# Tourism climate index on the Co To islands of Quang Ninh province, Vietnam

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**Abstract**

Tourism is one of the spearhead economic sectors of every country in the world and sensitive to weather conditions. The climate is one of the most important factors for each destination for vacation and recreation. Almost the measures are primarily based on particular local weather and climate, and part of them deals with energy balance estimation to assess thermal comfort. Tourism climate indicator developed by Mieczkowski (1985) incorporates 7 climate variables (average temperature, maximum temperature, average humidity, minimum humidity, precipitation, number of sunny hours, wind speed) relevant to general tourism activities is used to assess potential impacts of climate change on tourism climate resources of Co To islands in the Tonkin Gulf of Vietnam. The monthly tourism climate indicator classification results show that the tourism potentials of Co To islands range from unfavorable (30–39) to very good (70–79) in March, April, November and December. Daily tourism climate indicator classification results indicate that tourism potentials are from extremely unfavorable (20–29) to excellent (80–89). The days at very good to excellent for travel are on 2nd, 3rd, 5–7th of January; 6–8th and 20–28th of February; 1st–8th, 12–17th and 20–28th of March; 1st–2nd, 4–13th, 15–18th of April; 21st–24th of September; 1st–4th, 6th, 8–10th, 12th, 13th of November; 1st–26th of December. These findings are important for future research in assessing current and future climate suitability for sustainable tourism development.

**Keywords:** Tourism climate index (TCI), tourism, Co To islands.

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# INTRODUCTION

The human body and surrounding environment through physical-biological relationships show that climate has a close relationship with tourism and plays a vital role in three stages: Pre, during and post traveling. Climate is always taken into account when tourists make their plans on motivation, climate-dependent destinations and attractive points. Weather and climate are an intrinsic component of the holiday experience and have been found to be a central driver of tourism [1–3]. Climate impacts directly and indirectly on tourism activities, on physical, environmental and social resources for tourism and the comfort, awareness, and safety of participants [4]. At the same time, climate and weather contribute significantly to determining available tourism activities, the length of the tourist season, the quality and profitability of the tourism industry [5, 6]. Climate influences tour length and guest satisfaction [7, 8]. The climate also plays an important role in making plans and decisions of investors, managers, financial success, and the quality of visitors' experiences at special events and festivals [9].

There are many methods to determine the influence of climate factors on tourism, including the process of deciding the tourism climate index (TCI) proposed by Miezkowski (1985) [10]. This is a semi-quantitative method to assess the integration of 7 climate variables with 3 advantages of TCI: (i) Giving visitors an overview to determine the appropriate time to conduct tourism activities at the destination [11–13]; (ii) Changes of TCI at different stages quantifying climate change [14, 15]; (iii) Evaluating climate potential in different localities [16]. This method has been used to identify tourism climate resources and assess the impact of climate change on tourism in many countries thanks to its diversity and high reliability [17, 18].

This paper aims at applying TCI to the characteristics of climatic tourism conditions on Co To island in the Tonkin Gulf of Vietnam and determining the most appropriate months for tourism and tourists on this island. Also, special features on the variability of TCI values related to climate change were investigated.

# MATERIALS AND METHODS
## The study area

Co To islands are located in the Gulf of Tonkin, at geographical coordinates $20.16^oN$–$21.25^oN$, $107.58^oE$–$108.33^oE$, about 45 km far away from the mainland to Cai Rong port. Co To islands have long, wide, smooth and white sand beaches such as Hong Van, Van Chay, Bac Van beaches (figure 1).

Investigation and survey findings of the projects named "Planning for tourism development in Co To district, Quang Ninh province to 2020, vision to 2030" (2014) and "Detailed planning of Co To marine protected area, Tran island, Quang Ninh province" (2018) show that sea wave in Co To sea part is quite large (medium: 0.7 m to 1.3 m), the salinity of the sea water is high (medium: 30.9‰). The deep reef slopes are quite suitable for tourists who like surfing, bathing and exploring. In addition, sea part of Co To islands has 20 rare and endangered species listed in the Vietnam's Red Data Book (2007) and/or the IUCN Red List of Threatened Species (2018) such as *Haliotis diversicolor, Trochus maculatus, T. pyramis, Turbo marmoratus, Pinctada martensii, Pteria pinguin, Sepia Tigris, Hippocampus kuda, Chelonia mydas, Eretmochelys imbricata, finless porpoise, Porites lobata,...*

Observed data for many years (from 1959 to 2018) of Co To meteorological station show that it has oceanic climate; the annual average temperature is $22.8^o$, the humidity is 83%, the average number of sunny hours is 148 hours/month. In addition, Co To islands have rare specialties as abalone. Recently, Co To islands have become one of the attractive tourist places. However, the islands are directly affected by 5 to 7 typhoons with wind speed from level 8–11 every year. This significantly affects tourism activities on the island. Therefore, the TCI of Mieczkowski (1985) is used to determine the favorable time for tourism activities to take place on Co To islands.
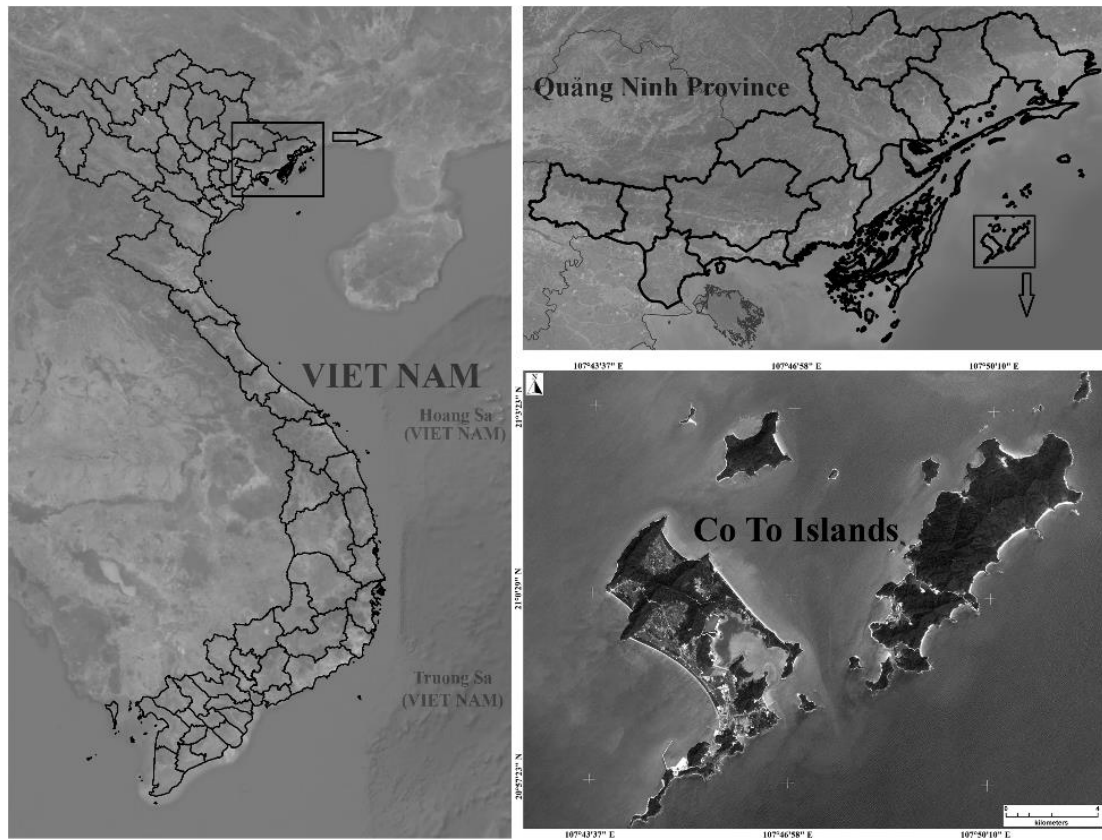
*Figure 1.* Location of the study area

**Materials and methods**

Average data series of 60 years (from 1959 to 2018) of the elements (average temperature, maximum temperature, average humidity, minimum humidity, precipitation, number of sunny hours, wind speed) are used to calculate monthly TCI, average data series of 20 years (from 1999 to 2018) of factors are used to calculate daily TCI of Co To meteorological station (20.93°N, 107.76°E, H = 70 m). The TCI is used to determine the influence of seven climate factors as average temperature (°C); maximum temperature (°C); average humidity (%); minimum humidity (%); precipitation (mm); number of sunny hours (hours); and wind speed (m/s) for Co To islands tourism activities, Quang Ninh province based on the model of Mieczkowski by the formula:

$$TCI = 2 \times (4 \times CID + CIA + 2P + 2 \times S + W) \tag{1}$$

*Where: CID* is an index of daily comfort, which shows the correlation between the daily maximum temperature and the daily minimum humidity (denoting the heat-moisture comfort in the daytime when tourists' activities take place); *CIA* is a daily comfort index, which shows the correlation between the average daily temperature and the average daily humidity (denoting the heat-moisture comfort during 24 hours, including the night hours when most of tourists stay indoors). Both *CID* and *CIA* represent a heat comfort suitability based on tourists' points of view. This correlation is determined based on findings of Mieczkowski's research (figure 2). Meanwhile, the factors: *P* - total rainfall (20%); *S* - total hours of sunshine (20%), and *W* - average wind speed (10%) are determined according to table 1. *TCI* results are ranked according to table 2.
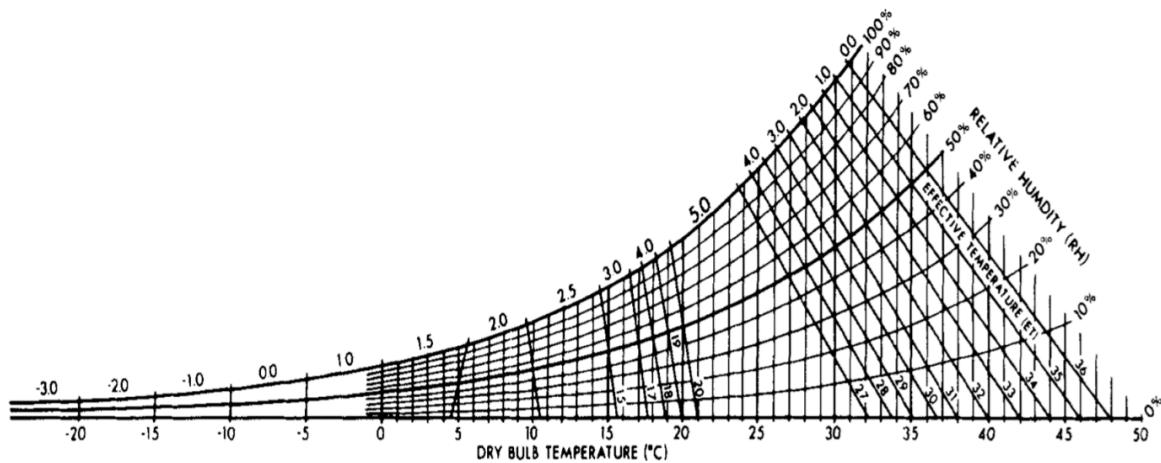
*Figure 2.* Classification of moist heat correlation [*Source:* [5]]

*Table 1.* Variable of elements [*Source:* [1]]

| Rates | Mean precipitation (mm) | Mean sunshine (h) | Win speed (km/h) |
|---|---|---|---|
| 5.0 | 0.0 - 14.9 | 10 | < 2.88 |
| 4.5 | 15.0 - 29.9 | 9 - 10 | 2.88 - 5.75 |
| 4.0 | 30.0 - 44.9 | 8 - 9 | 5.76 - 9.03 |
| 3.5 | 45.0 - 59.9 | 7 - 8 | 9.04 - 12.23 |
| 3.0 | 60.0 - 74.9 | 6 - 7 | 12.24 - 19.79 |
| 2.5 | 75.0 - 89.9 | 5 - 6 | 19.8 - 24.29 |
| 2.0 | 90.0 - 104.9 | 4 - 5 | 24.30 - 28.79 |
| 1.5 | 105.0 - 119.9 | 3 - 4 | 28.80 - 38.52 |
| 1.0 | 120.0 - 134.9 | 2 - 3 | - |
| 0.5 | 135.0 - 149.9 | 1 - 2 | - |
| 0.0 | > 150 | 0 - 1 | > 38.52 |

*Table 2.* Rating categories of TCI [*Source:* [1]]

| TCI score | Descriptive category |
|---|---|
| 90–100 | Ideal |
| 80–89 | Excellent |
| 70–79 | Very good |
| 60–69 | Good |
| 50–59 | Acceptable |
| 40–49 | Marginal |
| 30–39 | Unfavorable |
| 20–29 | Very unfavorable |
| 10–19 | Extremely unfavorable |
| 9 to -9 | Impossible |
| -10 to -30 | Impossible |

## RESULTS AND DISCUSSION

The results of monthly TCIs of Co To islands (figures 3–4) indicate that the climate in Co To islands is not considered excellent, ideal for tourism activities.

Compared with TCI findings of Mieczkowski for 453 meteorological stations (widely distributed in the Americas, Africa, Asia and Oceania from 40°N to 40°S), it shows that the Co To islands tourism climate type is the "winter peak" type, which means that the peak value of its climate is suitable for tourism in the dry season.

The favorable times for tourism activities focus in the months of spring and winter (from October of the previous year until April of the next year). In March, April, November and December, TCI results reaching 71–75% show the weather conditions for tourism classified as very good. In January, February and October, TCI results are 67–69%, indicating right weather conditions for tourism (good).
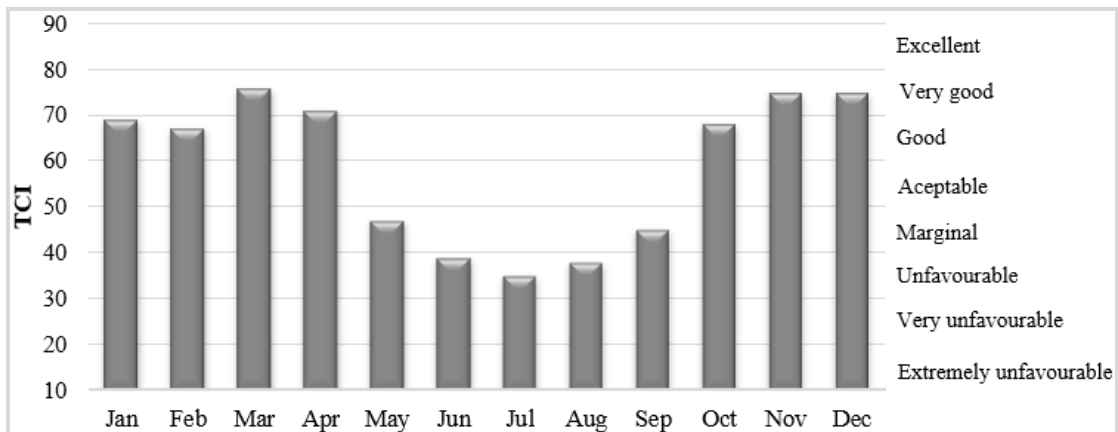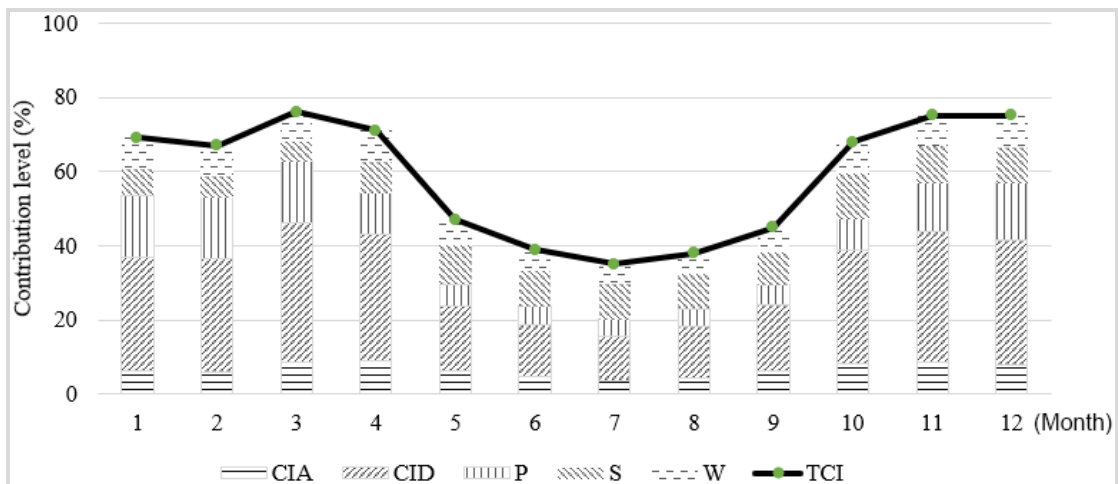
*Figure 3.* Monthly TCI values of Co To islands
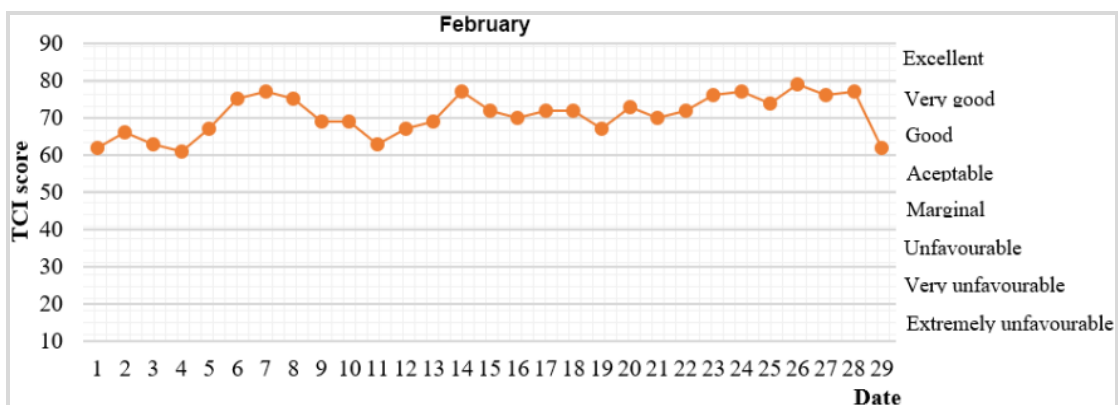


*Figure 4.* Monthly process of components



*Figure 5.* TCI of February in Co To islands

In spring months, TCIs generally range mainly from good (60–69) to excellent (80–90) (figures 5–7). In February, TCIs are from good (60–69) to very good (70–79). Days from 6–8th,

14–18th, 20–28th are rated very good for tourism activities. The remaining days are good for travel activities. In March, TCIs are excellent for tourism activities on the days of 5th, 15th, 26th. Days from 1st–4th, 6–8th, 12–14th, 16–17th, 19th, 25–30th are rated very good for tourism activities. The remaining four days of the month are appreciated for tourism activities. In April, TCI fluctuates from marginal (40–50) to excellent (80–90). There are seven days (1st, 4–6th, 9th, 11th, 15th) excellent for tourism activities (TCIs reaching 81–83), nine days (2nd, 7th, 8th, 10–13th, 16–18th, 23rd) classified as very good for tourism activities, eight days (13th, 14th, 19th, 21st, 24th, 26th, 29th, 30th) suitable for tourism activities. The remaining days are classified from marginal (40–49) to acceptable (50–59).
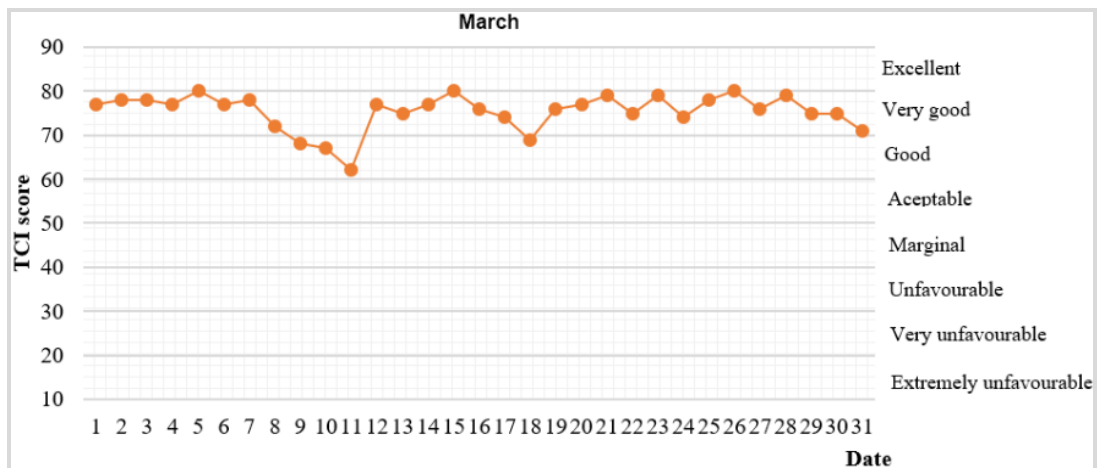


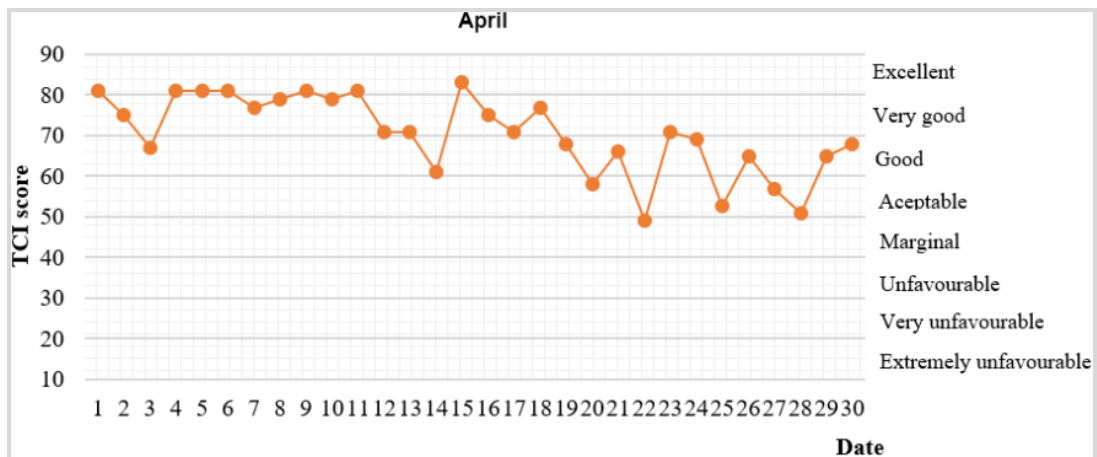*Figure 6.* TCI of March in Co To islands



*Figure 7.* TCI of April in Co To islands

Daily TCIs of winter months show a favorable period for tourism activities because of the thermal comfort of a pleasant climate, suitable for the operation of the human body. The scores achieved for CID and CIA are quite high and the rainfall at this time is not high, thus having little effect on outdoor tourism activities (figures 8–10). Daily TCIs of the months in the season are as follows:

In January, daily TCIs range from marginal (40–49) to very good (70–79). The days of 2nd, 3rd, 5th, 7th, and 16th are very good for tourism activities. The days 1st, 4th, 6th, 8–15th, 17–24th, 28–31st are rated good for travel

activities. Days from 25–27<sup>th</sup> are assessed at an acceptable level for travel activities. Only day 28<sup>th</sup> is limited to activities by high daily precipitation (129.1 mm).

In November and December, TCIs classification results range from good (60–69) to excellent (80–89). Most days of those months have TCIs at very good to excellent.
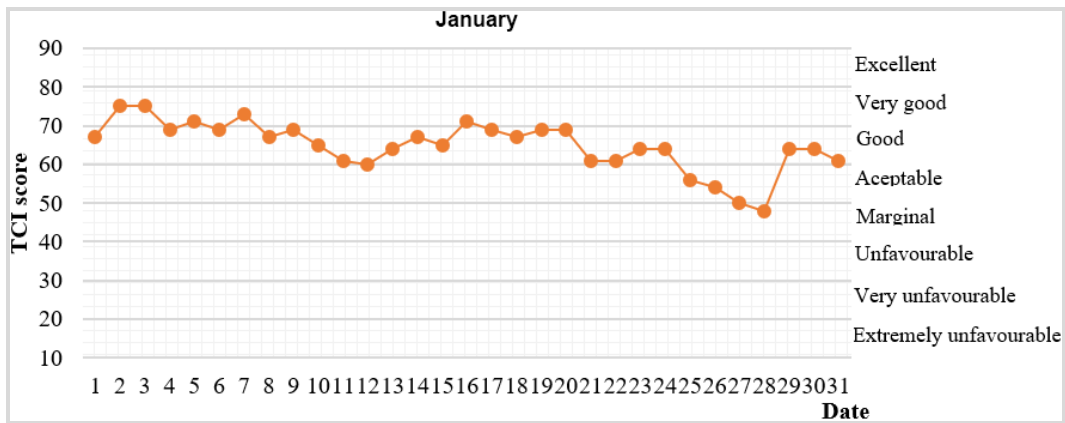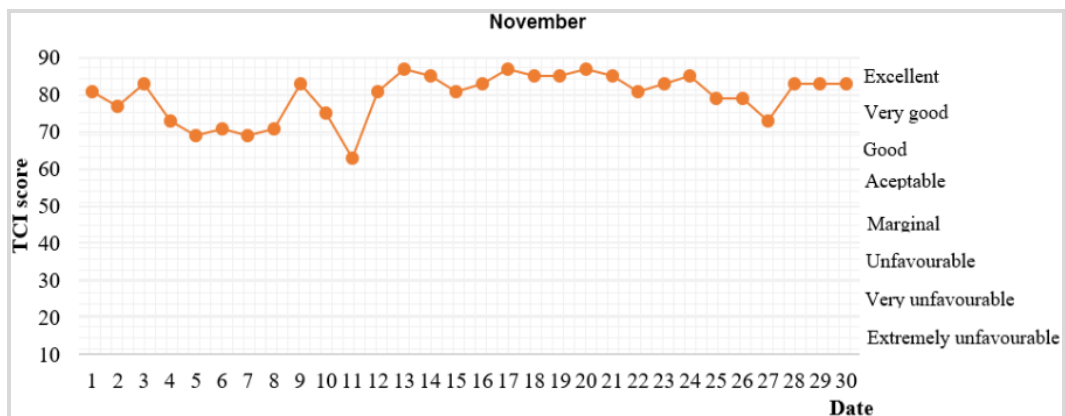


*Figure 8.* TCI of January in Co To islands



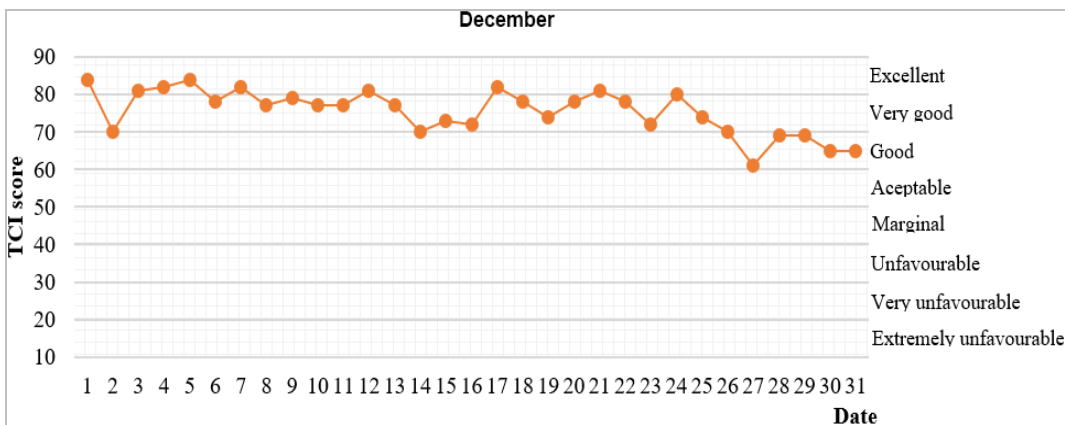*Figure 9.* TCI of November in Co To islands



*Figure 10.* TCI of December in Co To islands

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Meanwhile, in the months of summer and autumn, the monthly TCI ranges from unfavorable to marginal for tourism activities on Co To islands. In May, TCI results range from 45–47% indicating nine climatic conditions only limited (marginal) for tourism activities. In June, July, and August, TCI results at 35–39% represent the unfavorable climate conditions for tourism activities. The reasons for the reduction of tourism potential of Co To islands in June, July and August are the criteria of thermal comfort of hot climate (28–30°C), high humidity (76–85%) which are unsuitable for human body activities, hindering heat exchange, so CID and CIA often exceed pleasant thresholds of heat sensation, scores achieved by these two indicators are usually low. On the other hand, the rainfall in Co To islands in June, July and August is high (200–300 mm), which contributes to the difficulty of outdoor tourism activities, hindering movement.

In summer months, TCIs drop sharply and range from very unfavorable (20–29) to good (60–69) (figures 11–13). May has the highest TCIs in the season, reaching 62–65, suitable for tourism activities. These are days of 2nd, 5th, 6th, 10th, 11th. The days of 1st, 3rd, 4th, 7th, 15–17th, 30th, 31st are classified as acceptable for tourism activities. The remaining days are marginal for tourism activities. June and July have two days (1st and 2nd of June) with TCI reaching the maximum of 56, thirteen days with TCIs of 20–29, very unfavorable, including 7th, 10th, 17th, 18th, 29th of June and 4th, 5th, 12th, 15th, 18–21st of July. The remaining days are classified from unfavorable (30–39) to marginal (40–49).
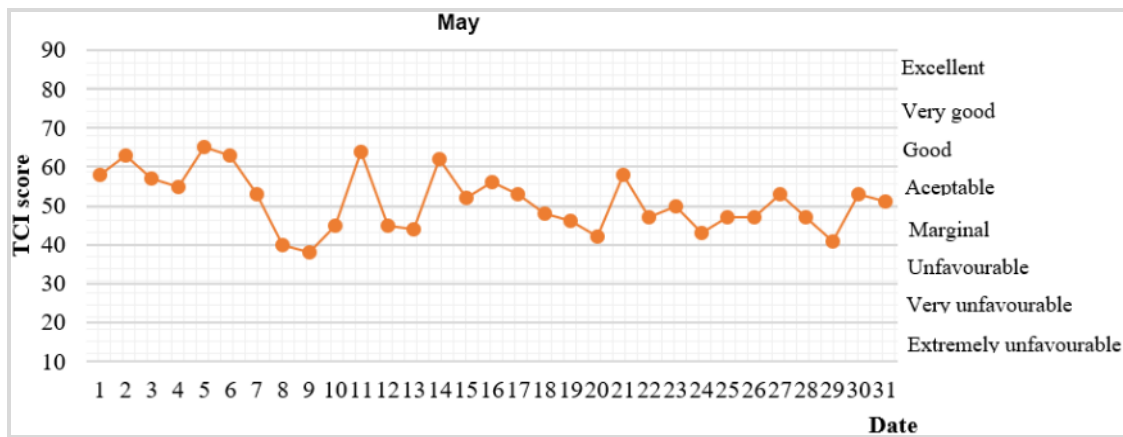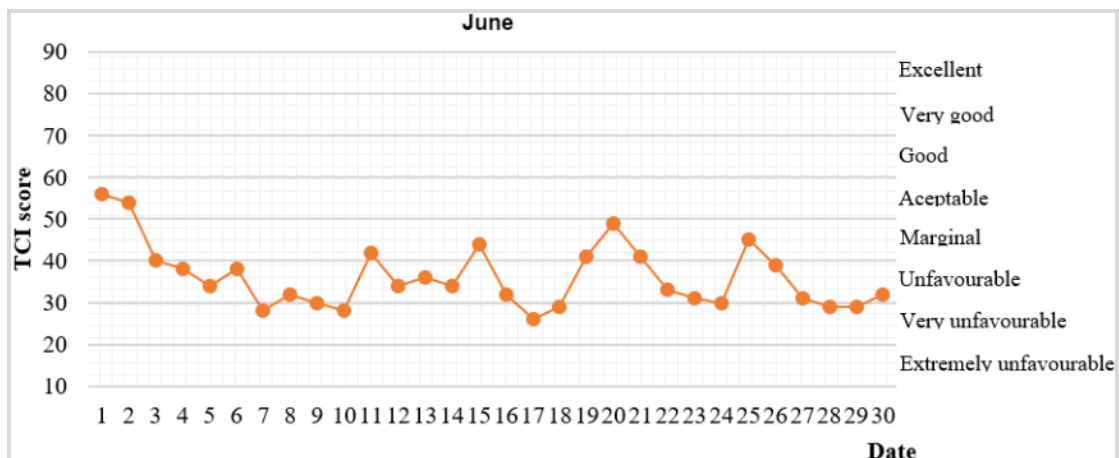


*Figure 11.* TCI of May in Co To islands



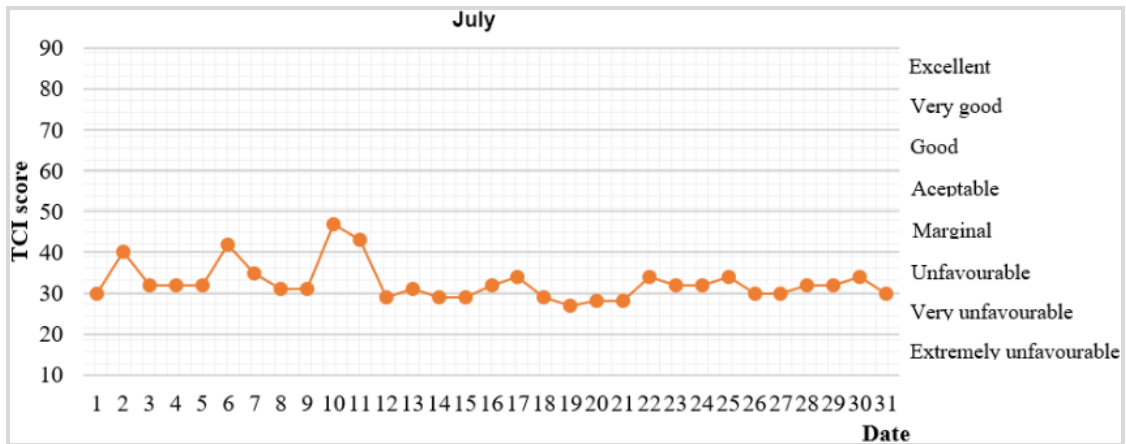*Figure 12.* TCI of June in Co To islands

*Figure 13.* TCI of July in Co To islands

TCIs decline in summer is due to very high rainfall of 487 mm every day (July) affecting the movement of tourism activities. This is also the typhoon season in Northern Vietnam.
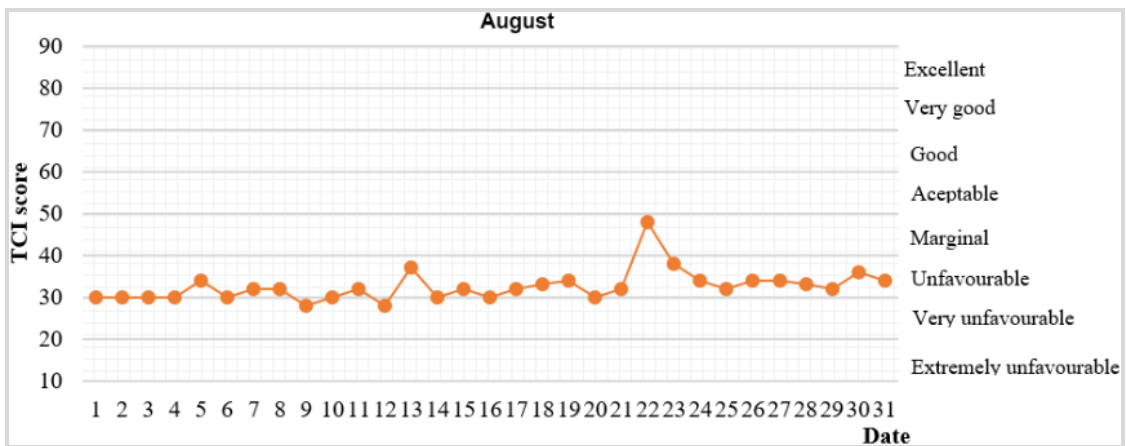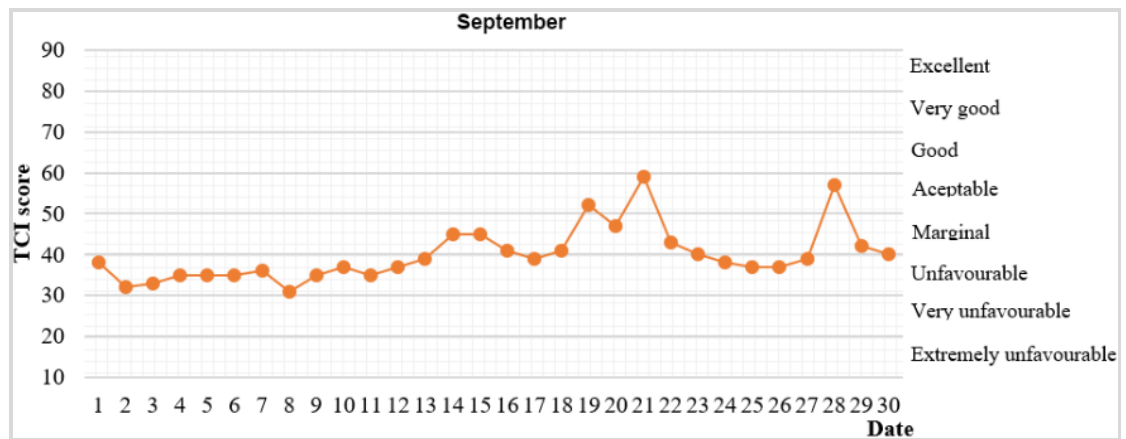


*Figure 14.* TCI of August in Co To islands



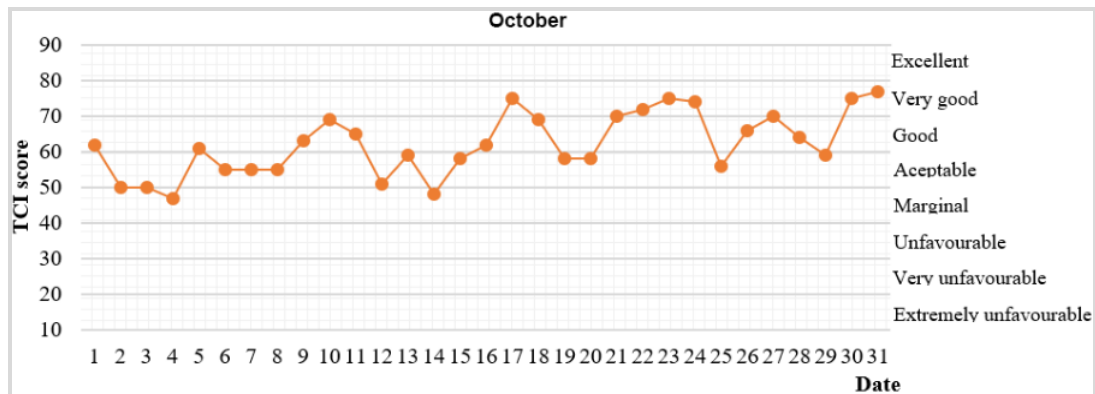*Figure 15.* TCI of September in Co To islands

*Figure 16.* TCI of October in Co To islands

TCIs of autumn months, the transition period between summer and winter, fluctuate strongly in range from very unfavorable (20–29) to very good (70–79). Daily TCIs in August and September are not high. The maximum TCI reaches 59 (19th, 21st and 28th of September) and the minimum TCI reaches 28 (9th and 12th of August). Meanwhile, daily TCIs in October are increased, in range from marginal (40–49) to very good (70–79). Daily TCIs are classified as good and very good for tourism activities from 7–31st (figures 14–16).

The results of the evaluations show that most of daytime tourism climate index (TCI) in winter and spring is in the good level to ideal level. However, during this time, tourism activities take place less than the current tourism development in Co To in particular and Quang Ninh in general. For explanation of the difference between the research result and the reality at the locality, the research team used the statistics (in 2018, 2019) on the number of tourists visiting Co To islands from People's Committee of Co To district. The statistics show that the total number of tourists visiting Co To increased (in 2018: 238 thousand of tourist arrivals; in 2019: 288 thousand of tourist arrivals), however, international tourist arrivals were not high (in 2018: 4,519 of tourist arrivals, accounting for 1.9% of total tourist arrivals; in 2019: 4,200 of tourist arrivals, accounting for 1.6%). International tourists visiting Co To mainly come from the Asian countries (49.3%), Europe (13.6%), America (5.9%), the tourist season is mainly November of the previous year to April of the next year. Unlike the international tourists, the domestic tourists who are mainly officials, pupils, students and workers from the tourist centers in the Red river Delta's tourism region choose the period from April to September that is the tourist season, because it coincides with the current time when the tourism activities on the Co To islands take place quite strongly. This shows a clear difference in the tourist season between international tourists and domestic tourists, which largely depends on the subjective decision in choosing the destination and the time of arrival. The reality of this difference in the tourist season can be due to many different reasons. The TCI calculation result from May to September is mostly at the limited level to unfavorable level for tourism activities. Tourism activities during this period in Co To are often potentially at high risks, especially in June and July when storms are strongly active as well as other severe weather phenomena (tropical depression, thunderstorms,...) together with the heavy rainfall, so the tourism activities are quite limited. However, CoTo islands still welcome a great number of domestic tourists; the reason is that it coincides with the time of traditional summer vacation, the tourists often choose a short stay, so there is no great influence. Nevertheless, the deeper and more important reason is that the tourism investment and promotion activities of CoTo islands are generally quite limited and weak, so it has not been able to help the tourists in choosing the suitable time for vacation.

## CONCLUSIONS

Tourism activities on Co To islands are significantly influenced by climate. Results of monthly TCIs and daily TCIs showed that two months of spring (March and April) and two months of winter (November and December) are very good time to attract tourists. However, most of the days in summer months (June and July) and August have unfavorable weather for tourism activities because of the high temperature, heavy rainfall and typhoons. The study results provide referential information for tourists in making their plans, for organizers, managers and tourism companies to manage tourism activities on the island, especially with climate change.

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