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A metric-based assessment of climate and tourism in major cities of Pakistan

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Abstract

Tourism plays an essential role in the economic development of a country and has become a growing phenomenon of global importance. The climate change on the other hand has a direct effect and degrades the environmental components and features of the destinations. Pakistan is highly vulnerable to changing the climate which has threatened the tourism sector. The study has emphasized on the significance of the climate in the tourism industry by using the Tourism Climate Index (TCI) which highlights suitable regions and seasons. TCI has been used worldwide to enumerate the impacts of climate change on tourism and tourist destinations. The current study calculates the TCI for four cities of Pakistan, chosen by public opinion. For measuring the index, climatic data of twenty-one years (1997–2017) were taken from the Pakistan Meteorological Department, which include temperature, precipitation, sunshine hours, humidity and wind speed. The results showed that among the seasonal distribution, autumn and spring are good seasons for tourism. Climatic suitability in summer was not favorable for Lahore and Islamabad because of high rainfall and lower thermal comfort. A rapid change in the Annual TCI score was observed and investigated through the contribution of TCI components which happens to be the core reason for the change. Analysis has shown that 75% of the study area as a Bi-modal shoulder peak and 25% as a winter peak. For city Lahore, a maximum number of months were observed as "Excellent" and "Good" for tourism due to a high TCI score. Furthermore, future projection predicts that tourism in Lahore will be highly threatened due to rapidly changing climate. Government and tourism stakeholders should conduct such relevant studies at large scale for a better understanding of favorable and unsuitable tourist destinations across Pakistan.

Keywords Climate change · Tourism climate index · Climate suitability · Pakistan

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1 Introduction

Tourism is a crucial factor in the economic growth of a country. It benefits the society and the people by providing more job opportunities with the involvement of 319 million people worldwide and accounts for 10.4% of the World's Gross Domestic Product (GDP) (WTTC 2019). In 2019 International tourist arrivals have reached a total of 1.5 billion worldwide with the growth of 4% (UNWTO 2020). Tourism has become the fastest and largest economic sector in the world. World export in goods and services now represents a 7% share of international tourism that was 6% back in 2016. The year of 2017 was declared as the International Year of Sustainable Tourism for Development. The long-term forecast report suggests that International tourist arrivals between 2010 and 2030 are expected to increase by 3.3% per year to reach 1.8 billion. The market share of the emerging economies increased by 45% in 2016 and is expected to reach 57% by 2030 (UNWTO 2017). The international arrival of tourists is more in developed countries. Asia and the Pacific are also the fast-growing regions with 308 million international tourist arrivals in 2016 (UNWTO 2017). Tourism and climate change are in a two-way relationship as tourism is sensitive to climate change and the contributor to the climate change through different activities of the tourists (Ullah and Takkaki 2016) as about 5% of global CO_2 is emitting from different tourism-related activities (Michailidou et al. 2016). This is how tourism is affecting environmental resources and resulting in large-scale degradation.

Natural resources, aquatic bodies, and climate are the three most important traits in the decision-making process of tourism (Pongkijvorasin and Chotiyaputta 2013). Climate change influences the decision and selection of the destination and attractiveness of the site (Scott and Lemieux 2010). On the other hand, Climate change is also considered the main challenge for the tourism industry in the twenty-first century (UNWTO 2008; Rashid and Robinson 2010). Climate change can directly impact the tourism industry as the natural climate and environmental conditions like rainfall, temperature, and snow can change the decision of tourists, durations, and frequencies of the tours (Richardson and Loomis 2004). The demand of destination selection by tourists is connected to the hours of sunlight exposure, snowfall, rainfall, temperature which also refers to the weather comfort. However, the pattern of reduced visits, less economic benefits and less rate of productivity occur in low and uncomfortable seasons (Ridderstaat et al. 2014).

The impact of climate change on tourism of the different areas and regions varies according to the nature of activity these provide (Pongkijvorasin and Chotiyaputta 2013). For instance, rainfall and tourism are inversely proportional to each other; increased rainfall has lessened the number of visitors except for the Kenting National Forest, Taiwan (Liu 2016). The impact of temperature was more varied on visitors. In the Kenting National Park located in the plains and more consistent temperature, the number of tourists increases by 6% with only a 1% increase in temperature. In the case of Yushan National Park of the Taiwan with addition of each degree Celsius, 4% reduction in the number of visitors occurs. Such studies also provide an idea that climate change plays an influential role in the selection of the destination by tourists (Michailidou et al. 2016). The impacts of climate change are diverse and dynamic. Climate change may cause loss of the attractiveness of the destination of a region and may help the other regions to emerge as a priority destination, for example, the number of tourists to the National Parks in Alaska has also increased due to climate change (Liu 2016). And if Europe loses all its snow because of climate change, whereas Switzerland loses half, then Europe will be on a least priority for the destination as compared to Switzerland (Hamilton et al. 2005; Peric et al. 2013).

Pakistan's geostrategic location, varying cultures, and history make it a quiet desirable tourist destination among tourists. The country offers ecotourism, religious tourism, adventure tourism, and archaeological tourism (Arshad et al. 2018). Although Pakistan is a prime example of a country, regardless of its low contribution to global GHGs emissions (0.8 percent annually), is the sixth most vulnerable country to climate change (Akram and Hamid 2015; Shahzad et al. 2019). Tourism contributed 2.9% to Pakistan's GDP in 2017 with an increase of 0.2 units as compare to 2016 and it is expected to increase up to 5.9% in 2018. Tourism is a major contributor to the economy and formed 1,493,000 jobs in 2017 which is 2.5% of total employment (WTTC 2018). Pakistan is ranked as the best-suited country for tourism by the UNWTO (Arshad et al. 2018). Pakistan has main cultural sites includes metropolitan cities, Indus Valley Civilization, Himalayan hill stations, Hunza and Chitral valley (Ali et al. 2017). The tourism industry can also improve the regressive areas of the country, for example 2 million tourists visited the Northern areas of Gilgit-Baltistan in year 2017 (Tariq 2018; Alasttal and Burdey 2017). Pakistan is emerging in the tourism sector, at the same time it is on the verge of the susceptibility to climate change. Developing countries are more vulnerable to climate change in terms of losses, for example, natural hazards like floods, snow melting, and degradation of biodiversity and loss of natural habitats (Ullah and Takkaki 2016).

Pakistan is a quite prone to climate change and research about the destinations and locations affected by the changing weather condition are very limited, so it is essential to study the determination of the suitability of the sites and destinations through TCI. Among all the indices that have been used to measure the favorability and suitability of climate for tourism activities, Tourism climate index is most widely used (Amelung and Nicholls, 2014). TCI comprises climatic variables like temperature, humidity, precipitation, the number of sunshine hours and the wind intensity which have potential to improve or decline the suitability and preferences of a location. Most of the studies found that rainfall is considered a destructive factor in tourism as most of the events are unable to continue in rainy situations (Beckan et al. 2015). TCI has been successfully used to determine climatic compatibility in many countries around the world, including Europe, Iran, China, France, Italy, Georgia, south Caucasus countries and Tbilisi (Roshan et al. 2015). However, use of TCI is Pakistan is limited, during the literature search we rarely find a comprehensive study on the topic. Therefore, it will be the first unique study to highlight the significance of climate change and tourism for a vulnerable country like Pakistan.

The study was carried out with the aim of assessing the effects of climate on the tourism sector by measuring the TCI for four major leisure cities of Pakistan. This study will help to project the trend and pattern in the change of destinations because of the rapidly changing climatic conditions. This study will also provide the efficiency and effectiveness of the Tourism Climate Index (TCI) in Pakistan and the state of destinations that are likely to be affected by the climate change. Tourism is a driving force for the economy of Pakistan. The development in the tourism sector can bring revenue, income, opportunities of employment to the country. The visible threat of climate change to Pakistan requires creative and effective policy and infrastructure in order to combat the potential effects on the tourism sector. The information produced in this study will help to analyze the vulnerability of tourism and extent of climate variability to this significant sector. Moreover, this study outset for future research into the use of the Tourism climate Index for other parts of Pakistan.

2 Methodology

2.1 Selection of Study sites

An opinion-based survey was performed to detect tourists' preferences of location. A total of 500 respondents were randomly selected to provide their choice of the site for recreation and tourism. A 10-item-based questionnaire was used to select the study sites which was circulated through emails, and interviewed face to face in some cases. It was asked from the respondents to name the sites of their tourist interest on a likert-scale of 1 to 5; 1 indicates a site of low choice and 5 high choice. Respondents were quite inclined towards locations with hilly and green open areas, metropolitan cities and cities with more cultural and historical value. The responses to questionnaire helped in shortlisting of 7 sites for assessing the relation of tourism and climate change in Pakistan. Out of those 7 sites, four sites were selected based on the availability of meteorological and sunshine data as there are limited weather stations in different provinces. Sites were Chitral (35.7699° N, 71.7741° E), Balakot (34.5482° N, 73.3532° E), Islamabad (33.6844° N, 73.0479° E) and Lahore (31.5204° N, 74.3587° E). (See Fig. 1).

2.2 Method of analysis

TCI was initially designed by Mieczowski (1985) which is a combination of different variables and requires specific type of data (Mieczkowski 1985; Perch-Nielsen et al. 2010; Kubokawa et al. 2014). TCI is being frequently used in numerous studies and research. For the calculation and analysis of the tourism climate index, meteorological data of 21 years (1997–2017) for study sites were obtained from the *Meteorological Weather Radar Station, Lahore*. This dataset includes temperature, humidity, wind, rainfall and sunshine

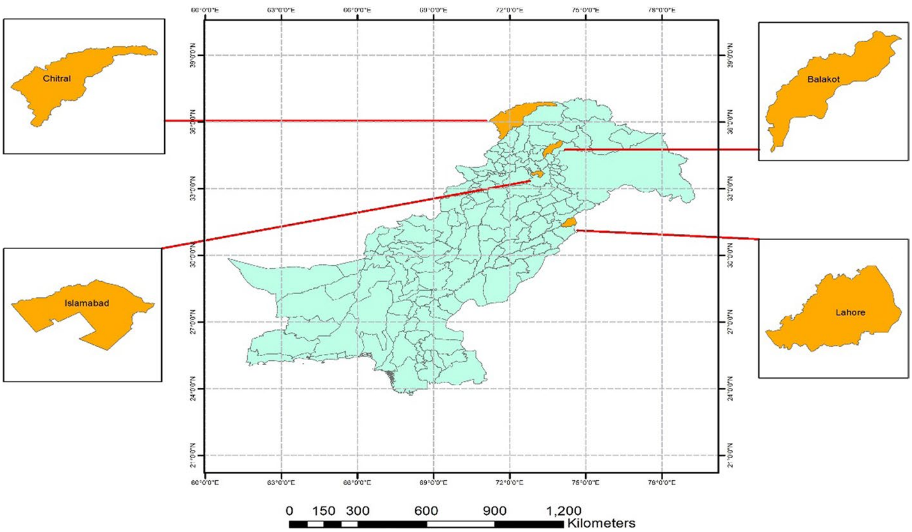

Fig. 1 Location map showing four study sites across Pakistan

hours. Data were available in a raw form and Excel 2016 was used for refining the data. TCI value for a specific location was calculated using the following equation.

$$\mathrm{TCI} = 2(4\mathrm{CD} + \mathrm{CA} + 2R + 2S + W)$$

It is universally recognized and accepted the equation of the Tourism Climate Index that contains five sub-indices which are; (Table 1)

TCI scores thus obtained were then categorized according to the TCI category chart (Table 2). Values in the chart range from 10 to 100. The climate is said to be ideal for tourism when the Tourism Climate Index score is ranging from 90 to 100. The unfavorable conditions for tourism are when the TCI score is less than 40.

Statistical analysis had been performed using statistix 8.1. In order to study the impacts of climatic changes on tourism, it is required to establish that some change has been observed in different climate variables over the study period (Roshan et al. 2016). Correlation analysis was used to identify the extent, trend and direction of change. The relationship between dependent variables (TCI) and independent variables (Time) was determined. Once the trends of TCI values over study period have been recognized, it is essential to identify the rate at which the change in TCI value is occurring over the study period. For this purpose, linear regression analysis was used to model the relationship between the dependent and independent variables. It is done by finding the increase or decrease in dependent variable (TCI) in response to a one unit increase in the time which is independent value. This statistical tool helps in identifying the amount and direction at which the climate change is happening, from the tourism perspective. Later, Coefficient of determination (R^2) was determined which helps to calculate the extent of change (percentage) by which independent variable (time) brings changes in the dependent variable (TCI) (Underhill and Bradfield, 2013). Statistical significance is determined once the strength and direction of TCI trends and the amount by which the change is occurring is calculated. It is imperative to note that larger datasets provide strong correlation between two variables within the data (Fitchett 2016).

ArcMap 10.5 was used to illustrate the results through maps for better and quick understanding. For the purpose different shape files (vector data) has been acquired from the data source of DIVA–GIS (REF IF ANY). Future climatic suitability was determined using the projected temperature trends for Pakistan mentioned in Climate Change Profile of Pakistan by Asian Development Bank. A methodological flowchart is developed to highlight the steps involved in conducting the study which is shown as Fig. 2.

3 Results and Discussion

3.1 Mean Annual Tourism Climate Index Scores

The mean annual TCI scores of sites under study were found to be ranging from 69 (good) to 74 (very good) as shown in Table 3. The annual scores for Lahore and Chitral were calculated to be 74, for Balakot the score was 70, whereas it was 64 for the Capital city, Islamabad. The results disclosed that tourists coming for sightseeing activities and nature-based tourism will get to experience conditions that are climatically categorized as “Good” and “Very Good.” Such comparable results were observed for Port Elizabeth and East London in South Africa (Fitchett et al. 2017). Statistical analysis revealed the insignificant trends in annual TCI scores for period 1997–2017 at Islamabad, Chitral and Balakot since the p

Table 1 TCI model sub-indices with their percentage in the TCI score. (Perch-Nielsen et al. 2010; Kovács and Unger 2014)

Sub-index	Abbreviation		Weight %
Daytime Thermal Comfort	CD	Mean monthly maximum temperature and Mean monthly minimum relative humidity plays an important role during maximum tourist activity	40
Average Thermal Comfort	CA	Mean monthly temperature and Mean monthly relative humidity Gives thermal comfort of an entire day	10
Wind	W	Monthly average wind speed Wind has a positive impact in hot climate and negative in cold regions	10
Rainfall	R	Total monthly rainfall. Rainfall has a negative impact on climate suitability	20
Sunshine	S	Daily sunshine hour. Sunshine positively adds to the attractiveness of the destination	20

CD Day Time Thermal Comfort, *CA* Average Thermal Comfort, *R* Total Monthly Rainfall, *S* Monthly Average Sunshine Hour and *W* Monthly Average Wind Speed

Table 2 Chart for the category of TCI scores (Mieczkowski 1985; Perch-Nielson 2010)

TCI score	Category
90–100	Ideal
80–89	Excellent
70–79	Very good
60–69	Good
50–59	Acceptable
40–49	Marginal
30–39	Unfavorable
19–29	Very unfavorable
10–19	Extremely unfavorable
< 10	Impossible

value were higher than that of 0.05. However, for Lahore the trend was found to be significant. Although the values of Pearson correlation were not high, this is because of the lower n value in datasets due to the limited data availability. This can have an impact on the statistical significance and attained lower values shows that the results obtained could not have occurred by an accident or any chance (Fitchett et al. 2016). Thus, no matter how low the values were, they still can play an important role through predicting the potential changes in tourism climate suitability in study areas.

In Islamabad, an apparent change in TCI value was observed for year 2000 and 2001 which was a shift from 69 to 73 (Fig. 3). On investigating the sub-indices values (Fig. 4a) it was revealed that this increase was attributed to decreased rainfall and increased CD values. The annual rainfall was found to be declining from 948.3 to 541.9 mm and the relative humidity decreased from 45.8 to 42.7% (Fig. 4a). The thermal comfort is an essential component in estimating climate tourism suitability as it contributes 40% to the TCI (Meiczkowski, 1985). Less rainfall and increased sunshine were also found to be responsible for the increase in TCI for year 2009, as increased sunshine hours had positive impact on the TCI (Tang, 2013). For year 2002 and 2003, a drop in TCI value was observed, i.e., from 71 to 68. The analysis of TCI sub-indices (Fig. 4a) determined a decreased value of rainfall from 13 to 10. As, decreased rainfall TCI value in the rating scale given by (Meiczkowski 1985) corresponds to increased rainfall. In this respect, the findings of a previously conducted study confirmed that increasing precipitation levels shows a negative influence on the TCI scoring (Jeuring and Becken 2013). In recent years (2015–2017), the TCI value was found to be presenting fluctuations 66–70–66 which could be responsible for lower tourism. This was attributed to the varying rainfall which was recorded to be 1619–858.5–1083 mm. The sunshine component declined from 13 (217.3 h) to 11 (190.8 h) during this time.

There was no significant variation in the mean annual TCI of Lahore in 21 years except for two periods as seen in (Fig. 3). First, the TCI value in 2003 was calculated to be 74 which were lower as compare to that of 2002. The further study of TCI sub-indices (Fig. 4b) revealed that the lowering of rainfall component from 17 to 15 was responsible for a significant decrease in TCI for the period 2002–2003, as increase in annual rainfall from 333.7 mm to 627.5 mm for 2002–2003 was observed (Day et al. 2013). Second, the investigations determined the contribution of Daytime thermal comfort component by increasing from 29 (30.2 °C, 48.4%) to 31 (31.1 °C, 42%) in increasing the TCI values from 73 to 78 in 2008–2009. In recent years, the instability was observed in TCI. On

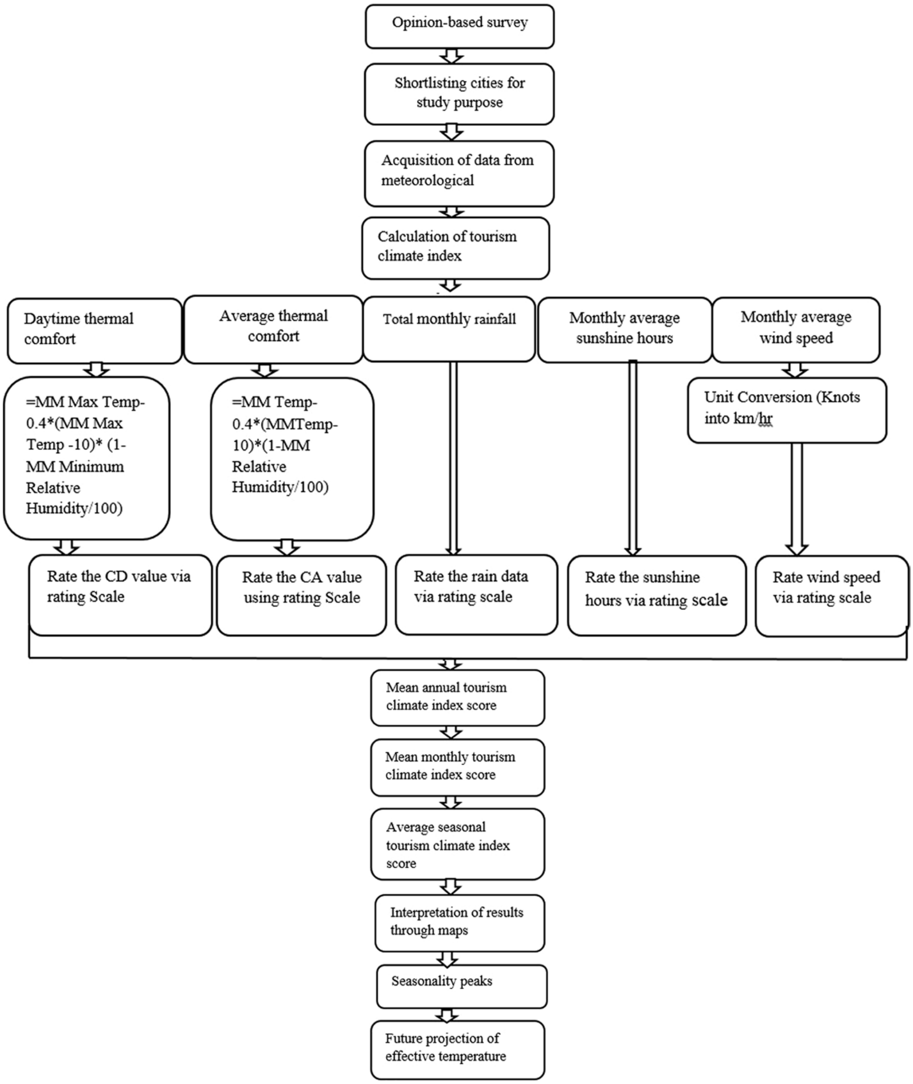

Fig. 2 A flowchart indicating the steps carried out from gathering data and generating TCI for selected cities of Pakistan

reviewing the TCI components (Fig. 4b), variations in rainfall value were observed, i.e., 16–12-14–16. Annually the rainfall during this period was found to be varying as well, i.e., 785.9–857.7–806.0–621.1 mm.

In Chitral, sharp changes in TCI values were observed (Fig. 3). In 2000–2001, the increase in rainfall value from 16 to 18 and an increase in sunshine from 13 to 14 corresponding to the increase in TCI values from 74 to 77. TCI values were found to be decreasing for the year 2005. The reason behind this drop was found by investigating the TCI components (Fig. 4c) which was the decrease in Daytime thermal comfort values because of the increased minimum relative humidity levels from 32.5% in

Table 3 Mean annual TCI score of each location for the period 1997–2017

	Islamabad	Lahore	Chitral	Balakot
Mean Annual TCI	69	74	74	70
Category	Good	Very Good	Very Good	Good
Max	73	78	77	80
Min	66	70	68	65
St Dev	1.8	2.2	1.8	3.25
CV	2.68	3.02	2.56	4.65
Range	7	8	9	15
r value	−0.27	−0.65	−0.06	−0.27
P value	0.23	0.00	0.78	0.22

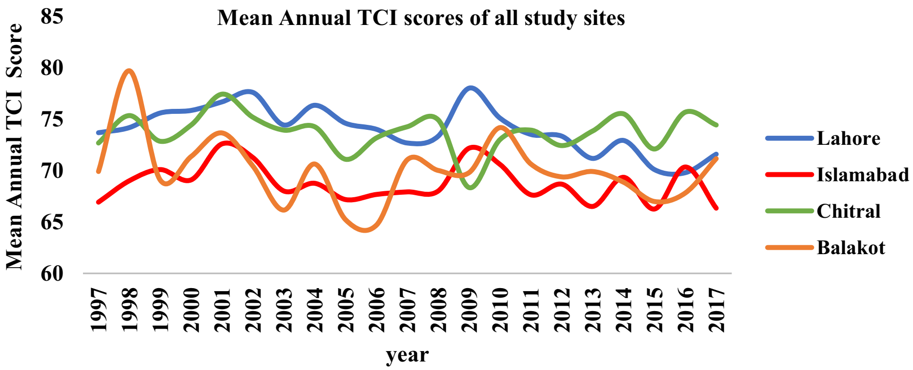

Fig. 3 Mean annual Tourism Climate Index scores along the study period (1997–2017)

2004 to 42.25% in 2005. A similar pattern was observed for the period 2008–2009. TCI values increased from 68 to 73 from 2009 to 2010 because of the inflation of CD values to 32. The minimum relative humidity was found to be declining from 43.25 to 38.5%. In recent years, varying rainfall and sunshine hours, i.e., 248.6 mm/521.2 h, 195.2 mm/220.8hours and 521.1 mm/386.1hours are responsible for the varying TCI.

In Balakot, the TCI score increased from "Very Good" to "Excellent" from the year 1997–1998 as shown in (Fig. 3). The difference was associated with the lower rainfall that occurred during 1998. The rainfall value was found to be increasing from 8 to 17 (Fig. 4d). The rainfall went on increasing to 1503 mm for the year 1999 hence a drop in TCI can be seen in the graph. The decrease in minimum relative humidity from 46.8 to 45.4%, i.e., an increased value of daytime thermal comfort was seen to be accountable for the increased TCI score from 71 to 74 during 2000–2001. The TCI displayed variation during the period 2003–2007; the variation here was because of the changing annual rainfall that kept on decreasing and increasing during this time. The maximum rainfall 2256 mm and a minimum of 1037.4 mm rainfall were recorded during this time. A similar pattern was observed in the TCI scores of recent years because of varying rainfall and sunshine hours.

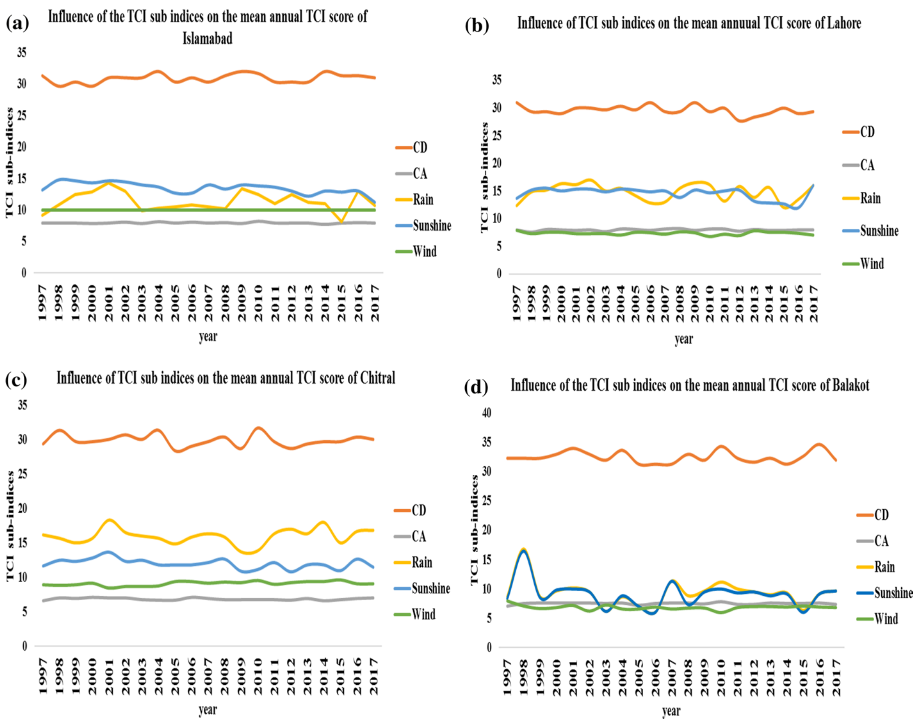

Fig. 4 Influence of TCI sub-indices on the mean annual TCI scores, **a** Islamabad, **b** Lahore, **c** Chitral and **d** Balakot

3.2 Mean Monthly Tourism Climate Index Scores

The mean monthly tourism climate index scores for each month were calculated and are shown in Table 4. For Chitral, the value ranged from 52 to 90. The climatic suitability for

Table 4 Mean monthly TCI score of each location for the period 1997–2017

Cities	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Chitral	52	52	57	76	89	89	83	84	90	86	68	58
Lahore	70	84	90	87	75	60	48	52	64	84	91	83
Islamabad	65	67	67	82	76	62	50	51	63	82	83	78
Balakot	58	53	68	79	82	69	57	61	74	84	85	69

**** Color Coding following the (Perch-Nielsen et al., 2010; Meiczkowski, 1985).***

****Dark Green= Ideal, Green= Excellent, Yellow= Good and Very Good and Brown= Acceptable***

*Color Coding following the (Perch-Nielsen et al. 2010; Meiczkowski 1985).

**Dark Green* Ideal, *Green* Excellent, *Yellow* Good and Very Good and *Brown* Acceptable

Lahore was found to be between 48 and 91. Islamabad, like Lahore, had suitable conditions along the years for most of the months and varied from category "Acceptable" (50) to "Excellent" (83). Balakot had TCI scores in the range of 53–85.

Chitral had five months ranging from May to October with a TCI score above 80 for tourism activities (Table 4). A similar pattern was observed in the study conducted in Iran where the above-mentioned months were identified suitable for tourism in Azerbaijan (Farajzadeh and Matzarakis 2012). From December to March "Acceptable" period of the TCI category was observed. This phase was because of Daytime thermal comfort value (Fig. 5a) which was lowest as compared to other months, whereas these months had been observed to be prominent in having a maximum value of mean monthly relative humidity such as January 41.65%, February 44.93%, March 39.78% and December with 42.36%. This is consistent with findings that thermal comfort declines with an increase in humidity (Mieczkowski 1985). Rainfall for the above-mentioned months was found to be recorded very high ranging from 64.22 mm to 89.3 mm. Our findings are in cohesion with the study which revealed that rainfall more than 60 mm causes an adverse impact on tourism (Olya 2015). TCI category interchanged rapidly from "Acceptable" to "Very Good" moving from March to April. Good values of CD, CA and sunshine hours were evolving aspects in this trend. Average thermal comfort was found to be decreasing for October, November and December that triggered cold in northern areas of Pakistan which was the reason behind discomfort of tourists.

Lahore had six months with TCI score "Excellent." TCI score of Lahore (Table 4) suggested maximum value in March and November, i.e., 90 and 91, respectively. There was a rapid increase in TCI value from January to February. Analysis of this change (Fig. 5b) described that daytime thermal comfort value was 10 units more for February as compared to January. It was observed that the winter months in the cities Chabhar and Bandar, Iran also showed an excellent category (Roshan et al. 2016). TCI category during July and August was evaluated as "Marginal" and "Acceptable," respectively. In a study of Yazd Province similar low TCI category had been identified for July and August with the worst

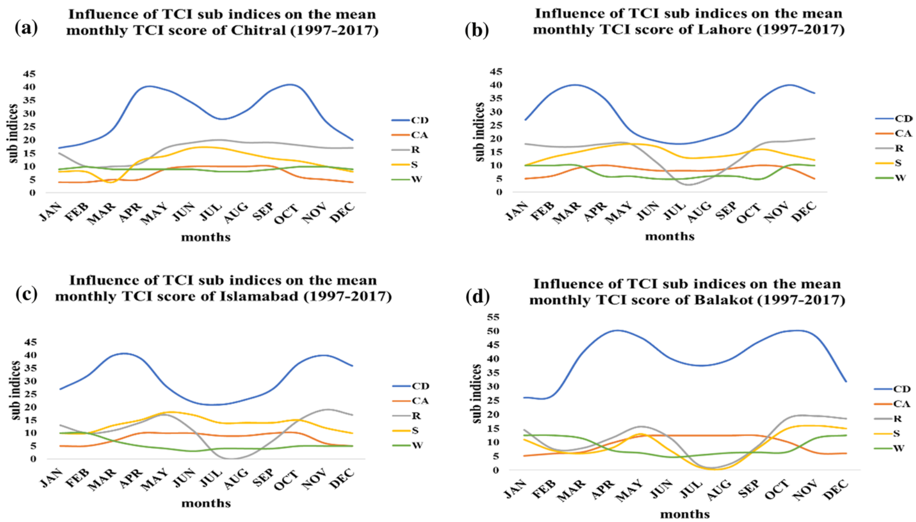

Fig. 5 Influence of TCI sub-indices on the mean monthly TCI scores, **a** Islamabad **b** Lahore **c** Chitral and **d** Balakot

climatic suitability (Shakoor 2011). High rainfall during the above-mentioned months also decreased the attractiveness of the destinations like mean monthly rainfall for July was 190.4 mm and August with 156.9 mm. Rainfall during the months with Excellent TCI category was very low and minimal like 12.2 mm for October 7.64 mm for November and 6.09 mm for December, consequently added more suitability and attraction to the tourism.

The maximum TCI score for Islamabad was “Excellent” which was observed in April, October and November (*Table 4*). A sharp increase in the TCI score was noticed from March to April because of the high value of CA and sunshine hours and less value of Rainfall (Fig. 5c). June and July also varied in suitability from each other because high rainfall and ultimately fewer sunshine hours in July were observed as main factors to decrease the TCI value. Sunshine hours and rainfall were in inverse relation with each other. The CD value for Islamabad determined that its contribution decreased for months of July and August, i.e., 21 and 23, respectively. In Islamabad high rainfall was also responsible for the low value of TCI for July and August, i.e., 345.9 mm and 297.9 mm, respectively. In September, 19 units less TCI score was observed as compare to that of October. On viewing the details of sub-indices, it was observed that low rainfall and the high value of daytime thermal comfort were main factors behind this positive shift, whereas average thermal comfort and wind speed were almost same for both months. In this way TCI value of Islamabad for months suggested that climatic conditions were best in April, October and November. The same pattern of TCI score for April and October month was observed in the Chaloos city of Iran (Ramazanipur and Behzadmoghaddam 2013). Investigation revealed that daytime thermal comfort value was contributing for the lower TCI scores in December.

In Balakot the TCI category of ‘Excellent” was observed in May, October, and November as shown in Table 4. Observing sub-indices (Fig. 5d) revealed high daytime thermal comfort scores for these months as compared to the rest of the months. From May to June TCI score decreased and the reason for this rapid downfall was found to be less value of daytime thermal comfort and average thermal comfort and a high value of wind. Relative humidity was recorded at 55.238%. More humidity had caused a decrease in thermal comfort (Morgan 2000). Wind value increased from July to August therefore, more pleasant conditions intend to increase TCI value. Rainfall was the same for both months. Summer of Balakot and Chitral had a good score for recreational activities. The high value of wind speed in the winter months contributed to the negative impact on the TCI score as the wind in cold areas cause discomfort by making the air colder and unfriendly than before (Meiczkowski 1985).

3.3 Statistical Analysis of the Traditional Tourism Climate Index

Statistical results help in understanding the induced change in tourism by the climate (Manly 2008). The knowledge of the direction and the rate at which this change is occurring is very essential in predicting the possible changes that can occur in the future. The results of the statistical analysis are shown in Table 5. Although the values of Pearson correlation and change in the TCI/year were not high, the fact that the lower n value in datasets because of the limited data availability can have an impact on the statistical significance and attained lower values shows that the results obtained could not have occurred by accident or any chance (Fitchett et al. 2016). Thus, no matter how low the values were, they still can play a vital role to forecast the potential future changes in tourism climate suitability in study areas.

Table 5 Statistical analysis of mean monthly TCI scores of each location (1997–2017)

Location	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Islamabad												
Strength of Trend	0.05	−0.09	−0.22	−0.02	−0.10	−0.06	−0.41	−0.20	−0.03	0.10	0.22	−0.15
Rate of change (unit/year)	0.08	−0.17	−0.22	−0.03	−0.07	−0.08	−0.31	−0.08	−0.03	0.09	0.09	−0.17
R^2 value	0.00	0.01	0.05	0.00	0.01	0.00	0.17	0.04	0.00	0.01	0.05	0.02
P value	0.84	0.69	0.36	0.92	0.67	0.79	0.07	0.38	0.91	0.67	0.34	0.52
Lahore												
Strength of Trend	−0.17	−0.15	−0.18	−0.14	−0.30	−0.44	−0.03	−0.42	−0.55	0.03	−0.29	0.01
Rate of change (unit/year)	−0.16	−0.19	−0.16	−0.07	−0.26	−0.61	−0.03	−0.50	−0.68	0.02	−0.18	0.02
R^2 value	0.03	0.02	0.03	0.02	0.09	0.20	0.00	0.17	0.31	0.00	0.08	0.00
P value	0.45	0.53	0.43	0.56	0.18	0.04	0.90	0.06	0.01	0.89	0.21	0.95
Chitral												
Strength of Trend	−0.08	−0.23	0.20	0.13	−0.03	−0.26	0.09	−0.48	0.10	−0.06	0.02	−0.08
Rate of change (unit/year)	−0.08	−0.33	0.31	0.16	−0.02	−0.13	0.04	−0.22	0.04	−0.06	0.02	−0.07
R^2 value	0.01	0.05	0.04	0.02	0.00	0.07	0.01	0.23	0.01	0.00	0.00	0.01
P value	0.72	0.33	0.38	0.57	0.89	0.26	0.70	0.03	0.67	0.79	0.94	0.72
Balakot												
Strength of Trend	0.11	−0.51	0.03	−0.32	0.12	0.27	−0.37	−0.48	−0.11	−0.41	0.17	0.01
Rate of change (unit/year)	0.18	−0.80	0.03	−0.40	0.12	0.42	−0.36	−0.57	−0.14	−0.44	0.19	0.01
R^2 value	0.01	0.25	0.00	0.09	0.01	0.06	0.15	0.23	0.01	0.15	0.02	0.00
P value	0.64	0.01	0.91	0.15	0.59	0.23	0.09	0.02	0.61	0.06	0.45	0.95

3.4 Average Seasonal Tourism Climate Index Score

In the winter season (Fig. 5), the higher wind and rainfall in higher latitude regions posed undesirable influence on the TCI score as in the case of Chitral and Balakot where the value was in the "Acceptable" category. Here, the sub-indices R and W were low and high, respectively. The study conducted by (Jawtusch 2014) confirmed this negative relationship between these two sub-indices and TCI. The lower levels of an average thermal comfort index CA in winters negatively affected the climatic suitability in mountainous regions as compared to that of areas located in lower latitudes, where lower values had a positive influence in the TCI category. This could be notably observed in Chitral and Balakot where the average thermal comfort values were lower as compared to their values in the spring and autumn season. This clearly determined that CA negatively influenced the cold areas. This observation was in accordance with the study conducted by (Ziervogel et al. 2014) which stated the detrimental effects of CA on TCI. However, future projections about increasing temperature seem to provide benefits for the areas with the lower temperature where previously the average thermal comfort was having damaging impacts to tourism. TCI calculations in many areas around the world determined an unfavorable and unacceptable TCI category during winter. Like in Anzali- Iran, the score was as low as 39.4. Capital cities of countries belonging to the South Caucasus also showed scores below 49 (Amiranashvili et al. 2014). This shows that however values for winters of Chitral and Balakot are low, scores are still better than many destinations around the world. Such a status of TCI, even low, can still attract international tourists looking for better and appropriate options.

In summer (Fig. 5), the latitudinal gradation was obvious and easily noticeable. The northern areas presented very appropriate conditions for tourism as compared to their counterparts. Such a similar pattern was observed in Australia where the best conditions were observed in the south and unfavorable in the north (Amelung and Nicholls 2014). The latitudinal gradation was also found in Iran, where climatic conditions become best when moving from north to south (Roshan et al. 2016). TCI score of Lahore and Islamabad fell in the "Acceptable" category during the monsoon period, similar TCI ranking was observed for winters in Chitral and Balakot. Further analysis of TCI sub-indices revealed that the reason behind the above-mentioned pattern was the increase in humidity that provoked lower values of daytime thermal comfort, which was the ultimate reason for the lowering of the TCI score. This was consistent with the findings that thermal comfort declines with an increase in humidity (Mieczkowski 1985).

In the spring and autumn season *(Fig. 5)* for all four cities, months were identified having "Excellent" to "Ideal" TCI score with higher daytime thermal comfort values. It was observed that the higher CD had a positive influence when it comes to TCI, as higher values of daytime thermal comfort indicated lower relative humidity levels. A similar study conducted in New York, Saint Louis, Charleston, New Orleans, and Batumi determined that the comfort indices had higher values during the spring and autumn season (Matzarakis and Rutz 2005). Our results were in accordance with the previous findings. In some parts of China (Fang and Yin 2015) and South Africa (Fitchett et al. 2017), the TCI categories for spring were determined to be "Good" and "Very Good" and even "Acceptable" at some places. This was because of the rainfall during that time period. For autumn, however, cities of South Africa had also been categorized as "Ideal" and "Excellent." This revealed the better climatic suitability of Pakistani cities that can attract lots of tourists during spring and autumn.

It is essential to discuss that TCI was only designed to determine the best and appropriate time about the suitable climate for visiting a place (Amelung and Nicholls 2014). It does not give a quantitative estimation of the tourists that arrive at destinations (Fang and Yin 2015). Thus, calculated TCI scores and categories for Islamabad, Lahore, Chitral, and Balakot only shows the suitable climate situation for tourism, it does not promise the high or even dwindling number of tourists at these places in mentioned time (see Figs. 6, 7, 8, 9).

3.5 Seasonality Peaks

Peaks were categorized according to the categories given by Scott and McBoyle (Scott and McBoyle 2001). 75% of the study sites presented a Bi-modal shoulder peak while winter peaks for the remaining 25%.

3.5.1 Bi-modal Shoulder Peaks

It is observed that the distribution of the bi-modal shoulder peak is 75% in our study (Fig. 10). Balakot, Chitral, and Islamabad gave bi-modal shoulder peaks. The reason behind the bi-modal shoulder peak of these cities was the bi-modal shoulder peak of the CD, the rest of the components other than CD did not show bi-modal shoulder peak. Cities of Jolfa, Sagez, Maragh, Mahabad also had a bi-modal shoulder peak distribution (Farajzadeh and Matzarakis 2009). Winter in Chitral and Balakot was harsh, whereas for Islamabad it was too cold for tourism. Although summer was a pleasant season for tourism in Balakot and Chitral, but more feasible components of TCI, temperature, and climatic conditions tended to increase the TCI score in spring and autumn. Spring was found to be a more pleasant season for sightseeing and tourism-related activities (Kovacs et al., 2016). Study

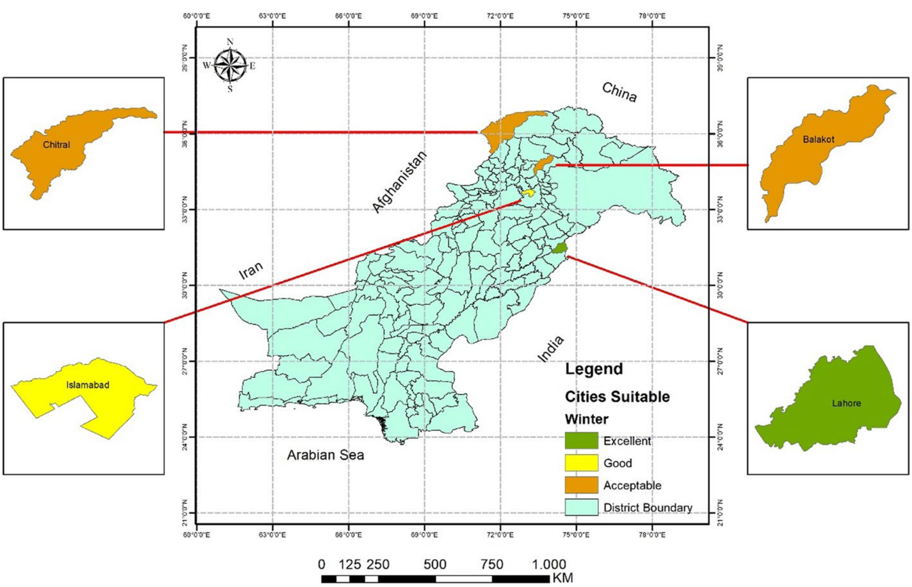

Fig. 6 Climate suitability during the winter season of each study location (1997–2017)

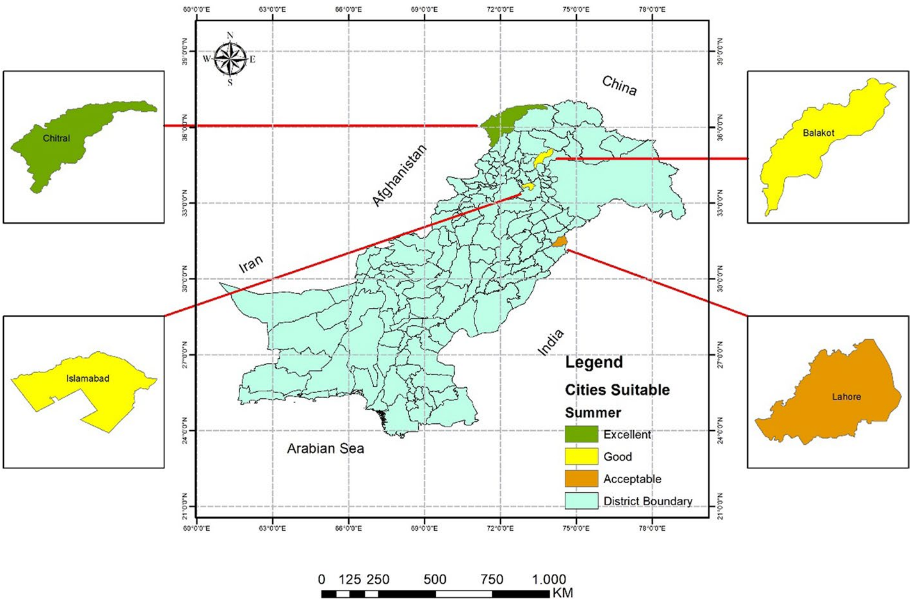

Fig. 7 Climate suitability during the summer season of each study location (1997–2017)

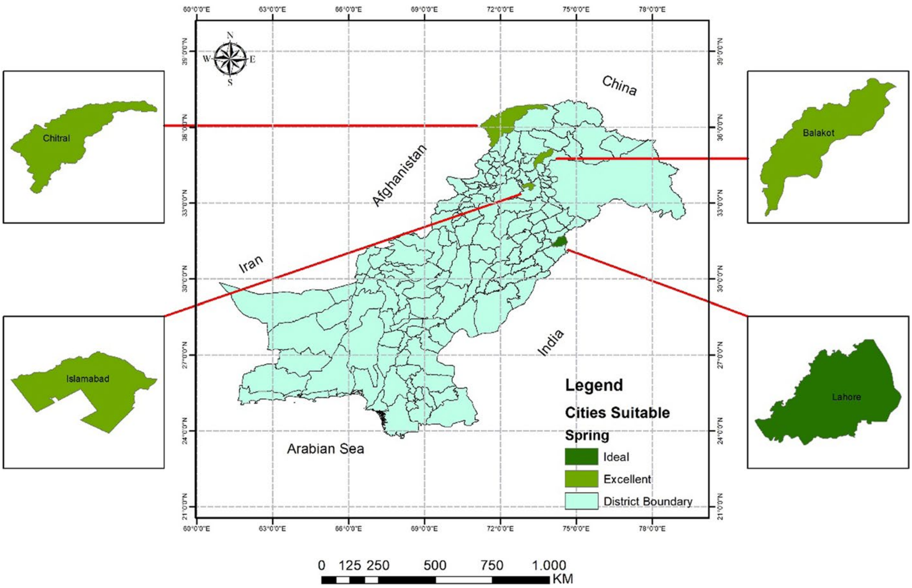

Fig. 8 Climate suitability during the spring season of each study location (1997–2017)

in South Africa for the cities Bethlehem, Kimberley, Lady Smith, Belfast, Pretoria, etc., found bi-modal shoulder peak in the locations that experience extreme temperature differences in summer and winter (Fitchett et al. 2017).

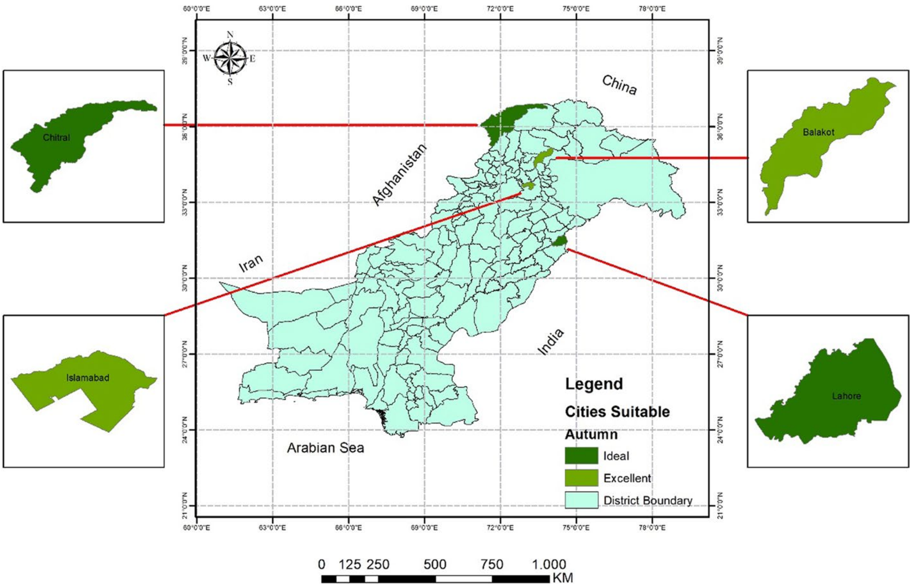

Fig. 9 Climate suitability during the autumn season of each study location (1997–2017)

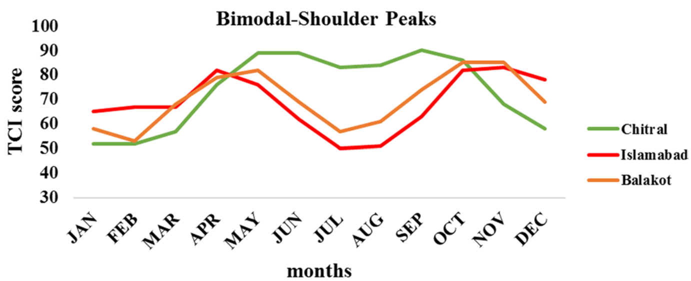

Fig. 10 Bi-modal Shoulder Peaks

3.5.2 Winter peak

The winter peak contributed 25% in the selected locations of the study. Winter peak for Lahore was observed (Fig. 11). This peak pattern in this study identified that winter was most suitable for recreational activities. The temperature in the summer was very warm and observed to be not good for outdoor activities.

Our results were per study conducted in China, where for the similar reasons southernmost regions which include Guangxi, southern Guangdong and Hainan have been observed to show winter peaks (Fang and Yin 2015). Moreover, monsoon and rainy season in Lahore from July to September contributed to reduced tourism activities and attraction of destinations. Mainly, rainfall in winter was low and minimum. Low rainfall was a positive indication for tourism activities. Thessaloniki, the city of Greece also showed a winter peak in a study conducted by (Kovács and Unger 2014).

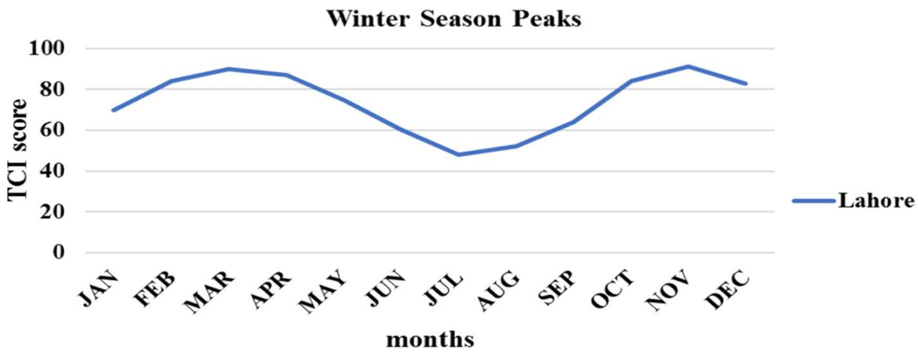

Fig. 11 Winter Peak

3.6 Future Projection of Effective Temperature

Global Impact Study Centre Islamabad, Pakistan projected the future trends of temperature and precipitation using General Circulation Model. According to the findings, there would be a noticeable increase in the temperature, i.e., 4.38 °C by the year 2080 in Pakistan (Chaudhary 2017; IPCC 2014). The future temperature will influence the CD component negatively (Ziervogel et al. 2014) and on the investigation, we found that our results show similar behavior. The locations that have a high probability of tourism, mainly because of CD will experience a decline in the climatic suitability because of elevated temperature (Table 6). An optimal threshold value for CD component is 26 °C, values above this temperature disturb the thermal comfort of tourism (Mieczkowski 1985). As for the location, Balakot, Lahore and Islamabad's future expected temperature would be 27.01, 30.25, and 29.39 °C, respectively, worsening the suitability, while for the Chitral, the rating is same as before.

Although CD is playing a positive role in all the locations at the moment, its positive impact may start to decline in the future (Table 6). This should be checked and monitored properly to see to which extent the future results would be in accordance with these findings.

Table 6 Current and future effective temperature readings

Location	Current effective temperature (°C)	Future effective temperature (°C)	Future CD rating (0–5)
Balakot	22.63	27.01	*4.5*
Lahore	25.87	30.25	*3*
Chitral	20.16	24.5	**5**
Islamabad	25.01	29.39	*3.5*

*Italicized values indicate a decrease, whereas bold value indicates no change in CD rating for future

4 Conclusion

The central aim of the study was to determine the first quantitative assessment of climate suitability for the tourism industry and to find the relation between climatic parameters for different cities of Pakistan. The mean monthly TCI score suggested that climate of the study area is more suitable during autumn and spring. The mean monthly TCI score of Lahore and Islamabad proposed that summer is less favorable for tourism, primarily because of high rainfall, which reduces suitable conditions require for outdoor tourism. The winter season of Chitral and Balakot presented less climate suitability for tourist activities. Moreover, the current study determined that the mean monthly TCI category of Islamabad was low as compare to other cities. Number of good months varies from 7 to 10 for each location. Overall, the mean Annual TCI scores of study sites were between 60 and 80 which revealed that the selected study sites had "good" to "excellent" climatic conditions for recreational activities. The daytime thermal comfort and rainfall are found to be the main contributing factors in this study for the alteration of TCI scores. This also recommended that the only determination of the TCI score was not helpful enough because TCI sub-indices were main driving factors for fluctuation. For the period 1997–2017, statistical analysis revealed both significant and insignificant decrease and increase in the tourism climate index scores making a place more suitable for certain month or making it less appropriate in another. Although the negative trend was not significant yet but if such trends continue to rise in the future, the area will lose its climatic suitability and attraction.

Considering the results of this study, it is concluded that there is higher dependency of the tourism sector on climate change in Pakistan. Hence, further research must be done to monitor the magnitude and extent of climate change impact on the tourism industry of the country. The findings obtained will help in a better understanding of favorable and unsuitable tourist destinations. Moreover, it will present a comprehensive knowledge about the spatial and temporal distribution of climate change impacts in recreational sites of Pakistan. The adaptive capacity of Pakistan like other developing countries is low owing to the country's decreased technological development and capital intensity similarly reactive measurements are preferred over proactive strategies. It is imperative to conduct such studies to quantify the impacts of climate change on a local and national scale. This will help tourism stakeholders in devising better plans for the promotion of tourism amid climate challenges. Moreover, such studies on a large scale with improved data networks would enable tourism stakeholders to better estimate the financial costs associated with adaptation strategies and capacity building.

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