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Assessment of Environment Carrying Capacity of Sam Son Tourism Area

Truong Sy Vinh, Nguyen Thuy Van, and Vu Chien Thang

Institute For Tourism Development Research, Vietnam National Administration of Tourism, Vietnam

Abstract: The tourism environmental carrying capacity (TECC) of a tourism area is understood as the capacity to satisfy the maximum tourist number in the space of the tourism area without harming the natural, economic, socio-cultural environment and the quality of traveler experience. To date, a number of studies on assessment of TECC of tourism area by national and international scholars whose are in different approaches. Yet, it its noted that each tourism area has different characteristics in terms of its nature, scope, socio-economic situations, and capacity of making the best use of its potentials... Thus, it is required to select appropriate calculation methods for evaluation. This study applies the existing calculation methods to evaluate the environment capacity of Sam Son tourism area. Accordingly, it provides recommendations for sustainable tourism development that satisfies the TECC limits.

Key words: tourism, environment, tourism environment carrying capacity (TECC), Sam Son Tourism Area (SSTA)

1. Introduction

Vietnam tourism makes encouraging results and great contributions to its socio-economic development. In 2017, as UNWTO's recognition, Viet Nam stood at the 6th rank out of the 10 fastest growing tourism destinations in the world and at the first rank in Asia. Viet Nam National Administration of Tourism reported that in 2019, Viet Nam welcomed about 18 million international arrivals, an increase of 16% compared to 2018, and served 85 million domestic tourists, which is 6.3% increase compared to 2018. Tourism development supports the transformation of the economic structure towards industrialization and modernization, increasing the GDP, income per capita, creating jobs for tens of thousands of workers, improving the quality of living, facilitating cultural exchange and integration into the region and the world.

However, besides the positive impacts, Viet Nam tourism brought certain consequences to the natural environment. The high growth of tourist arrivals, which is in mass tourism trend, along with high tourism seasonality resulted in many tourist sites and destinations overcrowded in terms of excessing their capacities of infrastructure; waste and wastewater collection and treatment; and ecosystems impact controlling. In the social environment aspect, tourism development may increase social evils and localities' transformed traditional cultures. More and more phenomena of damaging the originality of tangible and intangible cultural heritages in order to serve tourists have been witnessed [5]. The above mentioned issues significantly affect the sustainable development of Viet Nam tourism in general and the image of Viet Nam tourism in the eyes of international tourists.

Sam Son tourism area (SSTA), which is about 16 km from Thanh Hoa city, is located in the east of Thanh Hoa province. It owns a very rich and diverse tourism potential, including natural and cultural tourism resources. The beautiful beaches, that stretch along 3.5 km of coastline, are flat, gently sloping, having fine sand and clear blue water. It is endowed with a salt concentration of below 30%. Besides, it contains such

Corresponding author: Truong Sy Vinh, Ph.D.; research areas/interests: tourism and environment. E-mail: vinhts@itdr.org.vn.

many minerals and other substances as calcium that are therapeutic and very suitable for beach bathing and entertainment. However, in recent years, as the number of tourist arrivals to SSTA is on the rise, increasing tourism activities, that causes difficulties in management. It is important to balance the tourism development and environmental sustainability in terms of minimizing the environmental damage caused by such development pace. Therefore, calculating the maximum tourist number which is within SSTA's carrying capacity in terms of its natural, economic and social components (in other words is the TECC of SSTA) is an important content in tourism development management. To date, a number of studies on assessment of TECC of tourism areas by national and international scholars whose are in different approaches [6, 9]. However, there are no research on TECC in SSTA under impacts of tourism. This study focuses on assessing the current TECC of SSTA is to determine the excess capacity level on its natural and socio-economic environment with concerns of the number of tourist arrivals at the time of calculation. On that basis, policies are recommended to develop SSTA's tourism within the limits of the TECC.

2. Material and Methods

2.1 Research Area

This study was conducted at SSTA, Thanh Hoa province. It owns geographical position of bordering Hoang Hoa district to the North, where Ma river is the natural boundary; Quang Xuong district to the South; Gulf of Tonkin to the East; Thanh Hoa city to the West. SSTA is featured with total area of 44.94 km^2, and population of 108,320 people in 2019.

2.2 Materials

In this study, statistical data on current situation of tourism development (tourists, total income, accommodation rooms...); natural environment, characteristics of the beachs in SSTA; socio-economic infrastructure (systems of waste collection and treatment, water supply, and transportation...) are collected from the annual statistical reports by Sam Son city People's Committee (PC); Department of Culture, Sports and Tourism; Department of Natural Resources and Environment (DONRE) of Thanh Hoa province and other related documents [1, 2, 7, 8].

2.3 Methods

Methods of assessing the TECC that are used in this study is to calculate the carrying capacity of each environmental component (natural, socio-economic). On that basis, general assessment for SSTA is assessed. The evaluation formulas are selected from existing studies and synthesized during the implementation process, specifically as follows:

2.3.1 Natural Environment Carrying Capacity

a) The Beach Spatial Carrying Capacity

Spatial carrying capacity is calculated only for the beachs in SSTA, according to the formula of Boullón in 1985.

$$T_1 = A/D \quad (1)$$

In which:

A: Total beach area

D: Standard area for one tourist

In this study, the carrying indicators, which are determined by the following formula, shall be used to determine the spatial carrying capacity level:

$$E_1 = U/T_1 \quad (2)$$

In which:

E1: carrying indicator or spatial carrying capacity level for tourism area.

U: Number of tourist arrivals/day

If E1 = 1, the spatial carrying capacity reaches its capacity limit; if E1 < 1, spatial carrying capacity is under acceptable carrying limit, and if E1 > 1, spatial carrying capacity exceeds the carrying capacity.

b) Carrying Capacity of Coastal Water Environment

Carrying capacity of coastal water environment is calculated by formulas that relate to receiving capacity of coastal water environment. Among of which is GESAM's formular in 1986 [4]:

$$L_{tn} = (C_{tc} - C_{ht}) \times V \times (1+R) \quad (3)$$

In which:

L_{tn}: Receiving capacity of water environment

C_{tc}: Accepted limit concentration of pollutant parameters (kg/m^3)

C_{ht}: Current concentration of pollutant parameters (kg/m^3)

V: Average volume of the waterbody (m^3)

R: Water exchange ratio %

If $L_{tn} \leq 0$, that sea area is reached maximum or excess capacity, which is not able to receive more pollutants. Based on the evaluation results of the L_{tn}, the maximum tourist number (T_2) can be determined, so that seawater quality can be self-recovered.

The limited concentration of pollution parameters is based on QCVN 10-MT: 2015/ BTNMT and converted to kg/m^3.

The current concentration of the pollution parameter is based on the results of the analysis of the coastal water environment by the DONRE of Thanh Hoa Province and converted to kg/ m^3.

Similar to fomula (2), the carrying capacity level of the coastal water environment is determined by the formula:

$$E_2 = U/T_2 \quad (4)$$

2.3.2 Carrying Capacity of Socio-economic Environment

a) Carrying Capacity of Water Supply System

Water supply system carrying capacity is determined based on the ratio of existing water supply capacity (P_{hc}) and water consumption (P_{yc}). If $P_{yc} > P_{hc}$, the tourist site is excess with water supply at the time of calculation.

P_{yc} = Total population x Water supply standard/day + Tourist number × Water supply standard/day + P_{others}

Of which, according to Vietnam Construction Standard-TCXDVN 33: 2006, the average water quantity/people is defined as follows: 300-400 liters/tourist/ day for tourist sites; 80-150 liters/ person/ day for people in town or certain rural residents' spots; 40-60 liters/person/day for rural areas. P_{others} is for other economic activities.

$$E_3 = U/T_3 \quad (5)$$

T_3 is maximum tourist number that can be served within the water supply capacity.

b**)** Carrying Capacity of Waste Collection and Treatment Infrastructure

The capacity of wastewater collection and treatment infrastructure is calculated by the following formula:

$$T_4 = (N - M)/320 \quad (6)$$

Of which:

M: total amount of wastewater/day

N: is total amount of wastewater collected and treated/day

$$E_4 = U/T_4 \quad (7)$$

The capacity of solid waste collection and treatment system in SSTA is evaluated through the total solid waste generating amount and the solid waste collecting and treating ability.

$$T_5 = N - M \quad (8)$$

In which:

M: Total solid waste amount/day

N: Total amount of solid waste collected and treated/day

$$E_5 = M/N \quad (9)$$

c) Carrying Capacity of Accommodation Establishments

Carrying capacity of accommodation establishments, which is the maximum tourist number that the establishments can serve in a day or in a year, is determined as follows:

$$\mathbf{T6} = \frac{\mathbf{Existing\ room\ x\ Beds/\ room}}{\mathbf{Average\ accommodated\ days}} \quad (10)$$

In which: T_6: the Carrying capacity of the accommodation establishments on a daily basis.

$$E_6 = U/T_6 \quad (11)$$

3. Results and Discussion

3.1 Natural Environment Carrying Capacity

3.1.1 Spatial Carrying Capacity

SSTA has four beaches, namely: A, B, C, D, which is 3,500 m long and 200 m wide totally. The swimming

enabled area accounts for about 75% (the remaining 25% is for service provision, terrain transformation, and fishermen's boats anchoring). The beaches are defined as a public and affordable or popularized beach. Therefore, SSTA's spatial standard for swimming of each tourist is about 10 to 15 m^2 [3].

Regarding the number of tourists to SSTA's beaches on weekdays: According to statistics of Sam Son City's PC, in 2019, it served 4,950,000 accommodated tourists and 360,000 day-used tourists [1, 8]. Therefore, the average tourist arrivals for the whole year reached 14,548 arrivals/day.

Regarding the tourist number in the beaches on peak days, 60% of tourists come to SSTA on weekends during 6 months of hot season, which is equivalent to 52 days. Therefore, at the peak season, the beaches welcomed 57,115 accommodated tourists/day. In addition, the number of day-used tourists to SSTA in 2019 reached 360,000. Thus, in peak season, SSTA's beaches welcomed a total of 61,269 tourists/day.

The above formulas (1) and (2) works out spatial carrying capacity which results are given in Table 1.

As shown in Table 1, on weekdays, SSTA's beaches is not overloaded; in the peak season, the exceeded spatial capacity by 1.46 times is witnessed. The excess of the swimming spatial affects the tourist experience. Instead of having about 12.5 m^2 per tourist to swim in the beach, in the peak season, it only has 8.6 m^2 relatively. In fact, on such peak days as 30 April and 1 May 2019, the tourist number in SSTA reached 146,000 arrivals/day, which exceeded the spatial carrying capacity by 3.48 times. However, this phenomenon does not happen often.

Table 1 Spatial carrying capacity of SSTA's beaches.

Beach area *(m^2)* (A)	Spatial standard *(m^2)* (D)	Spatial CC **(T_1)**	Tourist arrivals/day (weekdays)	Tourist arrivals/day (peak days)	Weekday CC indicator **(E_{1tb})**	Peakday CC indicator **(E_{1cd})**
525,000	12.5	42,000	14,548	61,269	**0.35**	**1.46**

3.1.2 Carrying Capacity of Coastal Water Environment

a) Wastewater Sources Investigation

SSTA wastewater, which is from local residents' daily life and socio-economic activities, is specifically identified as follows:

Wastewater from residents: In 2019, SSTA reached 108,320 people. The average using standard is 115 liters/day and night, and the wastewater amount of the people is 10,500 m^3/day and night.

Wastewater from tourists: According to Sam Son City People's Committee report, in 2019, SSTA served 9,750,000 tourist days [8]. The average using standard is 320 liters/day and night/tourist. Wastewater from tourists is determined at 8,548 m^3/day and night.

Other waste sources: Wastewater from industrial zones and from public works is determined by 10% of the domestic wastewater relatively: 1,050 m^3/day and night. Particularly, wastewater from industrial zones is on-spot treated by the wastewater treatment system of each industrial zone.

Thus, the source of polluting waste in SSTA is determined to be mainly from local residents' wastewater, tourists, and public works, with the total amount of wastewater of 20,098 m^3/day and night. Currently, the wastewater collection and treatment ratio in SSTA is approximately 60% (through the biological sedimentation system in the central wastewater treatment area of the city and septic tanks). Therefore, there shall be more than 40% of untreated wastewater discharged into the environment, equivalent to 8,399 m^3/day and night. The amount of untreated wastewater is determined by the following sources:

(1) Wastewater from residents' daily use in six communes, wards, and extended communes, where there is lack of a collection system. This amount of wastewater is discharged directly to the surrounding

fields and ponds. The population of the six expanded wards and communes is about 39,760 people [8]. The amount of wastewater equivalents to 3,887 m^3/day and night.

(2) Wastewater from residential, tourism and public activities in the central areas is collected together with the rainwater system. However, due to overflowing as overloaded situations, it runs into the sea from the two manholes.

Accordingly, the average amount of discharged wastewater runs into the sea is:

8,399 - 3,887 = 4,512 m^3/day and night.

b) Pollutants Volume in Wastewater Discharged into the Beach

At present, the total population of SSTA center is 68,560 people [8]; The average number of accommodated tourists/day in SSTA is 9,750,000/365 = 26,712 (arrivals), the rate of daily accommodated tourists/ residents is 26,712/68,560 = 0.39. According to the discharge standards of tourists and residents, and the discharge rates of other sources (public facilities discharge is 10% out of that from the residents), the amount of waste discharged by each group can be determined.

Assuming K is the average number of stays/day, we have the following wastewater discharge volume equation:

$$(0.32 \times K + 0.115 \times \frac{K}{0.39} + 0.115 \times \frac{K}{0.39} \times 10\%) \times 85\% = 4.512$$

K = 8,238, so the wastewater amount of 4,512 m^3/day and night flown into the sea is caused by 8,238 tourists/day, 17,797 people, and the remaining 10% due to works public, emissions and emissions rates are as follows:

Table 2 shows that untreated or discharged wastewater flown into the sea by accommodated tourists/day accounts for 49.7%; by the residents 45.7% and from other sources 4.6%. The amount of the untreated water pollutants discharged into Sam Son sea is determined based on the pollution coefficient and the volume of waste sources.

Pollution coefficient in local wastewater is based on the assessment of the World Health Organization [10] in Table 3.

Pollutant amounts contained in wastewater by specific sources are shown in Table 4.

Table 2 Wastewater generated and discharged into SSTA's sea.

Unit: m^3/day and night

Waste sources	Amount	Discharge standard	Discharge amount	Rate (%)
(1) Average accommodated tourists/day	8,238	0.272	2,240	**49.7**
(2) Residents	21,144	0.098	2,066	**45.7**
(3) Other sources	10% (2)		206	**4.6**
Total			**4,512**	**100%**

Table 3 Pollution coefficient in domestic wastewater.

Pollutants	Amount (g/person/day)	Average amount (g/person/day)
Suspended solids (TSS)	70-145	**107.5**
BOD_5	45-54	**49.5**
COD	72-102	**87**
Ammonium (NH_4^+)	2.4-4.8	**3.6**
Total Nitrogen (N)	6-12	**9**
Total Phosphorus (P)	0.8 – 4.0	**2.4**

Source: WHO, 1993 - Rapid Environmental Assessment

Table 4 Pollutants volume in untreated local wastewater discharged into SSTA's sea.

Waste sources	Quantity (Person)	Suspended solids (kg/day.night)	BOD_5 (kg/day.night)	COD (kg/day.night)	Ammonium (NH_4^+) (kg/day.night)	Total Nitrogen (N) (kg/day.night)	Total Phosphorus (P) (kg/day.night)	Emission rate (%)
(1) Accommodated tourist *(arrivals/day)*	8.238	886	408	717	30	74	20	**26.32**
(2) Residents	21.144	2273	1047	1840	76	190	51	**67.10**
(3) Other waste sources	10% (2)	227	105	184	8	19	5	**6.58**
Total (kg/day.night)		**3.386**	**1.559**	**2.740**	**113**	**283**	**76**	**-**

Thus, it can be seen that the pollutants volume discharged into the seawater environment is mainly sourced from local people's living, accounting for 67.1%; 26.32% from tourists, the rest 6.58% from other sources.

For beaches in SSTA, the average volume of the waterbody is determined in the coastal boundary (3 nautical miles from the shore), with 8m of average depth, and 2.5km length of the waste receiving beach. Water exchange ratio is about 30%. The carrying capacity of coastal water environment is calculated by the formula (3), resulted in Table 5.

The Table 5 shows the excess capacity of beaches for receiving suspended solids (TSS) ($L_{tn} < 0$); other parameters can be receivable more are as follows: 94.98kg/day for Ammonium (NH_4^+); 110.82 kg/day for Phosphorus. The amount of suspended solids discharged into the beaches due to the residents living, tourists and public works has exceeded its receiving capacity at 474.92 kg/day and night.

Based on the emission factor and emission rate among objects, the suspended solids (TSS) generating capacity can be divided by the following sources (Table 6).

For SSTA's current tourism activities, receiving 26,712 accommodated tourists per day and night in 2019 exceeded its seawater environment carrying capacity. The number of accommodated tourists/day and night that can be received to ensure the self-recovery of the seawater environment:

T_2 = 26.712 - 1.163 = 25.549 arrivals/day.night. As the formula (4) is used, the carrying capacity of coastal water environment is exceed 1.05 times of its capacity limit at the time of calculation (Table 7).

3.2 Carrying Capacity of Socio-economic Environmental

3.2.1 Water Supply System

According to Sam Son Water Supply Branch, the total water consumption of inner city customers is 150,000 m^3/month (in winter, when tourists are few), equivalent to 5,000 m^3/day and night; 210,000 m^3/month, equivalent to 7,000 m^3/day and night (in summer). Accordingly, the required supply water capacity in SSTA at peak days is: P_{yc} = 7,000 (m^3/day and night).

The carrying capacity of the water supply system is determined on the basis of the ratio between the water supply capacity and the water consumption: P_{hc}/P_{yc} = 10,000/7,000 = 1.43 > 1

Thus, at present, with a water supply capacity of 10,000 m^3/day and night of SSTA is enough for such activities as production, daily life and tourism in normal days. Besides, the remaining current water supply capacity can serve more accommodated tourists/day: 3,000/0.32 = 9,735 arrivals/day and night.

Maximum accommodated tourist number/day:

T_3 = 26,712 + 9,375 = 36,087 (arrivals/day and night)

Thus, on normal days, the water supply system in SSTA is not overloaded. On the peak days, the accommodated tourists in SSTA reach 57,155 arrivals/day and night, carrying capacity of the water supply system on peak days: E_3 = 1.58. However, Sam Son has not encountered the water shortage phenomenon because in addition to the city water supply, 75% people and establishments also use their self-exploited underground water.

Table 5 Carrying capacity of coastal water environment.

Parameters	Suspended solids (TSS)	Ammonium (NH_4^+)	Phosphorus
C_{tc}	0.05	0.0005	0.0003
C_{ht}	0.0512	0.00026	0.00002
(1+R)%	1.3	1.3	1.3
V	111,120,000	111,120,000	111,120,000
$L_{tn/year}$	-173,347.2	34,669.44	40,447.68
$L_{tn/day}$	-474.92	94.98	110.82

Table 6 Division of excess suspended solids (TSS) by generating sources.

Divisions	Generatingrate *(%)*	Capacity amount (kg/day and night)	Capacity crowd (person/day and night)
Accommodated tourists	26.32	125	1,163
Residents	67.1	318.67	2,964
Other sources	6.58	31.25	-
Total	**100%**	**474.92**	**-**

Table 7 Carrying capacity of coastal water environment.

Maximum servable tourist number (T_2)	Arrivals/ day (average/year)	Capacity indicator (E_{2cd})
25,549	26,712	1.05

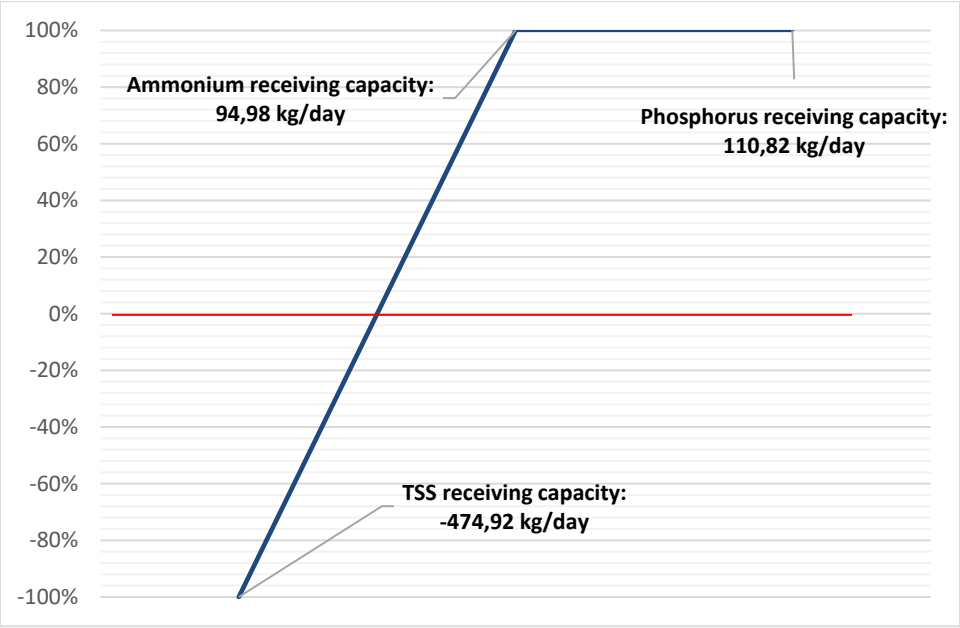

Fig. 1 Receiving capacity for pollutant substances for coastal water environment.

3.2.2 Carrying Capacity of Waste Collection and Treatment System

Carrying capacity of waste collection and treatment system in SSTA is calculated by the above mentioned formulas (6-9).

a) For Wastewater

Regarding the total wastewater volume: According to the authors' calculation, the total wastewater amount in SSTA reaches 20,098 m^3/day and night.

Regarding wastewater collection and treatment capacity: Currently, residents' wastewater is collected and pumped through the settling lake system in Trung

Son commune for treatment, the rate of wastewater collection is approximately 60%. Accordingly, the total volume of wastewater collected and treated reaches 11,699 m^3/day and night. Based on the above wastewater treatment capacity, the maximum accommodated tourist number can be served/day:

T_4 = 19,226 arrivals/ day and night

Thus, the current wastewater collection and treatment infrastructure in SSTA exceeded the carrying capacity on both normal days and peak day.

b) For Solid Waste

Regarding the solid waste amount generation: On yearly-based average, it is discharged 117.42 m^3/day and night into SSTA. However, during the peak season, solid waste is generated up to 144 m^3/day and night.

Regarding solid waste collection and treatment system: Currently, the total volume of domestic solid waste in SSTA is treated at 50 m^3 day and night.

Thus, the amount of solid waste generated in SSTA exceeded many-time higher than the treating capacity.

Thus, the carrying capacity of the solid waste collection and treatment infrastructure in SSTA is currently exceeded on both normal days and peak days.

Table 8 Carrying capacity of water supply system at SSTA.

Maximum servable tourist number **(T_3)**	Tourist arrivals/ actual weekdays	Tourist arrivals/actual peak days	Week day carrying indicator **(E_{3tb})**	Peak days carrying indicator **(E_{3cd})**
36,087	26,712	57,115	**0.74**	**1.58**

Table 9 Carrying capacity of the wastewater collection and treatment system.

Maximum servable tourist number **(T_4)**	Accommodated tourist number/day (weekdays)	Tourist arrivals/day (peak days)	Carrying capacity indicator on weekdays **(E_{4tb})**	Carrying capacity indicator on peak days **(E_{4cd})**
19,266	26,712	57,115	**1.39**	**2.96**

Table 10 Carrying capacity of solid waste treatment system.

Maximum treating capacity	Solid waste generation volume/ weekdays	Solid waste generation/ peak days	Weekdays capacity indicator **(E_{5tb})**	Peak days capacity indicator **(E_{5cd})**
50	117.42	144	**2.35**	**2.88**

3.2.3 Carrying Capacity of Accommodation Establishments

According to Sam Son People's Committee, in 2019, the number of rooms in SSTA is 19,000; According to the standard of 2 people/room, the maximum accommodated tourist number/day in SSTA is: T_6 (per day) = 38,000 arrivals; Average accommodated days is 1.97 days. Accordingly, the maximum accommodated tourist number/year in SSTA reached 7,040,609.

Thus, on normal days the accommodation establishments in SSTA have not exceeded its capacity. However, during the tourism peak days, the system exceeded the capacity by 1.5 times.

3.3 Overall Observations of the TECC in SSTA

Based on the results of the evaluation of TECC on each component, TECC of SSTA is summarized in Table 12. As a sea tourism area, the tourist main purpose to SSTA is to enjoy the sea vacations.

Therefore, the accumulated TECC of a concerned area is considered as the carrying capacity of beach spatial, carrying capacity of socio-economic infrastructure are the limiting conditions.

Calculation results show that: In the whole year, the number of tourists to SSTA is still under spatial carrying capacity. However, in the peak season, the spatial carrying capacity exceeded 146%. The carrying capacity of socio-economic environment exceeded its capacity at a high level. In particular, the solid waste collection and treatment system exceeds 497%, causing waste pollution; the wastewater collection and treatment system exceeds 297%; the seawater environment exceeds 105% its carrying capacity, which causes the sea water environment pollution in the beaches and

affects the tourist experience.

Theoretically, SSTA can receive up to 42,000 tourists/day. However, if the recovering conditions in terms of seawater quality, water supply, waste collection and treatment in SSTA are satisfied, there can only be a maximum of 11,486 accommodated tourists/day.

Table 11 Carrying capacity of accommodation establishments.

Maximum servable tourist number **(T_6)**	Accommodated tourist number/day (weekdays)	Tourist arrivals/day (peak days)	Weekdays capacity indicator **(E_{6tb})**	Peak days capacity indicator **(E_{6cd})**
38,000	26,712	57,115	**0.7**	**1.5**

Table 12 Summary of TECC of SSTA.

TECC components	**Carrying capacity (T)**	**Capacity indicators (E)**	
		Week days **(E_{tb})**	Peak days **(E_{cd})**
1. Natural Environment			
1.1 Spatial carrying capacity (T_1, E_1)	42.000	35%	146%
1.2 Coastal water environment (T_2, E_2) (***)	25.549	105%	-
2. Socio-economic Environment			
2.1 Carrying capacity and capacity indicator of water supply system (*) (T_3, E_3)	36.087	74%	158%
2.2 Carrying capacity and capacity indicator of wastewater collection and treatment system (**) (T_4, E_4)	19.266	139%	296%
2.3 Carrying capacity and capacity indicator of solid waste collection and treatment system (T_5, E_5)	50 (m^3)	235%	288%
2.4 Carrying capacity and capacity indicator of accommodation establishments (T_6, E_6)	38.000	70%	150%

Notes: (*) Only for accommodated tourists; (**) Only for collection capacity; (***) Only for the whole year observation.

Given the accommodated tourists in 2019 of SSTA is 26,712 arrivals/day, current carrying capacity of SSTA's TECC only meets 43% of this crowd.

However, the TECC in SSTA can increase a lot to effectively make good use of tourism activities, while the carrying capacity of the beach resources spatial is met, if the waste collection and treatment (especially solid waste treatment system) and water supply system is invested to increase the capacity.

Currently, thanks to implementation and completion of a number of waste treatment infrastructure projects in SSTA, which will be put into operation in 2021 [7], TECC of SSTA would be increased, contributing to effective and sustainable use of tourism.

4. Conclusion

The above assessments show that, during the peak season, the TECC in SSTA is exceeded. The beach capacity crowd is not spacious enough to serve that many tourists. The main cause of excess capacity is the waste collection and treatment system cannot deal with the daily discharge. To improve carrying capacity and efficiency of SSTA operation, the following recommendations are proposed:

Organizing division of tourist flows to reduce the carrying capacity of the beach space at peak occasions.

Strengthening the inspection of tourism business and environmental protection, which is in the form of autonomy and self-responsibility for tourism service providing establishments to ensure quality of service and environmental sanitation.

Investing in the construction and improvement of environmental treatment infrastructure in order to increase the treatment capacity to meet the socio-economic development requirements of SSTA. For wastewater treatment infrastructure, it is necessary to separate the wastewater collection from the rainwater system to avoid overflowing pollutants in domestic wastewater into the sea. For solid waste treatment infrastructure, priority should be given to

promptly investment and construction and put into operation a waste treatment plant to ensure all waste in SSTA and its vicinity is handled

Besides, it is necessary to perform well dissemination and awareness raising of environmental protection for residents and tourists. Particularly, such activities should be done: sorting solid waste at sources, using water economically, using less plastic bags and disposable plastic products... to preserve the environment of the tourist area while reducing the capacity of waste collection and treatment systems.

References

[1] Department of Culture, Sports and Tourism (DCST) of Thanh Hoa province, Report on current situation of tourism development in Thanh Hoa province in the period of 2015-2019.

[2] Department of Natural Resources and Environment of Thanh Hoa Province, Report on environmental monitoring data in Sam Son region for the period of 2016-2019.

[3] Fred Lawson and Manuel Baud-Bovy, *Tourism and Recreation Development*, 1977 and 1998.

[4] GESAM, Monitoring the ecological effects of coastal aquaculture wastes, GESAM reports and studies, 1996.

[5] Institute for Tourism Development Research, Report on the strategic environmental assessment for Strategy on Vietnam Tourism Development to 2030, vision to 2050, 2018.

[6] Li, Zhiqiang, A research on evaluation method of tourism environmental bearing capacity in the context of ecological environment protection, *International Journal of Earth Sciences and Engineering* 9 (2016).

[7] Sam Son City People's Committee, Adjusting the general planning of Sam Son urban area in Thanh Hoa province to 2035, vision to 2050, 2018.

[8] Sam Son City People's Committee, *Report on the Situation of Tourism Development, Environment, and Technical Infrastructure in Sam Son City*, 2020.

[9] Vietnam Academy of Science and Technology, Environmental carrying capacity of typical coastal waters of Vietnam, 2016.

[10] World Heath Organization, Gevera, *Assessment of Sources of Air, Water, and Land Pollution*, 1993.