, the economic development of coastal cities far exceeds that of many inland cities. Therefore, many inland residents seek a better employment environment and salaries have migrated to coastal cities, which has directly led to an increase in the population of coastal cities. The land resources of coastal

| Table 3 Early warning zone for tourism environmental carrying capacity |
|---|---|---|---|---|
| Guard zone | 2004–2011 | | | |
| | Low load area | Growth zone | Health zone | Suitable load zone | Overload zone |
| Tourism environmental carrying capacity | (.4,4.6518) | (4.6518,4.9046) | (4.9046,5.4102) | [5.4102,5.6630) | [5.6630, ∞) |
| Tourism ecological environment carrying capacity | (.4,4.6518) | [0.4316,0.4693) | (0.4693,0.5448) | (0.5448,0.5825) | [0.5825, ∞) |
| Tourism social environmental carrying capacity | (.4,4.6518) | (0.1846,0.2435) | (0.2435,0.3611) | (0.3611,0.4199) | [0.4199, ∞) |
| Tourism economic environmental carrying capacity | (.4,4.6518) | [4.6453,4.8519) | (4.8519,5.2652) | (5.2652,5.4719) | [5.4719, ∞) |
| Environmental carrying capacity of tourism resources | (.4,4.6518) | (0.2222,0.4985) | (0.4985,0.5914) | (0.5914,0.6936) | [0.6936, ∞) |

| Guard zone | 2012–2025 | | | |
| | Low load area | Growth zone | Health zone | Suitable load zone | Overload zone |
| Tourism environmental carrying capacity | (.3,3.5633) | 5633,10827 | (7.0827,14.1215) | (14.1215,17.649) | (17.6409, ∞) |
| Tourism ecological environment carrying capacity | (.0,0.4701) | (0.4703,0.5914) | (0.5914,0.8336) | (0.8336,0.9547) | (0.9547, ∞) |
| Tourism social environmental carrying capacity | (.0,0.3562) | (0.3562,0.3901) | (0.3901,0.4576) | (0.4576,0.4914) | (0.4914, ∞) |
| Tourism economic environmental carrying capacity | (.0,0.5224) | (3.5224,6.6773) | (6.6773,12.987) | (12.9870,16.1418) | (16.1418, ∞) |
| Environmental carrying capacity of tourism resources | (.0,0.3406) | (0.3406,2.0516) | (2.0516,5.4736) | (5.4736,7.1846) | (7.1846, ∞) |
cities are limited, so as the population grows, the per-capita land occupation of coastal residents shows a downward trend. The second is that the excessive development of tourism resources in coastal cities has led to a continuous decrease in the land occupation rate of urban residents (Su et al. 2019). The excessive development of tourism resources will also lead to a decline in the level of intensive use of tourism resources. Although the development of tourism resources in coastal cities has continued to grow at an extremely high rate in recent years, experts predict that in the next 20 years, the development of tourism resources in coastal areas will gradually stabilize, which will greatly improve coastal cities (Yazdi-Moghadam et al. 2018): the environmental carrying capacity of tourism resources. Therefore, we can summarize the influencing factors of the environmental carrying capacity of tourism resources in coastal cities: the total amount of tourism resources in coastal areas, the spatial distribution and the laws of time development, the total and distribution of water resources, and the per capita land resources. The environmental carrying capacity of tourism resources in the region has a relatively large impact (Fig. 9).

The carrying capacity of the ecological environment in coastal areas increased year by year at a steady rate during 2004–2011, which shows that with the improvement of people's concepts and the progress of thinking, the ecological construction of coastal areas has achieved good results, which is beneficial to tourism resources in coastal areas. The development and construction of tourist areas are conducive to promoting local economic development and ecological civilization construction. In the first 2 years, although the carrying capacity of the ecological environment in coastal areas is gradually increasing, its maximum carrying capacity is still at a low level, so we call it the growth stage; in the following years, the ecological environment carrying capacity in coastal areas is still in a state of gradual increase (Elamri et al. 2014). At this time, the environmental carrying capacity has been greatly improved compared with that in previous years, so we call it the healthy stage. By 2019, the ecological

| Years | Tourism environmental carrying capacity | Tourism ecological environment carrying capacity | Tourism social environmental carrying capacity | Tourism economic environmental carrying capacity | Environmental carrying capacity of tourism resources |
|-------|----------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|--------------------------------------------------|
| 2004  | 4.90584 Health zone 0.45241 Growth zone | 0.21829 Growth zone 0.21829 Growth zone      | 4.85542 Health zone 0.48979 Growth zone       | 5.8735 Health zone 0.65205 Health zone        |
| 2005  | 4.89456 Growth zone 0.46020 Growth zone | 0.23274 Growth zone 0.23274 Growth zone      | 4.83118 Health zone 0.58735 Health zone       | 5.09152 Health zone 0.74630 Health zone        |
| 2006  | 5.16242 Health zone 0.47827 Health zone | 0.27041 Health zone 0.27041 Health zone      | 5.00571 Health zone 0.74676 Health zone       | 5.09572 Health zone 0.74630 Health zone        |
| 2007  | 5.09391 Health zone 0.50471 Health zone | 0.27593 Health zone 0.27593 Health zone      | 4.86327 Health zone 0.74676 Health zone       | 5.09572 Health zone 0.74630 Health zone        |
| 2008  | 4.95851 Health zone 0.52575 Health zone | 0.31618 Health zone 0.31618 Health zone      | 5.11816 Health zone 0.74676 Health zone       | 5.09572 Health zone 0.74630 Health zone        |
| 2009  | 5.21068 Health zone 0.52704 Health zone | 0.34678 Health zone 0.34678 Health zone      | 5.11816 Health zone 0.74676 Health zone       | 5.09572 Health zone 0.74630 Health zone        |
| 2010  | 5.32420 Health zone 0.54400 Health zone | 0.38627 Health zone 0.38627 Health zone      | 5.22714 Health zone 0.74676 Health zone       | 5.09572 Health zone 0.74630 Health zone        |
| 2011  | 5.70921 Overload zone 0.56421 Suitable load zone | 0.37188 Suitable load zone 0.37188 Suitable load zone | 5.47645 Overload zone 0.48979 Growth zone 0.48979 Growth zone | 5.09572 Health zone 0.74630 Health zone |
| 2012  | 6.08461 Growth zone 0.57234 Growth zone | 0.37698 Growth zone 0.37698 Growth zone      | 5.51154 Growth zone 0.74630 Growth zone       | 5.09152 Health zone 0.74630 Health zone        |
| 2013  | 6.50538 Growth zone 0.58194 Growth zone | 0.38227 Growth zone 0.38227 Growth zone      | 6.20433 Growth zone 0.74630 Growth zone       | 5.09152 Health zone 0.74630 Health zone        |
| 2014  | 6.97608 Growth zone 0.59325 Growth zone | 0.38782 Growth zone 0.38782 Growth zone      | 6.63226 Growth zone 0.74630 Growth zone       | 5.09152 Health zone 0.74630 Health zone        |
| 2015  | 7.50184 Health zone 0.60658 Health zone | 0.39367 Health zone 0.39367 Health zone      | 7.10848 Health zone 0.74630 Health zone       | 5.09152 Health zone 0.74630 Health zone        |
| 2016  | 8.09056 Health zone 0.62433 Health zone | 0.40129 Health zone 0.40129 Health zone      | 7.659 Health zone 0.74630 Health zone         | 5.09152 Health zone 0.74630 Health zone        |
| 2017  | 8.74601 Health zone 0.64468 Health zone | 0.40914 Health zone 0.40914 Health zone      | 8.292 Health zone 0.74630 Health zone         | 5.09152 Health zone 0.74630 Health zone        |
| 2018  | 9.47531 Health zone 0.66802 Health zone | 0.41726 Health zone 0.41726 Health zone      | 8.88 Health zone 0.74630 Health zone          | 5.09152 Health zone 0.74630 Health zone        |
| 2019  | 10.2976 Health zone 0.69477 Health zone | 0.42576 Health zone 0.42576 Health zone      | 9.6076 Health zone 0.74630 Health zone        | 5.09152 Health zone 0.74630 Health zone        |
| 2020  | 11.2015 Health zone 0.72537 Health zone | 0.43475 Health zone 0.43475 Health zone      | 10.497 Health zone 0.74630 Health zone        | 5.09152 Health zone 0.74630 Health zone        |
| 2021  | 12.2041 Health zone 0.76147 Health zone | 0.44223 Health zone 0.44223 Health zone      | 11.2965 Health zone 0.74630 Health zone       | 5.09152 Health zone 0.74630 Health zone        |
| 2022  | 13.3209 Health zone 0.80239 Health zone | 0.45063 Health zone 0.45063 Health zone      | 12.2812 Health zone 0.74630 Health zone       | 5.09152 Health zone 0.74630 Health zone        |
| 2023  | 14.5656 Suitable load zone 0.84869 Suitable load zone | 0.46032 Suitable load zone 0.46032 Suitable load zone | 13.3757 Suitable load zone 0.5845 Suitable load zone | 5.09152 Health zone 0.74630 Health zone |
| 2024  | 15.9544 Suitable load zone 0.900981 Suitable load zone | 0.47746 Suitable load zone 0.47746 Suitable load zone | 14.5941 Suitable load zone 0.5845 Suitable load zone | 5.09152 Health zone 0.74630 Health zone        |
| 2025  | 17.5061 Suitable load zone 0.95992 Overload zone 0.95992 Overload zone | 0.48534 Suitable load zone 0.48534 Suitable load zone | 15.9527 Suitable load zone 0.5845 Suitable load zone | 5.09152 Health zone 0.74630 Health zone |

Table 4 Simulation value and alert status of tourism environmental carrying capacity in coastal areas from 2004 to 2025.
environment carrying capacity of coastal areas has been at a high level, and the protection of the ecological environment by residents in coastal areas has also increased a lot, so we call it the load-bearing stage. At this time, the ecological environment carrying capacity in coastal areas is close to the overload level. Experts estimate that if this trend continues to increase, it may have a certain negative impact on the local ecological environment and the normal life of residents (Yazdi-Moghadam et al. 2017). Excessive carrying capacity will cause certain damage to local land resources, water resources, and coastlines, which will lead to a decline in the quality of the local ecological environment, which will affect the development of tourism resources. Therefore, in order to ensure the sustainable development of the tourism industry and improve the ecological environment, we need to increase the protection of the environment, appropriately develop tourism resources, and formulate a detailed overall plan for environmental protection and environmental governance (Sun et al. 2019). Experts estimate that if the current trend is to develop, the resource and environmental carrying capacity of coastal areas will be overloaded by 2025 at the latest. The main reason is that the excessive development of tourism resources not only consumes a lot of ecological resources but also causes extreme serious problems such as environmental pollution. Among environmental pollution, the most significant negative impact on the carrying capacity of the tourism ecological environment is the pollution of industrial wastewater and domestic wastewater (Zha et al. 2010). Because the discharge of wastewater will not only affect the quality of fresh water and seawater on land but also affect the quality of soil and vegetation in coastal areas, therefore, the primary task of improving the environmental carrying capacity of coastal areas is to reduce the discharge of industrial wastewater and domestic wastewater, improve wastewater discharge standards, standardize wastewater treatment processes, increase environmental protection efforts and investment in environmental protection, and improve coastal water quality (Elamri and Zaghbib 2014).

As shown in Fig. 10, in recent years, the carrying capacity of the tourism economic environment in coastal areas has been increasing year by year. Moreover, compared with the carrying capacity of resources, ecology, and biological environment in the same year, the carrying capacity of economic environment in coastal areas has always been at a relatively high level, which fully shows that the carrying capacity of the tourism economy in coastal areas is relatively strong, and the development of tourism and the income from tourism are relatively high and stable (Zhang et al. 2018). Through the analysis of the curve in the graph, we can know that the carrying capacity of the tourism economic environment in coastal areas has shown an upward trend since 2004. At that time, the construction of tourist areas in coastal areas was in its infancy. With greater development efforts, the tourism demand of tourists from other places is also higher. Therefore, at the initial stage of development, the tourism economic income and tourist consumption in coastal areas have increased at a relatively fast rate. At this time, the carrying capacity of the tourism economic environment in coastal areas still has more room for development. A few years later, tourism development in coastal areas has not decreased but increased. Various governments have successively increased the development and utilization of tourism resources, but this is still difficult to meet the tourism needs of tourists across the country (Ghasemi-Nejad et al. 2006). Therefore, despite the local tourism economic environment carrying capacity, it is still on an upward trend, but its overall level has declined. In 2010, as the Chinese government proposed to increase the construction of coastal areas and proposed the 11th Five-Year Plan, the carrying capacity of the tourism economic environment in coastal areas has been greatly improved. However, affected by the
economic crisis in the previous few years, the number of tourists, tourism consumption, and the scale of tourists in coastal areas have all declined. Therefore, although the government has increased the development and capital investment in coastal scenic spots, the carrying capacity of the tourism economic environment in coastal areas is still difficult to meet the development needs of the tourism industry. During this period of time, people have summarized the development experience of previous years, adjusted the focus of development based on the previous development experience, and increased the development of tourism economic structure, economic scale, and economic benefits. By 2019, although the carrying capacity of the tourism economy in coastal areas is still on the rise, the carrying capacity of the tourism economy in coastal areas is on the verge of overloading. Due to the rapid economic development in coastal areas, a large number of tourism companies and tourism products have appeared in the market within a few years. The price competition and product competition among tourism companies have evolved to a very fierce level, which has also caused local governments and highly valued by tourism developers (Zhang et al. 2019). Through research on the economic environmental carrying capacity of coastal areas in recent years, experts have found that the economic structure and economic foundation of coastal scenic spots have the most obvious impact on the economic carrying capacity of coastal areas. Therefore, in order to ensure that the carrying capacity of the economic environment in coastal areas will be given greater prompts in the next few years, relevant government personnel need to strictly control the local government’s capital investment in the development of tourism resources, the optimization of the economic structure of the tourism industry, and the adjustment of tourism economic benefits. At the same time, the local government should also make full use of the basic economic resources in coastal areas, improve the competitiveness of the local tourism economy, maintain a sense of crisis and urgency at all times, make reasonable plans for the development and structure of the market, and avoid chaotic market order and structure and occurrence and ensure the sustained and efficient development of tourism economy in coastal areas.

As shown in the figure, in recent years, the social-environmental carrying capacity of tourism in our country’s coastal areas has been steadily rising, which shows that with the development of society and economic progress, the development of tourism has made more and more contributions to society. Through the analysis of the chart, we can know that with the development of tourism in coastal areas, the life satisfaction, life happiness, per-capita education level, and information level of local residents have been greatly improved. However, in the later period, the life satisfaction of local residents, the enthusiasm of residents to participate in social activities, and the construction of ecological civilization in the community decreased (Jafarzadeh et al. 2014). The main reason is that with the excessive development of tourism resources, local residents gradually tend to be utilitarian, profitable, and commercialized in the development process. Therefore, while developing the tourism industry, the government must also attach importance to the ideological construction of residents and check the behavior of the residents. Because the local folk customs and the humanistic environment of the community are closely related to the development of tourism, if the local folkways are not good and the humanistic environment of the community is chaotic, this will put great pressure on the development of local tourism. Our most significant impact on local folk customs and community environment is the education level of local residents. It is difficult to improve the education level of residents in a short time. Therefore, the government needs to pay attention to the
education of local residents as soon as possible. A series of long-term effective policies and strategies to improve local ideological and cultural development should be formulated. In addition, the social security, the level of technological development, and the employment rate of tourism practitioners in coastal cities also have a relatively large impact on the level of tourism social-environmental carrying capacity in coastal areas. Therefore, the local government needs to strictly control the scale of local tourism employment, increase scientific and technological investment in the tourism industry, and do a good job in social security, so as to ensure that tourists can get a better travel experience while protecting their personal safety and property safety.

**Regulation and control analysis of the early warning index of tourism environmental carrying capacity in coastal areas**

Regulation is to regulate and control the operating trends and operating conditions of the tourism industry in coastal areas. Under the premise of following the development of the market economy, some means are adopted to interfere with the development of the tourism industry, thereby enhancing the development of the tourism industry.

**Simulation and analysis system of tourism environmental carrying capacity**

From the above content, we can know that the carrying capacity of the tourism environment of coastal cities is affected in many ways (Li et al. 2018). Therefore, the relevant staff introduced the dynamic model to simulate the early warning system of the tourism environmental carrying capacity in the coastal area. The dynamic model can simulate not only the environmental carrying capacity of the coastal area but also the development and environment of the tourism industry. The relationship between protections is simulated. And we know from the above that the development of tourism in coastal areas is closely related to the construction of the local ecological environment, so the results obtained by using dynamic models to carry out simulation experiments are very valuable for referencing. A review of the current development of tourism in some coastal areas of our country, this paper proposes a total of four sets of programs to carry out simulation experiments. The experimental results are shown in Table 5.

According to the experimental results, we can know that if we want to improve the development of tourism and the construction of ecological civilization in coastal areas, it is far from enough to control the number of employed people, increase the amount of scientific and technological input, and reduce the discharge of domestic sewage. We also need to be subjective, go up and reduce the speed of tourism development, increase environmental protection efforts, and improve the carrying capacity of the local tourism environment.

**Selection of tourism development model in coastal areas of our country**

There are various tourism development models in our country’s coastal areas, and the most widely distributed tourism industry model is the extended tourism industry. The development concept of the original tourism industry is to take the domestic market as the main market and domestic tourists as the main consumption objects and promote the development of the tourism industry through the combination of entry and exit. Our country’s tourism development model can be divided into four categories: private enterprise-led, government-led, foreign merchant-led, and private enterprise-led according to different investment subjects.

**Discuss on**

**Countermeasures to reduce urban storms and floods**

Based on the above analysis, this article puts forward the following related suggestions on how to improve the ability of coastal areas to resist floods: First, to improve the economic development of coastal cities, economic strength and material foundation are the prerequisites for all planning. Structural adjustments should be made to reduce the process of urbanization. Third, relevant departments should take relief and protection measures, establish emergency funds, and material reserve institutions. Fourth, the government should increase publicity on flood disasters and improve disaster prevention for local residents, disaster reduction awareness, and emergency response capabilities.

**Early warning management countermeasures of tourism environmental carrying capacity in our country’s coastal areas**

Building an early warning management information system

The analysis of the carrying capacity of the tourism environment requires a lot of manpower, material resources, and funds (Li et al. 2013). Therefore, the full use of geographic information and multimedia technology will help to increase the carrying capacity of the tourism environment in coastal areas, increase the development rate of the tourism industry, and reduce manpower and funds or cost.
Improve the legal management system

The form and content of the “Tourism Law” are very rich, and we mainly discuss the generalized tourism law. The formulation and implementation of the Tourism Law are conducive to regulating the rights, obligations and responsibilities of tourism entities, safeguarding the legal rights and interests of tourism entities, ensuring the healthy operation of the tourism industry, and improving the country’s legal system.

Conclusion

The rapid development of tourism is faced with various threats, especially the flood disaster. Considering the evaluation method of tourism environmental carrying capacity, based on the contrast model, the economic loss model of environmental carrying capacity of urban tourism area caused by flood disaster is optimized. The experimental results show that the model calculation error is small; because the design method reduces the data collection error, the calculation index involved is relatively clear, and the problems existing in the calculation of the control model are solved, so this method has certain applicability. Because the economic loss model of environmental carrying capacity of urban tourism area caused by flood disaster is still a relatively new research field, the economic loss caused by flood disaster is different in different areas. For example, hydrology, vegetation, biodiversity, and other aspects are directly related to the carrying capacity of urban tourism areas. Therefore, in the next step of research, we need to combine a variety of research methods to conduct a comprehensive analysis and build a perfect economic loss model of the environmental carrying capacity of urban tourism areas.

Declarations

Conflict of interest

Authors declare that they have no competing interests.

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Table 5 Control variables of tourism environmental carrying capacity

| Regulation scheme | Variable                                | Original value | Control value |
|-------------------|-----------------------------------------|----------------|---------------|
| Scenario 1        | Growth rate of tourism resources         | 0.12           | 0.2           |
|                   | Water growth rate                        | 0.1            | 0.15          |
|                   | Green space resources                    | 15729          | 20000/30000   |
| Scenario 2        | Total tourism revenue growth rate        | 0.2            | 0.25          |
|                   | GDP growth rate                          | 0.1            | 0.2           |
|                   | Social fixed asset investment ratio      | 0.47           | 0.5           |
| Scheme 3          | Sea water quality                        | 73%            | 90%           |
|                   | Environmental protection investment ratio| 0.01           | 0.0           |
|                   | Directly discharged into the mass        | 180000         | 12000         |
| Scheme 4          | Tourism employment growth rate           | 0.02           | 0.1           |
|                   | Technology investment ratio              | 0.012          | 0.002         |
