The impact of climate change on the outdoor tourism with a focus on the outdoor tourism climate index (OTCI) in Hormozgan province, Iran

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Abstract
The aim of this study was to investigate the effects of climate change on the climate condition of outdoor tourists in Hormozgan province, Iran, through Outdoor Tourism Climate Index (OTCI). For this purpose, the data pertaining to 7 weather stations as well as 2 global climate models (GCMs) under 2.6 and 8.5 Representative Concentration Pathways (RCP) were applied. GCMs were statistically downscaled by the change factor (CF) approach. The findings illuminated that, based on OTCI, December, January, February, and March were regarded as the optimal months for the outdoor tourism activities. Nevertheless, for the concerned months, the range of OTCI score in twenty-first century is changing from 2 to −12 regarding the base period (1980–2010). Mostly, the changes in OTCI score is predicted to occur at March, April, May, October, and November, whereas June would record the least. Moreover, Hajiabad and Kish stations in the North and South of the under-study area would encounter the most and least changes, respectively, in the future.

1 Introduction
Climate enjoys a pivotal contribution to tourism decision-makings, travel patterns, costs, and the overall holiday satisfaction (Scott et al. 2012a; Scott and Lemieux 2010). Any changes in climate and environment would inevitably affect tourism sector (Becken and Hay 2007; de Freitas et al. 2008; Kaján and Saarinen 2013; Scott et al. 2012b). Therefore, in recent decades, climate change is considered as the most crucial challenge for tourism, especially regarding the nature-based and outdoor tourism, leading to opportunities and threats (Kaján and Saarinen 2013). Although there is an ample literature focusing mainly on the impact of climate change on winter tourism, glacier landscape, sea, and sand tourism, publications are limited in less developed countries and the study area. These studies indicate that the impact of climate change on tourism sector is complicated due to the aesthetic and physiologic (human comfort) aspects as well as the season changes. The impacts of climate change have been assessed throughout the changes within the essential physical conditions for tourists, applying tourism climate indices for the appeal of tourists’ destinations, and also, throughout modeling tourism demand based on the climate determinant (Rosselló-Nadal 2014).

Some indices have been designed in order to determine the climate comfort of tourists, and to examine the relationship between the qualities of destinations climate in the tourism process. The most widely used index in this context is Tourism Climate Index (TCI), presented by Mieczkowski (1985), and applied in enormous researches regarding the climate change impacts (e.g., Amelung and Nicholls 2014; Yazdanpanah et al. 2016; Scott et al. 2016). Moreover, Outdoor Climate index (OTCI) has been developed by Valizadeh and Khoorani (2020) in order to eliminate the demerits of former indices. OTCI removes the time restriction (utilizing monthly, daily, and hourly data) of previous indices, taking into consideration the negative scores of physical factors, such as wind and precipitation, applying the percentage of cloudiness instead of the sunshine hours, accounting for the adaptation between the travel origin and the destinations climate, and taking into account the purpose of travel.

Owing to the geographical coordination, adjacency to the Persian Gulf and Oman Sea, proximity to Zagros Mountain chain, having charming islands, geologic landforms, unique ecology, and cultural and historical attractions, Hormozgan
province has a high potential for tourism activities. The contribution of tourism to the province’s economic growth is positive, ranking the eighth among 31 of Iran’s provinces (Habibi et al. 2018). Before the COVID-19 pandemic, more than 4.5 million tourists visited Hormozgan province per year, aiming to reach 10 million tourists per year.

Observations from previous decades indicate temperature changes (maximum, minimum, and mean) and precipitation over the study area, including an increase in temperature and a decrease in precipitation (Sharafi and Mir Karim 2020; Ghasemi 2015). It is projected that these changes will strengthen till the end of the twenty-first century (Mansouri Daneshvar et al. 2019; Parandin et al. 2019, Khoorani and Monjazeb Marvdasht 2014); an increase in extreme temperature and precipitation events is projected as well (Vaghef Monjazeb Marvdasht 2014); an increase in extreme temperature and precipitation events is projected as well (Vaghef et al. 2019; Molodi et al. 2016). Nevertheless, there were a limited number of references with regard to the impact of climate change on the tourism climatology of the study area. Khoorani and Marvdashti (2014) evaluated the impacts of climate change on Hengam island tourism based on the regression methods through the HADCM3 model for the period of 2010–2040. The study reported an increase in summer and autumn and a decrease in spring and winter visitors of the island. Karimi et al. (2017) found similar results for the thermal, physical, and aesthetics aspects of the tourism in Khalij-e-Fars shoreline for the period of 1979–2008. Accordingly, the present study attempts to enhance the impacts of climate change on the tourism climate in Hormozgan province, Iran, via OTCI.

2 Method

2.1 Study area

Hormozgan province is located in the South of Iran, the North of Hormoz Strait, with geographical coordinates between 25° 23′ to 28° 57′ N and 52° 41′ and 59° and 15′ E. The boundaries of the province lie on the Oman Sea from the East to the Persian Gulf on the West (Fig. 1).

Due to the natural and cultural attractions such as geographical location, landscapes, moderate weather in the autumn and winter, sandy and rocky beaches, the islands with special ecosystems, mangrove forests, and salt domes, Hormozgan province is regarded as one of the most crucial areas of coastal and outdoor tourism at the national and international scales.

The study area has an arid climate. Although the amount of precipitation is low (168 mm), the variance is high. The mean relative humidity of the coastal area is 60–70% during different months and sometimes it reaches to 100%. The temperature hardly ever exceeds 42 °C in the summer and the mean temperature is about 27 °C.

2.2 Materials and procedures

The required data include maximum, minimum, and mean temperature; mean humidity, cloudiness percentage, total precipitation, and average wind speed were obtained from Bandar Lengeh, Bastak, Bandar Abbas, Minab, Jask, Hajjabad, and Kish weather stations from 1980 to 2010 in a monthly time scale. The data obtained from Iranian Meteorological Organization (IRIMO) and did not contain any missing sectors. The OTCI was calculated according to Valizadeh and Khoorani (2020). Furthermore, in order to evaluate the climate change induced through variation and changes, the index was calculated for the periods of 2010–2040, 2040–2070, and 2070–2100 via two climatic models of CMIP5 (BCC-CSM1.1 and BNU-ESM) based on two Representative Concentration Pathways (RCP2.6 and RCP8.5). General Circulation Models (GCMs) are three-dimensional and they are the most important widely used models for projecting the future climate and the climate change phenomenon.

2.3 Downscaling GCM outputs

Downscaling methods are used in order to use GCM outputs in a local scale. Change factor (CF) or delta method is one of the simplest and widely used statistical downscaling approach. This method is a ratio between GCM outputs and observed climate applied as a multiplicative factor to obtain the local and site scale climate. The CF downscaling methods are utilized based on the following equation:

\[
X'_O = X_{CF}(X_O), X_{CF} \text{calibrated on } X_M \text{ and } X'_M
\]

where \(X_O\) is the observational data climatic variable for the baseline period; \(X'_O\) is the future projection; \(X_{CF}\) is the statistical transformation functions for the CF-based method (mean-based method is used here); \(X_M\) and \(X'_M\) are the model simulations of this variable for the baseline and future periods, respectively (Wang et al. 2016; Trzaska and Schnarr; 2014; Prudhomme et al. 2002; Fowler et al. 2007).

2.4 Outdoor Tourism Climate Index (OTCI)

Outdoor Tourism Climate Index studies the relationship between the quality of the climate in an area and the outdoor tourists’ comfort and satisfaction. OTCI evaluates the quality of the climatic characteristics relevant to the outdoor tourism
Table 1 shows the main factors and variables of OTCI contain thermal comfort (CID and CIA), beauty (Cl), physical (Pr and Wi), similarity to the destination’s climate (AET), and degree of adaptation destination/purpose (Ap).

Generally, this index indicates whether or not the mixture of different climatic characteristics and their similarity to the climate of the travel origin as well as the purpose of travel are suitable for travelers. Although OTCI can extract in daily, monthly, and annual time scales, this research is extracted in monthly and annual time scales. This index is computed as:

\[
\text{OTCI} = 8\text{CID} + \text{CIA} + \text{Pr} + \text{Cl} + \text{Wi} + \text{A}_{\text{ET}} + 3\text{Ap}
\]  

where, \(\text{CID} \) and \(\text{CIA} \) are the values of sequence \(i \) and \(j \); \(n \) is the length of the time series and:

\[
\text{sgn} (x_j - x_i) = \begin{cases} 
+1 & \text{if } (x_j - x_i) > 0 \\
0 & \text{if } (x_j - x_i) = 0 \\
-1 & \text{if } (x_j - x_i) < 0 
\end{cases}
\]

The range of this index varies from −43 to 100. Similar to the Tourism Climate Index (TCI), each variable of OTCI is defined based on literature review and the author’s expert views.

### 2.5 Mann–Kendall (MK) trend test

The non-parametric Mann–Kendall (MK) test reveals increasing or decreasing trends (monotonic) in a time series (Mann 1945; Kendall 1957). For MK test, \(H_0\) indicates that the series is independently distributed, and the \(H_1\) implies the existence of a monotonic trend. The MK test statistic is given as:

\[
s = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} \text{sgn} (x_j - x_i)
\]  

were, \(X_i\) and \(X_j\) are the values of sequence \(i\) and \(j\); \(n\) is the length of the time series and:

\[
\text{sgn} (x_j - x_i) = \begin{cases} 
+1 & \text{if } (x_j - x_i) > 0 \\
0 & \text{if } (x_j - x_i) = 0 \\
-1 & \text{if } (x_j - x_i) < 0 
\end{cases}
\]

The mean and the variance of \(S\) is written as:

\[
E[s] = 0
\]  

\[
\text{Var}[s] = \frac{n(n - 1)(2n + 5)}{18} - \sum_{i=1}^{p} T_i(i - 1)(2i + 5)
\]  

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**Fig. 1** Geographical location of the study area (Bandarelangeh, Bastak, Bandar Abbas, Minab, Jask, Hajiabad, and Kish weather stations, Hormozgan province, Iran)
In this equation, \( Ti \) indicates the number of data in the tied group and \( p \) is the number of groups of tied ranks. Finally, \( ZMK \) is calculated as:

\[
Z_{MK} = \begin{cases} 
\frac{s-1}{\sqrt{\text{Var}(s)}} & (s > 0) \\
0 & (s = 0) \\
\frac{s+1}{\sqrt{\text{Var}(s)}} & (s < 0)
\end{cases}
\] (6)

When the absolute value of \( Z \) is larger than the theoretical, the H0 is rejected and will conclude that the data have a certain trend.

To compare the mean OTCI values for Hajiabad station with the mean value of other stations, \( T \)-test was used that is a statistical test to compare or to determining the difference in one continuous variable between two groups of data.

3 Results

Temperature and humidity are the main climatic factors affecting the climate comfort of human, and are applied in tourism climate indices like TCI and OTCI. Based on the Mann–Kendall trend test (Table 1), a positive significant trend is determined for the annual temperature values in the base period (1980–2006) as well as for February, March, April, May, Jun, September, and October. In addition, based on RCP 2.6 annual, April, May, Jun, August, and September show positive significant trends in the temperature for the future period. Also, RCP 8.5 annual and all the months indicate a positive trend in temperature values for the future period.

No significant trend is recognizable in the base period as well as in the projected values of relative humidity for the future period based on RCP 2.6; however, RCP 8.5 illustrates a positive trend for annual and all months except for March (Table 2) in this period.

Based on OTCI (Fig. 2), two distinct seasons are distinguishable for the stations. The first season contains January, February, December, and November with the average OTCI of 87.22. The second season contains May, June, July, August, and September with the average OTCI of 44.56. Shifting from the first season to the second takes only 1 month (October), while changing the second season to the first lasts 2 months (March & April).

For February, the range of OTCI \((\text{OTCImax-OTCImin})\) of all the stations is minimum (Hajiabad = 92, Bandar Lengeh and Minab = 90). In contrast, the maximum range amount is for November, i.e., Hajiabad OTCI = 90 and Bastak and Kish = 70.

Projected OTCI values for the future periods are illustrated in Fig. 3 based on RCP2.6 and RCP8.5. According to RCP 2.6 (Fig. 3a), it is obvious that there is no distinct difference between OTCI values for the three different future periods (near future, middle future, and far future). Furthermore, OTCI scores would be more than the base period in June, July, August, and January, while almost the same in September. Therefore, based on RCP 2.6, the climate condition of tourists would improve a little in these months, but would worsen in the other ones. The maximum projected increase of OTCI score based on RCP2.6 was recorded in June (1.8 OTCI unit) for the near future and the maximum projected decrease dealt with May (6.3 OTCI unit) for the near future.

| weight Final | Coefficients | Weight | Symbol | Factor |
|--------------|--------------|--------|--------|--------|
| \(-24-+40\) | 8            | \(-3-+5\) | Monthly | CID    | Thermal comfort |
| \(-3-+5\)   | 1            | \(-3-+5\) |       | CIA    |                   |
| 0-+10       | 1            | 0-+10  |       | Cl     | Beauty            |
| \(-10-+10\) | 1            | \(-10-+10\) | Total precipitation | Pr     | Physical          |
| \(-10-+10\) | 1            | \(-10-+10\) | Mean daily wind speed per month | Wi     |                   |
| +1-+10      | 1            | +1-+10  | Mean temp/humid of travel origin and destination | \(A_{ET}\) | Similarity to the destination’s climate |
| +3-+15      | 3            | +1-+5   | Descriptive | \(A_p\) | Degree of adaptation destination/purpose |

Table 1 Factors and variables used in OTCI (Valizade and Khoorani 2020)
Based on RCP8.5 (Fig. 3b), the projected OTCI values would increase in June, July, and August for the near future, and in June for the far future. The projected OTCI value of June for the far future indicated no changes compared to the base period. The OTCI values would reduce in the other months revealing that, based on RCP 8.5, the climate condition for the tourism would degrade compared to the base period. The maximum increase in the OTCI values based on such a scenario is related to June (1.8 unit) for the near future. While the maximum decrease in the OTCI scores (using RCP 8.5) compared to the base period is 7.2 in May for the near future, it is projected to be 14 units in April for the far future.

A comparison between Figs. 2 and 4 reveals that the projected OTCI values contained similar seasonal patterns as the base period. Based on both RCP, the range (OTCI_max-OTCI_min) of the projected values would increase regarding the base period. Exception pertained to May, Aug, and Sep (Feb and March) for RCP8.5 (RCP2.6) where the projected values were slightly less than the based-period value. Similar to the base period, the projected OTCI values of Hajiabad station under both RCP indicated higher values than the other stations all over the year except for May. Accordingly, the climate conditions of the outdoor tourists would increase in the future for Hajiabad in comparison with the other stations. The minimum projected difference between OTCI_max and OTCI_min was 2.67 and 3 for 2.6 and 8.5 RCP, respectively, in February. The maximum projected range of OTCI values based on RCP2.6 and RCP8.5 pertained to October and November yielding 24.65 and 25.83, respectively.

### 4 Discussion

The findings from this study suggested that tourism climate of Hormozgan province, Iran, may be affected by climate change. Outdoor Tourism Climate Index (OTCI) is a newly developed index for investigating the climate condition of the outdoor tourists. Considering the similarity of the travel origin and the destination climate, the purpose of travel as

| Annual | Des | Nov | Oct | Sep | Aug | Jul | Jun | May | Apr | Mar | Feb | Jan |
|--------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| +      | o   | o   | +   | o   | o   | +   | +   | +   | +   | +   | +   | o   |
| +      | o   | o   | o   | o   | o   | +   | +   | +   | +   | +   | +   | o   |
| +      | +   | +   | +   | +   | +   | +   | +   | +   | +   | +   | +   | o   |
| o      | o   | o   | o   | o   | o   | o   | o   | o   | o   | o   | o   | o   |
| +      | +   | +   | +   | +   | +   | +   | +   | +   | +   | +   | +   | o   |

+ (positive significant trend)
0 (no significant trend)
Temperature and humidity are the most crucial factors in the human thermal comfort taken into account in the effective temperature (ET) index. Annual temperature alterations in Hormozgan province were statistically significant (using Mann–Kendall test) not only in the base period, but also in the projected values for the future periods under RCP 2.6 and RCP 8.5. Therefore, the changes in the annual relative humidity were only significant for the future period under RCP 8.5. Khoorani and Marvdashti (2014), Köberl et al. (2016), Førland et al. (2013), and Dube and Nhamo (2018) have reported the same findings on the temperature changes up to the end of the century.

Seasonal shifts and variations are of the common impacts of climate change in the tourism sector. The projected values of OTCI compared to the base period values illuminated a slight increase in the summer and a decrease in the autumn and winter. Indeed, such kinds of changes are inevitable for tourism planning and management in Hormozgan province. Since the low tourism season of Hormozgan province coincides with the warm months (April–August), this change can have a positive effect on the tourism climate of the region.

While the OTCI score of 60 separates the good and acceptable climatic conditions of the outdoor tourism (Valizadeh and Khoorani 2020), based on RCP 8.5 (Fig. 4b), a 60-day decrease in good and excellent conditions of the outdoor tourism would be projected for Hormozgan province up to 2100. This result can be congruent with Amelung and Nicholls (2014), Karimi et al. (2017), Amelung et al. (2007), and Yazdanpanah et al. (2016).
According to OTCI, all the investigated climate stations were homogeneous with regard to the annual and monthly timescales. Although the projected OTCI values for Hajiabad seem different from the others, and reveal a noticeable range in November, October, and May, it is not statistically significant (based on \( T \)-test) at 0.05 level. The difference is probably due to its distance from the sea compared to the other stations with less relative humidity and more elevation from the sea level.

5 Conclusion

Overall, this research utilizes OTCI to assess the impacts of climate change on the outdoor tourism climatology in Hormozgan province, Iran. The research also points to detect the trends in the most influencing climate parameters in human thermal comfort (temperature and relative humidity) and the seasonal changes in the tourism climate of the study area based on OTCI.

It must be borne in mind that this study was only conducted on the part of southern Iran and includes a limited number of weather stations (7 stations). Further research is needed to reveal the performance of OTCI in different regions with different climates. It is also recommended to use an ensemble of GCMs in future studies to reduce the uncertainty of climate model outputs.

**Author contribution** Two authors contributed to this paper (Mansour Valizadeh; Asadollah Khoorani). It is mentioned in the contribution section of the manuscript. MV calculated and interpreted OTCI and AK analyzed the data and was a major contributor in writing the manuscript. All authors read and approved the final manuscript.

**Data availability** The data and materials are clarified in the material and methods section of the manuscript. Data will be made available on reasonable request.
Code availability All custom codes are available.

Declarations

Ethics approval Not applicable.

Consent to participate All authors agree to participate, submit, and publish the paper.

Consent for publication All authors agree to submit and publish the paper.

Conflict of interest The authors declare no competing interests.

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