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Influence of some climatic factors on tourism activities on Co To Island, Vietnam

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ABSTRACT

Co To is a small Island that is a well-known tourist destination for Vietnamese people and it is known to have a very special climate for each season of the year. The purpose of this study is to discuss the limitations of climatic factors as well as find out a favorable time for tourism activities on Co To Island, Vietnam. One of the important things to choose Co To Island to become the main subject is because it has a very special geographic location and tourism is one of the most important drivers of economic development on Co To Island. However, in addition to social reasons, Co To Island tourism is also influenced by climatic factors. Each climate factor has different effects, but the assessment shows that temperature, humidity, and precipitation have the strongest influence. The results also show that in the summer (May-September) on Co To Island, the most frequent and dangerous weather conditions for humans are related to hot weather as well as heavy rainstorms. Mainly in winter (December, January, February), outdoor tourism activities are limited by the cold climate and changing northeast monsoon. However, March, April, October, and November have very favorable tourist conditions.

1. Introduction

Tourism is the most important and fastest-growing economic sector of the global economy. Tourism has been improving the life quality for millions of people, changing the lives of communities in many different countries and regions. However, tourism is also the economic sector that is mostly affected by climate and weather (UNWTO and UNEP, 2008). There is a diverse and complex relationship between climate, weather, and tourism; climate has been recognized as a form of tourism resource, a factor that greatly influences the choice of tourist destinations as well as tourism activities that tourists directly participate in Becken (2013) and Becken and Wilson (2013). In the context of increasingly complex climate change, understanding the relationship between climate and tourism is becoming increasingly important. However, a detailed understanding of the role and impacts of climate on tourism is quite limited, few people know about climate impacts and their role in tourism because this connection has only been studied in tourism geography and climatology.

From the point of view of climatologists, the climate is considered to be a geophysical factor that creates geographical space and environmental conditions (Faradiba et al., 2021). From the perspective of tourism geographers, in relation to other natural tourism resources, climate resources are considered as a link to connect the geographical components of natural resources (topography, hydrology, plants), creating a typical form of local tourism resource. This type of resource is endless and free of charge, but cannot be stored and transported, to it requires tourists to enjoy directly. For tourism planners, the climate is an important basis to orient the development of space-based on the identification of 5 main factors: (1) Location of tourism centers; (2) Length and quality of tourism season (Scott et al., 2016; Rutty and Scott, 2010); (3)

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Tourist experience activity schedule and plan; (4) Efficient use of infrastructure and profit from tourism; (5) Length of stay and expenses paid by tourists (Timmis et al., 2018).

For tourism activities, the climate has both positive and negative impacts. On the positive side, the climate is considered an intangible resource, creating destination competitiveness and influencing tourist destination choices. Tourists then consider the weather experience to be part of the set of destination experiences. Bigano et al. (2006) collected data from tourists from 45 countries by interview, the results showed that tourists preferred countries with a warm but temperate climate. Rutty and Scott (2014) found that a temperature below 34°C was acceptable for tourism activities by using a sociological survey of tourists on the beaches, but heat resistance also varied depending on tourists' age and origin. French tourists aged 18-24 were more sensitive to the weather (Dubois et al., 2016). Moreover, the climate is also a factor affecting the satisfaction and loyalty of tourists (Coghlan and Prideaux, 2009).

On the negative side, bad climate causes tourists to limit their travel decision, affecting the arrangement of the experience schedule, limiting the needs of tourists; or to be more precise, the climate has a strong influence on tourism season; from there, it has a direct and indirect impact on the cost, revenue and profit of the tourism sector. Specifically, the impact of extreme weather events (rain, thunderstorms, snow, flood, ...), especially during the period of climate change, can also affect the inspiration and safety of tourists as well as destroying tourism infrastructure (Day et al., 2013). Brodie et al. (2020) found that climate was the driving force behind seasonal tourism demand in many climates, which helped to gain a more general understanding of the role of climate in tourism's seasonality. In more detail, Dubois et al. (2016) found that rain had a greater impact on tourist decision-making than high temperature. However, the negative effects of climate and weather on tourism are governed by tourist behaviors. Becken's (2010) spot observations and Freitas et al. (2008) found tourist behavior indicating their comfort level and how willing they were to adopt.

When studying the relationship between climate and tourism, scientists have paid attention to quantifying the role of climate factors to best serve tourists as well as tourism. Quantifying and understanding the suitability of climate to tourism in a destination has been around for a long time, but studies on the relationship were studied from the 60s, 70s, which was called the climate revolution. At this stage, studies focused on clarifying the separate role of each climate and weather factor with tourism activities. One of them was the study of Brunet (1970) to show the human temperature threshold upon participating in beach tourism. However, in practice, the individual effects of each climatic factor are difficult to recognize, the change of this component will lead to the change of the other related components. Thus, during development, many researchers have realized the need for a destination's climate indicator to meet the needs of tourists who are not concerned about the annual climate indicators but are very concerned about the climate of their vacation. Therefore, there are many indicators of outdoor thermal comfort as well as indoor environment based on climatic factors. There are three main research directions for tourist climate indicators: (1) Based on the relationship between two factors: Temperature and humidity (Nikolopoulou et al., 2001); (2) Based on the relationship between four factors of air temperature, radiation temperature (i.e., wall), air humidity and airflow velocity in terms of thermal comfort; (3) Based on the integrated relationship between 5-7 climate variables (Mieczkowski, 1985; Freitas et al., 2008). Compared to the above two directions, the third research direction is more general because it has fully considered the impact aspects of climate on tourism.

In Vietnam, since the late nineteenth century, the French have attached great importance to climate research for relaxation. From a temperate country to a humid tropic region, the relationship between the state of the French soldiers and the climate has been designed to seek cool climates in the highlands to rest and improve the health of French soldiers and officials. French authorities sent the scientist and explorer Alexandre Yersin to lead expeditions from 1892 to 1894 aimed at "searching for a Switzerland in Indochina". They later found Lang-Bian plateau and praised that windswept plateau as being similar to the "Mediterranean climate in spring" and built the first resort there in 1987. Subsequently, Ba Na in Da Nang was turned into a second resort in 1919 and another sub-resort network on the highlands such as Sa Pa, Tam Dao, and Mau Son was built. Although it has been more than a century, those resorts selected by the French are still very valuable.

During the war and economic recovery, since 1990, researches on climate and tourism have received attention from Vietnamese scientists; Using a weighted scale for integrated assessment of climate resources for tourism and relaxation in some tourism centers in Vietnam. The studies have been based on climatic and weather characteristics such as temperature, humidity, rainfall, wind, number of sunny days ... to assess the degree of adaptability of climatic factors to tourism activities and resort activities suitable for Vietnamese people. Recently, the tourist climate index Mieczkowski (1985) has been applied by Nhung and Bac (2016) and Thu et al. (2020) to measure and determine the length of the tourism season in the Central Highlands of Vietnam and Moc Chau district, Son La province.

2. Data and method

2.1. Research area

Co To is an archipelago located in Bai Tu Long Bay, about 40 km from the mainland. Co To Island

also was formerly known as Chang Son (Chang Mountain) for its long history of formation. From a geographical perspective, Co To Island has great potential for developing different types of tourism, including beach tourism. The potentials and strengths of Co To tourism are clearly shown through the attractiveness of the clear water beaches, the laid-back beaches associated with intact preserved tropical ecosystems with wild beauty. Co To is also considered as the leading biodiversity area in Vietnam with the presence of many typical ecosystems of tropical waters, including a concentrated coral reef ecosystem. This is also rich in seafood structure with many rare and high-value varieties such as lobster, abalone, sea cucumber, sea urchin, crab, grouper, squid, horn coral.

2.2. Data and research methods

Holiday Climate Index (HCI) is used to determine the relationship between climate factors and tourism activities on Co To Island. The word "vacation" refers to the outdoor tourism activities of tourists. Because tourism activities take place in the daytime and the decrease in temperature at night (amplitude of temperature fluctuation of day and night reaches 4.5°C) as well as the strong influence of the beach climate, HCI is ignored the nighttime heat factor. HCI focuses on three main factors: (1) Thermal comfort (correlation between maximum air temperature and minimum relative humidity); (2) Aesthetics (reflected by the clouds in the sky); (3) Physical properties (reflected by precipitation and wind speed). The relationship between climate and tourism is quantified by the formula:

$$HCI = 4 * TC + 2 * Cs + 3 * P + W \quad (1)$$

In which: HCI: Holiday climate index (%), TC: Thermal comfort (oC), Cs: Clouds (%), P: Precipitation (mm), W: Wind speed (m/s).

HCI does not place too much emphasis on the heat component because it will ignore the impact of other climatic factors on tourism such as clouds, precipitation, or excessive disparity between those factors. Variable TC is calculated according to the effective temperature (Effective Temperature-ET), which establishes the same state relationship of the human ability to regulate temperature (ability to feel hot, cold) and ambient temperature, humidity. ET index may help to determine the effective temperature that humans perceive as well as determine the heat exchange between humans and the surrounding environment. Under normal atmospheric pressure, normal human body temperature (37°C), the calculation of ET is reflected by formula 2-suggested by Houghton and Yaglou (1923):

$$ET = Ta - 0.4(Ta - 10) * (1 - Rh/100) \quad (2)$$

In which: ET-Effective temperature (°C), Ta-air temperature (°C), Rh-relative humidity (%). However, because the annual temperature fluctuation range in Co To is quite large (13.4°C), at the same time, it is strongly influenced by the northeast monsoon (from November of the previous year to February of the following year), ET is calculated according to the index of Missenard (1933):

$$ET = 37 - (37 - Ta)/(0.68 - 0.0014 * Rh + 1/(1{,}76 + 1.4 * V0.75)) - 0.29 * Ta * (1 - Rh/100) \quad (3)$$

Each climate variable in HCI is assessed on a scale of 0-10 and HCI scores from 0 to 100 points (Tables 1 and 2). At the same time, to divide the HCI data into groups, while minimizing the difference within a group and maximizing the difference between groups, the article used the method of classifying Natural Breaks according to Jenks's optimization defaulted in ArcView software (Table 2).

Table 1: Classification of variables in HCI

Rating	TC (°C)	P (mm)	Cloud Amounts (%)	Wind Speed (m/s)
10	23–25	0	11–20	0.2-2.6
9	20-22 26	< 3	1-10 21–30	2.7-5.3
8	27–28	3 - 5	0 31–40	0 5.6-8.1
7	18-19 29–30		41–50	
6	15-17 31–32		51-60	8.3-10.8
5	11-14 33–34	6 - 8	61-70	
4	7-10 35–36		71-80	
3	0–6		81-90	11.1-13.6
2	-5 - -1 37–39	9 - 12	>90	
1	< -5			
0	> 39	> 12		13.9-19.5
-1		> 25		
-10				>19.5

Table 2: Rating categories of HCI

TCI score	Descriptive category	Classification
90 - 100	Ideal	High advantage
80 - 89	Excellent	
70 - 79	Very good	
60 - 69	Good	Advantage
50 - 59	Acceptable	Low advantage
40 - 49	Marginal	
10 - 39	Unacceptable	
0 – 9	Dangerous	

3. Results

Based on a series of data over 20 years (1998-2018) of meteorological l factors (maximum temperature, minimum warmth, clouds, and wind speed) of co to the meteorological station, in combination with other calculation Eqs. 1-3, HCI results are as follows (Table 3).

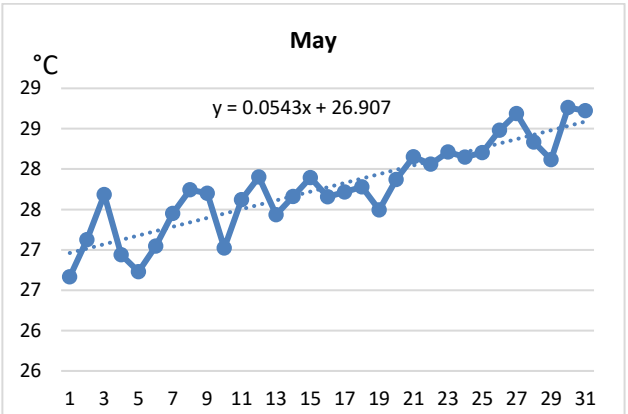
HCI on Co To Island is a sinusoidal chart, strongly differentiating between days of the month, between months of the year, reaching maximum in April (84%), and October (90%), minimum in January (33 %) and July (38%). Through calculation results, it is confirmed that tourism on Co To Island is strongly influenced by climatic factors.

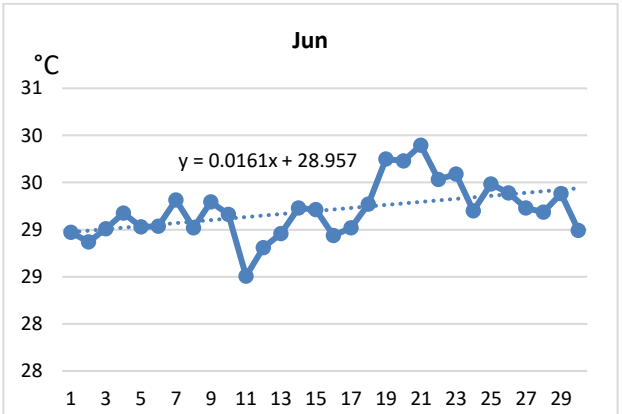
Table 3: HCI on Co To Island

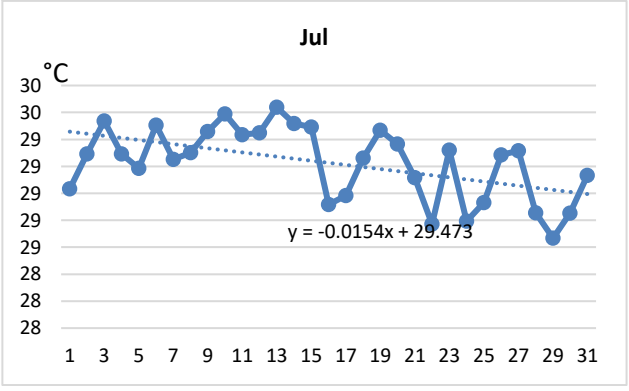
Date	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1	62	58	70	80	55	74	44	47	49	81	80	70
2	66	58	70	74	76	75	51	47	48	70	53	45
3	66	58	70	61	76	55	44	42	48	59	66	63
4	60	46	72	82	70	47	47	47	48	53	49	67
5	62	58	80	80	82	44	44	47	48	57	57	66
6	62	66	78	82	76	47	54	44	46	56	65	58
7	60	60	70	73	57	42	47	48	57	58	63	64
8	58	60	70	78	51	45	47	47	51	57	72	49
9	58	60	61	84	51	42	47	47	49	59	84	52
10	57	60	70	82	51	40	68	47	48	86	64	61
11	55	58	56	82	78	62	45	46	48	74	57	58
12	55	56	68	76	55	49	45	45	48	77	73	61
13	60	56	68	69	51	51	47	51	51	66	76	64
14	60	62	68	57	72	51	44	49	62	54	81	61
15	54	62	78	82	51	71	47	45	53	67	68	62
16	60	62	76	81	66	49	49	46	52	65	72	59
17	60	62	73	81	51	45	45	49	55	90	74	63
18	57	62	66	84	61	45	45	48	61	87	72	66
19	58	62	75	82	49	47	45	47	76	61	70	47
20	58	60	78	53	51	69	45	49	55	61	72	68
21	55	62	78	70	73	66	45	46	77	79	72	63
22	55	62	75	57	57	45	46	73	52	87	60	68
23	49	62	76	84	66	45	44	53	52	80	69	56
24	58	60	66	81	51	42	49	53	53	78	70	68
25	55	59	76	59	57	69	49	46	53	59	60	66
26	55	62	78	72	57	51	44	44	53	72	64	61
27	35	62	78	63	53	42	42	47	53	85	52	48
28	33	60	78	54	66	42	46	51	70	67	70	57
29	58	60	66	77	51	44	49	51	52	58	67	60
30	58		75	80	73	44	48	53	50	85	70	54
31	60		67		75		38	40		52		53

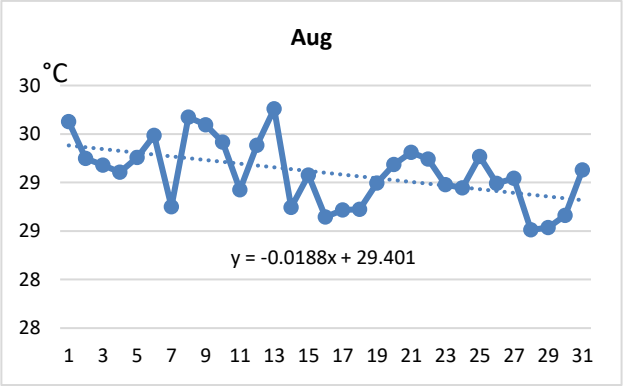
High advantage — Ideal, Excellent, Very good — Advantage — Good — Low advantage — Acceptable, Marginal, Unacceptable

HCI achieved from May to September is not high, classified as less favorable for tourism activities. During this time, the ET value gradually increases from May (27.6°C) to August (29.8°C), in the human heat sensation level from hot to very hot (Fig. 1), High humidity (75-78%) causes discomfort, fatigue in the human body, reduces the need to travel as well as participate in travel activities.









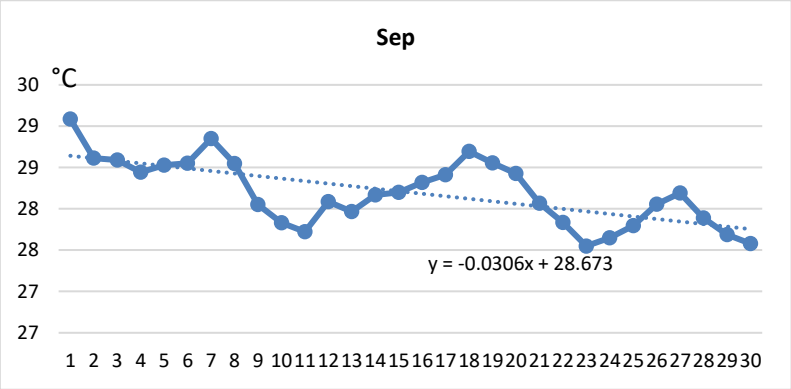
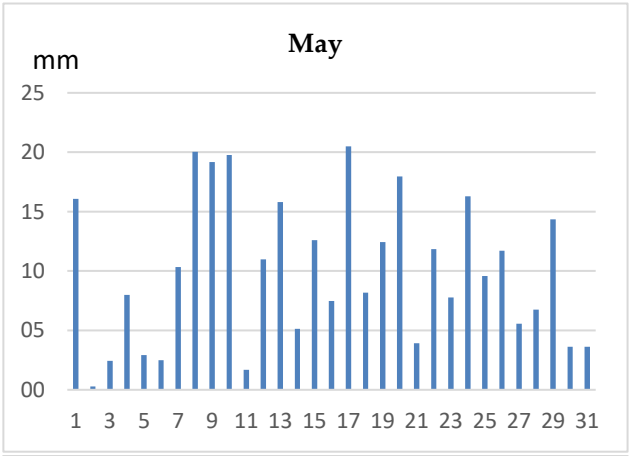
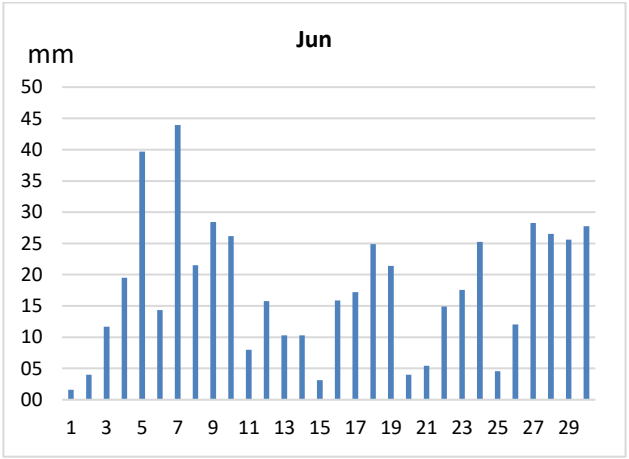


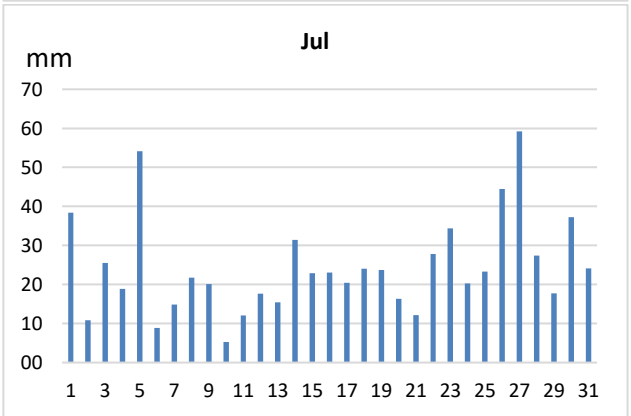
Fig. 1: ET calculation results for May to September

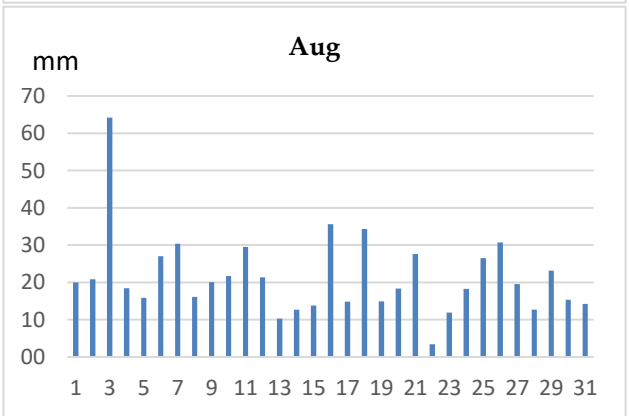
In May, Co To still has cool spring weather, but there are days when the temperature is high and rain appears to show that summer is coming; In June and August, the discomfort is higher because most days of ET month reach between 28.7°C-29.8°C, humidity 78%. Fig. 2 shows total daily precipitation from May to August.

Besides, Co To regularly receives storms in July and August. According to statistics, in the period 1998-2017, on average, there were 3-4 storms in Quang Ninh province, including Co To. The storms usually caused very heavy rain for 3-4 days, sometimes up to 6-7 days (Fig. 2). The appearance of storms not only directly affects tourism activities in general but also the health of tourists related to 03 weather conditions: Before a storm, during a storm, and after a storm. Before the storm, the human body feels hot, uncomfortable, and drowsy due to high temperature, high humidity, no wind, and decreased cloud volume. This sensation persists over 1-2 days leading to a decrease in energy to participate in travel activities that take place directly outdoors due to a disturbance in temperature regulation function. During and after a storm, it not only directly affects the organization of tourism activities, tourism infrastructure, and technical materials but also causes a sudden drop in atmospheric pressure, a rapid increase in winds and clouds with heavy rain for 3-4 days leading to biological response, climate, tourists' psychology. That leads to a great seasonality in tourism in Co To.









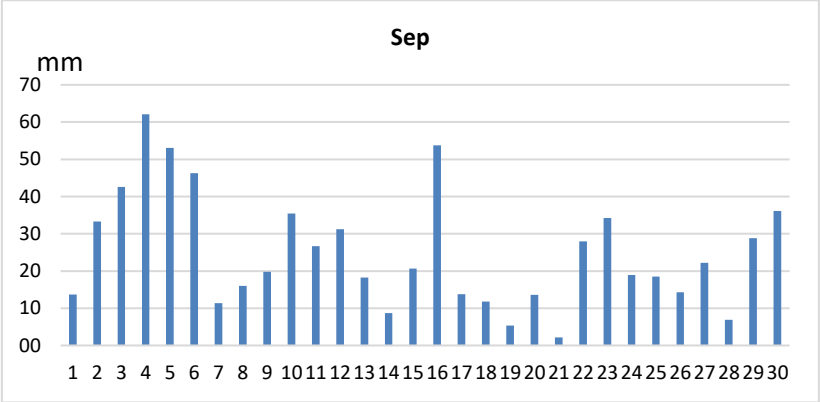


Fig. 2: Total daily precipitation from May to August

In fact, this is the period when tourism activities take place strongly on Co To Island. The reasons for the difference between the reality and the research results are explored by the research team based on tourism statistics in 2018, 2019 of the People's Committee of Co To district. The results showed that there is a difference in the choice of time to travel in Co To between international and domestic tourists. The international tourist market in Co To is mainly from Asia (49.3%), Europe (13.6%), America (5.9%) from November of the previous year to April of the following year. Contrary to international tourists, the domestic tourist market is mainly cadres, students, and workers from tourism centers in the Red River Delta tourist area from April to September, when tourism activities on Co To Island are taking place quite strongly. This shows a clear divergence in tourism season between international tourists and domestic tourists, depending mainly on subjective decisions in the choice of destination and destination time of tourists. However, it cannot be denied that in the summer months, the total cloud volume on Co To Island is moderate, not too much, the highest monthly average cloud amount reaches 7.8/10 of the sky and S, SE wind is active in this period, the wind speed ranges from 2.9 to 5.7 m/s, which is considered good for human health. Fig. 3 shows ET calculation results in March-April, October–November.

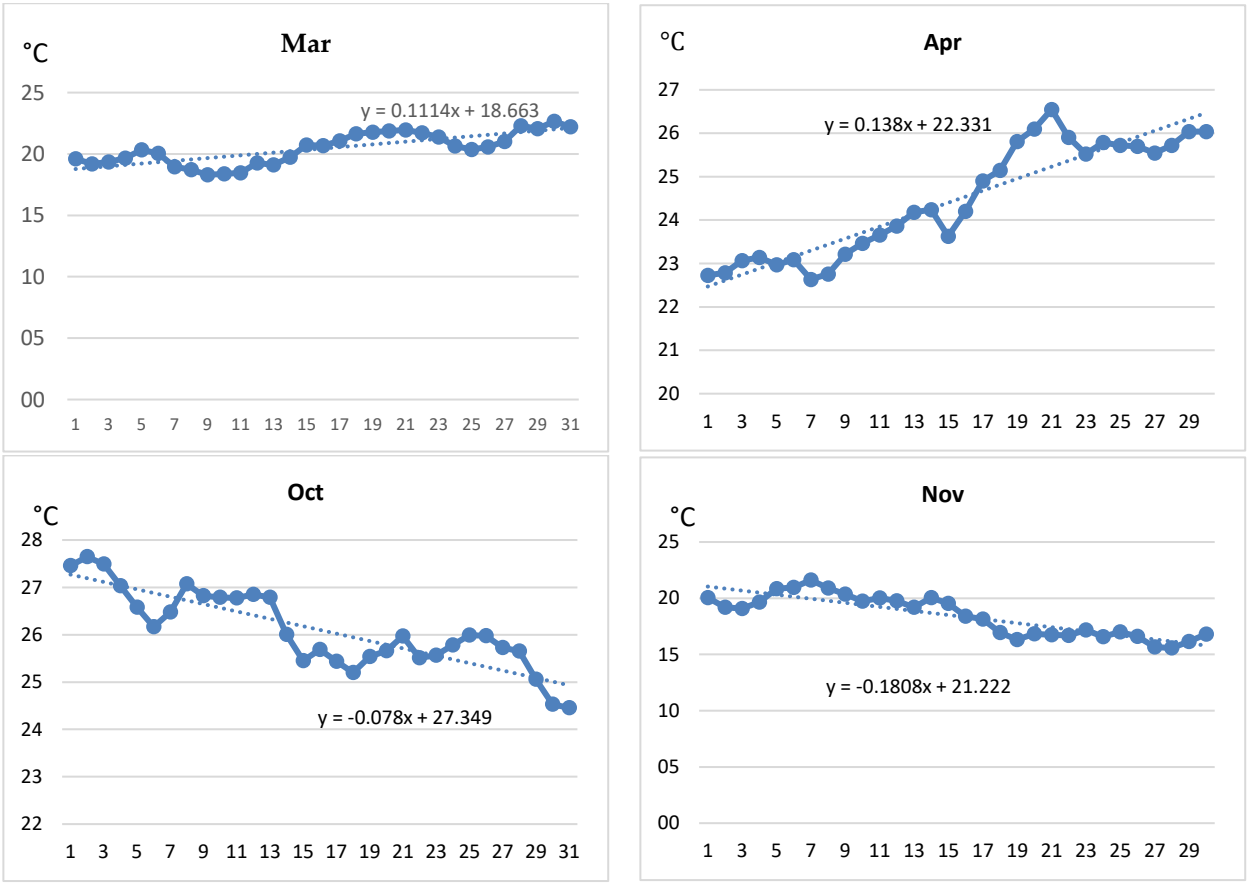


Fig. 3: ET calculation results in March-April, October-November

Most of the time in March-April, October-November, HCI is ideal for tourism activities on Co To Island. ET value ranges from 16°C-27°C, people feel cool and comfortable due to the drop in

temperature as well as humidity, combined with light wind, facilitating strong evaporation (Fig. 3). This is a favorable condition for the heat exchange process between the human body and the surrounding environment, then outdoor activities become more comfortable. During this period, the precipitation in Co To is not great, the wind is light, the radiation is not too great, so it is very convenient for tourism activities on the Island. Fig. 4 shows ET calculation results in December, January-February.

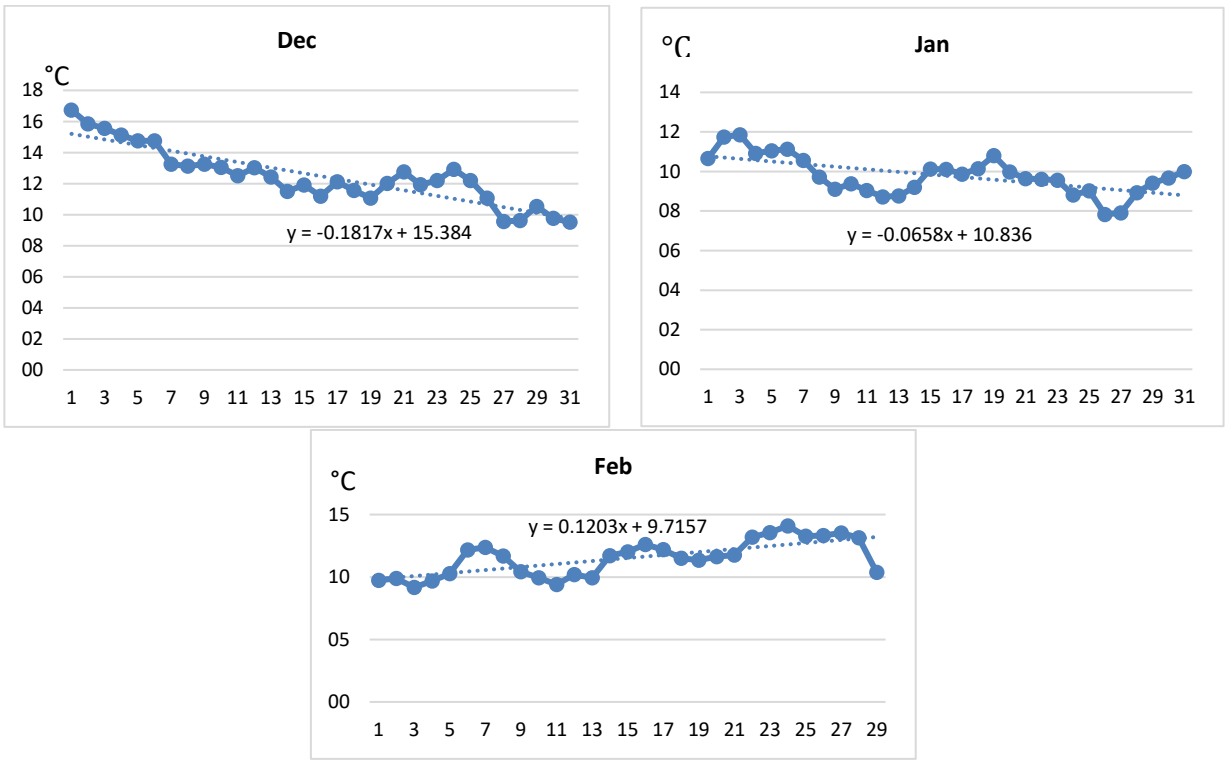


Fig. 4: ET calculation results in December, January-February

For the rest of the year (January, February, December), HCI is classified as favorable for tourism, but the number of days in a month to be rated as good is not much, even some days are completely unsuitable for traveling activities (HCI is 38%). ET value achieves at a low level, the highest is 16.7°C, so the human heat sensation threshold is in a cold and very cold state (Fig. 4). The overall amount of clouds is high and is influenced by the northeast monsoon denatured with the pattern of prolonged small rains, causing humidity in the air, limiting the process of evaporation in the human body, hindering human activities.

To determine the reliability of the method used in the study as well as to confirm the influence of climate factors on tourism, the research team has compared the results of the calculation of the tourism climate index on Co To Island, following the model of Mieszkin (1985) (Tourism Climate Index-TCI), implemented by Nguyen et al. (2020). The results show that both methods have the similarity of favorable times for tourism activities on Co To Island, focusing on March, April, October, and November as well as the unfavorable time for tourism activities from May to September. The results also show that heat-humidity and precipitation factors not only directly affect tourism activities on Co To Island but also affect the health of tourists. That is an important factor in the decision-making process to choose a tourist destination and time.

4. Discussion and conclusion

Tourism has significantly contributed to the economic development of Co To Island. However, tourism on Co To Island depends a lot on the climate conditions on the Island. Calculation results by HCI index and comparison with TCI calculation results on Co To Island express the general influence of climate factors on tourism. However, compared to other factors, humidity and precipitation factors have the most influence. March, April, October, and November are evaluated to be very favorable for tourism activities on the Island, and in this period, the threshold of feeling the heat, precipitation, clouds, and wind speed is assessed to have a good effect on the human health in general and tourists on Co To Island in particular. Due to high temperature, high humidity, storms, and heavy rain, the months from May to September are not favorable for tourism activities. The results are a reference for tourists in making decisions on the travel time. At the same time, it is a reference for managers and organizations in the development of climate-suitable tourism types on Co To Island.

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Compliance with ethical standards

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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