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Determination of tourism climate index in Kerman province

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Abstract

Climate is a natural resource that effects decision making for selection of destinations in tourism and ecotourism. The relationship between climate and tourism is a complex one. But application of a climate index provides an ideal approach to understanding this complexity and is a useful tool for the tourism industry. In this study, a modified version of Mieczkowski's (1985) Tourism Climate Index (TCI) for months was used for Kerman province to determine climate comfort ratings ranging from ideal to unfavorable. Data covering a network of 12 meteorological stations was used to compute a TCI for the study region. Then index evaluations in each city were classified according to one of the six annual TCI distributions presented by Scott and Mcboyle (2001). Results of modeling showed bimodal-shoulder peaks in seven stations namely (Anar, Rafsanjan, Zarand, Sirjan, Shahre-Babak, Bam and Kerman); two stations namely (Baft and Lalehzar) had summer peak, and three cities (Shahdad, Kahnouj and Jiroft) had winter peak. TCI scores for all months in the study stations were transferred into Geographic Information System to determine the most suitable areas and months for tourism activities in Kerman province.

Keywords: Climate comfort; Southeast Iran; Tourism climate index

1. Introduction

Weather and climate have a strong influence on tourism and the recreation sector, which is a major growth industry worldwide. Usually, geographical location, topography, landscape, vegetation and fauna are factors that influence decision making on area to be visited. Weather and climate are also important factors considered by tourists (Matzarakis 2006). The characteristics of weather and climate are not necessarily good determinates for tourism but they do constitute an important factor in both financial terms, for tourism operators and tourists' experiences. It is a fact that weather and recreational tourism are interconnected in diverse ways (Lecha and Shackleford 1997), and tourists, tour organizers and tourism planners need to be reliably informed about the role of weather and climate (Matzarakis et al. 2004; Matzarakis 2006). Climate has a major effect on tourism demand and satisfaction, thus there is a need to assess suitability of a climate for tourism so that tourists can use the information for decision-making within the tourism industry. Several attempts have been made to identify optimal climate conditions for tourism in general and for specific tourism activities (Mieczkowski

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1985; de Freitas 1990; Becker 1998; Morgan et al. 2000; Maddison 2001; Lise and Tol 2002; Hamilton and Lau 2005; Bigano et al. 2006). Climatic factors, such as temperature, relative humidity, hours of sunshine, wind speed and rainfall have a major effect on international tourism within an area. Statistical analyses by Maddison (2001), Lise and Tol (2002), Hamilton (2003), and a simulation study by Hamilton et al. (2003) show the relevance of climate as a factor that determines demand for tourists Accordingly, climate is an important resource for tourism and tourism planners that needs to be measured and evaluated. An index approach is useful for this task because of the multifaceted nature of weather and the complex ways in which weather variables come together to give meaning to climate in relation to tourism (de Freitas et al. 2008). Because of this complexity, considerable effort has gone into devising climate indices that integrate and rate the natural resource of climate for the purpose of tourism. The concept of climate indices specifically for tourism has evolved from more general development of climate indices in sectors such as health (e.g., UV index, Wind Chill, and Humidity index) and agriculture (e.g. various drought indices) (de Freitas et al. 2008). Several indices have been developed over the last 40 years to assess climate suitability for tourism activities (Crowe et al. 1973; Mieczkowski 1985; Perry 1997; Becker 2000; Morgan et al. 2000; Maddison 2001; Lise and Tol 2002; G´omez Mart´ın 2004; Hamilton and Lau 2005; Bigano et al. 2006; Matzarakis 2007; de Freitas et al. 2008). Tourists and tour operators can use climate indices to select the best time and place for a particular vacation, or plan activities appropriate to weather expectations. Marketing agents and tourism planners could use the index to promote tourism during off-peak periods and discourage it during the busy peak times. It could be used to assess potential visitor numbers to assist in planning resort development programs. Tourism marketing could use this information to make objective comparisons of tourism products to other better-known destinations, and to provide potential visitors with information to reduce the gap between expected (or promoted) and real weather conditions, so as to increase the potential for return visits. An important limitation of most existing climate indices for tourism is that rating schemes for individual climate variables and the weighting of climate variables in the index were largely based on the subjective opinions of researcher(s) and not empirically tested on tourists or within the tourism marketplace (de Freitas et al. 2008). One of the commonly applied indices is that of Physiologically Equivalent Temperature (PET). This index evaluates thermal conditions relating to human energy balance. It is well suited to making evaluations of the thermal components of different climates. As well as having a detailed thermo-physiological basis, PET is preferable to other thermal indexes such as the Predicted Mean Vote because of its unit of evaluation (°C), which makes results more comprehensible to urban or regional planners and those less familiar with modern human-biometeorology terms. PET results can be presented graphically or as a bioclimatic map. Graphs mostly display the temporal behavior of PET, whereas spatial distribution is specified in bioclimatic maps (Matzarakis et al. 1999). Other possibilities are CIT (Climate Index for Tourism) (de Freitas et al. 2008) and CTIS (Climate Tourism Information Scheme) (Matzarakis 2007; Lin and Matzarakis 2008), both of which are based on the integration of thermal (T), aesthetic (A) and physical (P) facets of weather and climate. CIT combines a weather typology matrix to determine climate satisfaction rating from very poor (1 = unacceptable) to very good (7 = optimal). Parameter A refers to sky conditions and P to rain or high wind speed. T is air temperature based on the human energy balance and integrating the thermal atmospheric variables thermophysiological variables, such as solar heat load, heat loss by convection (wind) and by evaporation (sweating), long wave radiation exchange and metabolic heat (activity level) (de Freitas 2008). CTIS is based on the integration of information of single factors based on thresholds that are strongly connected with facets of climate on tourism (Matzarakis 2007). One of the most comprehensive schemes proposed so far is that of Mieczkowski (1985), who developed the ‘Tourism Climate Index’ (TCI). Mieczkowski’s (1985) index was designed to use climate data that was already widely available for tourist destinations worldwide. The TCI merges seven features of climate into a single climate index. The TCI was originally conceptualized as a composite measure that would systematically assess the climatic elements that were most relevant to the quality of the tourist experience for the ‘average’ tourist (i.e., the most common tourism activities of sight-seeing and shopping). TCI has subsequently been used in a slightly modified form by Morgan et al. (2000) for beach environments, and in a number of recent studies that assess the potential impact of global climate change on the climate resources of destinations around the world (Scott and McBoyle 2001; Scott et al. 2003; Amelung and Viner 2006). Morgan et al. (2000) conducted in situ surveys with tourists in beach environments in Wales, Malta and Turkey (summers of 1994 and 1995) in order to modify the TCI. The study identified four climate parameters ranked according to relative importance; absence of rain, sunshine duration, temperature sensation and wind speed. The study by de Freitas (1990) determined a high correlation between HEBIDEX, a body–atmosphere energy/budget index, and the subjective rating of the weather by beach users. Furthermore, the research determined that the optimal thermal condition for beach users was not at the minimum heat stress level but at the point of mild heat stress. Matzarakis (2002) uses an index of thermal comfort to identify areas of Greece where there is a high likelihood of conditions that could induce heat stress. The author states that climate change scenarios with course resolution are not suitable for use with such indices. Farajzadeh and Matzarakis (2009) computed PET and TCI in northwest of Iran in the period 1985-2005 from a network of 15 meteorological stations. This paper aimed to apply the TCI developed by Mieczkowski (1985) to make determinations of the most suitable months for areas for tourism and tourist activities in Kerman province-southeastern Iran. It was the first attempt to use this index in Kerman province.

2. Material and methods

2.1. Study area and Data

In general, Kerman has an abundance of cultural, historical and environmental attractions (ecotourism and agritourism) making it an area with high potential capacity for tourism. The area was visited by domestic and foreign tourists, and there was climatic variation among areas of the province. Topography of Kerman province is very complex and highly variable. 12 synoptic meteorological stations were located in the province (Figure 1). Table 1 lists geographic positions of the synoptic meteorological stations of the cities considered in the analysis. These stations were located in different subclasses of arid and semiarid climates of the province based on extended-De Martonne classification (Khalili, 1997). The climate data used in this research was obtained from the I. R. of Iran’s Meteorological Organization (IRIMO). Data on mean annual climate collected from the meteorological stations are presented in Table 2.

Table 1. Geographic positions and climate classification in extended De Martonne (Khalili 1997) of meteorological stations in Kerman province

Station	Latitude (°N)	Longitude (°E)	Elevation from sea level (m)	Climate Classification
Anar	30.88	57.58	1408.8	Arid-Cold
Baft	29.23	56.58	2280.0	Semiarid-Cold
Bam	29.1	58.35	1066.9	Arid-Moderate
Rafsanjan	30.41	55.9	1580.9	Arid- Moderate
Zarand	30.8	56.56	1670.0	Arid-Cold
Sirjan	29.46	57.32	1739.4	Arid-Cold
Shahdad	30.41	57.7	400.0	Arid-Warm
Shahre-Babak	30.1	55.13	1834.1	Arid-Cold
Kerman	30.25	56.96	1753.8	Arid-Cold
Kahnouj	27.96	57.7	469.7	Arid-Warm
Lalehzar	29.51	56.83	2775.0	Semiarid-Cold
Jiroft	28.58	57.8	601.0	Arid-Warm

Table 2. Climate data of meteorological stations in Kerman province

Station	Period	DBT (^oC)	$\overline{T}_{max}$ (^oC)	RH_{mean} (%)	R (mm)	S (hrs)	W (km hr^{-1})
Anar	1986-2008	19.6	26.7	31	72.3	3333.8	8.3
Baft	1989-2005	15.3	21.2	39	261.2	3254.1	98
Bam	1956-2005	23.1	29.2	31	61.3	3381.6	10.6
Rafsanjan	1992-2005	19.1	25.9	29	89.7	3380.9	15.7
Zarand	2003-2008	17.8	26.7	33	95.1	3208.6	8.9
Sirjan	1985-2005	17.7	25.2	35	141.5	3410.1	8.7
Shahdad	2002-2008	27.6	36.1	21	31.1	3387.1	9.6
Shahre-Babak	1987-2005	16.3	23.6	34	163.8	3364.9	10.0
Kerman	1951-2005	17.0	24.7	32	152.9	3174.7	11.3
Kahnouj	1989-2005	27.4	33.8	39	209.0	3321.6	11.2
Lalehzar	2033-2008	10.3	16.9	33	214.5	3182.5	14.4
Jiroft	1989-2005	26.3	32.9	43	193.7	3166.2	3.9

DBT is dry bulb temperature, $\overline{T}_{max}$ is average of maximum temperature, RH_{mean} is average of relative humidity, R is mean annual total of precipitation, S is annual total of sunshine hours, W is average of wind speed.

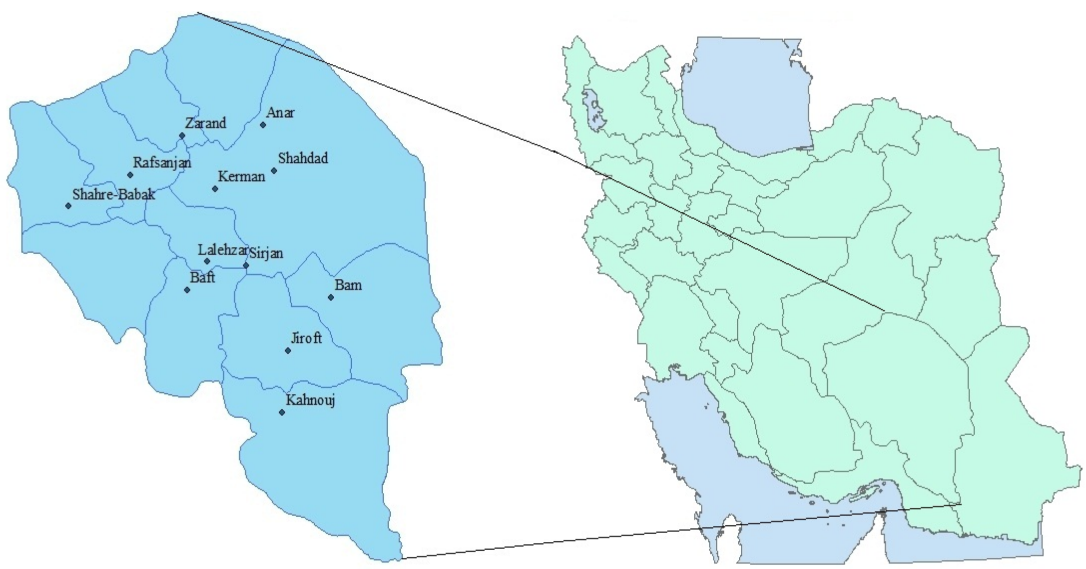

Fig. 1. Study area and location of stations

2.2. Method

2.2.1. Mieczkowski's Tourism climate index

The TCI developed by Mieczkowski (1985) was based on previous research related to climate classification for tourism and recreation (Crowe, 1976) and theoretical considerations from the biometeorological literature related to human comfort, with particular reference to tourism activities (Danilova 1973, Kandror et al. 1974). The TCI consists of five sub-indices, each represented by one or two monthly climate variables. The five sub-indices and their constituent variables were as follows: (1) daytime comfort index (maximum daily temperature [in ºC] and minimum daily relative humidity [%]), (2) daily comfort index (mean daily temperature [ºC] and mean daily relative humidity [%]), (3) precipitation (total precipitation, in mm), (4) sunshine (total hours of sunshine), and (5) wind (average wind speed, in m s^{-1} or km h^{-1}). The index takes on the following expression:

$$TCI = 2\times(4\times CId + CIa + 2\times R + 2\times S + W) \qquad (1)$$

where CId is daytime comfort index, CIa is daily comfort index, R is precipitation, S is sunshine, and W is wind speed.

With an optimal rating for each variable of 5.0, the maximum value of the index was 100. Based on each location's index value, its suitability for tourism activity was then rated on a scale from –30 to 100. Mieczkowski (1985) divided this scale into 10 categories, ranging from ideal (90 to 100), excellent (80 to 89), and very good (70 to 79) to extremely unfavorable (10 to 19) and impossible (9 to –30). In the equation proposed by Mieczkowski (1985), the highest weight was given to the daytime comfort index to reflect the fact that tourists are generally most active during the day. Amounts of sunshine and precipitation were given the second highest weights, followed by daily thermal comfort and wind speed. After summing the weighted individual components, results were multiplied by two, so that the maximum TCI score was 100. In this study, a TCI value of 70 or higher was considered attractive to the "typical" tourist engaged in relatively light activities such as sightseeing and shopping. It should be noted that the TCI is inappropriate for making predictions for number of tourist visits. The index was designed solely to indicate levels of climatic comfort for tourism activity and did not take account of the existence and quality of vital tourism infrastructure such as transportation and attractions. Thus, a region with a high TCI may experience low levels of tourist visitors and vice versa, because a multitude of factors other than climatic conditions influence tourism activity. Tables 3 and 4 illustrate components of the index and the rating scale for tourist comfort.

Table 3. Sub-indices within the monthly climate variables (Mieczkowski 1985)

Sub-index	Monthly climate variables
Daytime comfort index (CId)	Maximum daily air temperature (^oC) and minimum daily relative humidity (%)
Daily comfort index (CIa)	Mean daily air temperature (^oC)
Precipitation (R)	Total precipitation (mm)
Sunshine (S)	Total hours of sunshine (hrs)
Wind (W)	Average wind speed (km h^{-1})

Table 4. Rating categories in the Mieczkowski (1985) tourism climate index

Numeric value of Index	Description of Comfort Level for Tourism Activity
90-100	Ideal
80-89	Excellent
70-79	Very good
60-69	Good
50-59	Acceptable
40-49	Marginal
30-39	Unfavorable
20-29	Very unfavorable
10-19	Extremely unfavorable
-3 to 9	Impossible

2.2.2. Scott and McBoyle (2001) Models

Scott and McBoyle (2001) theorized that the natural resource of climate could be classified for each tourist destination into one of six annual distributions (Figure 2). Tourism climate typology in the model ranged from and 'optimal' year round tourism climate (TCI ≥80 for each month of the year) to a 'poor' year-round tourism climate (TCI <40 throughout the year). The peak curves for 'summer' and 'winter peak' were similar, and distinguished by season in which more favorable climatic conditions occurred. A 'summer peak' was indicative of mid- to high latitude locations where summer was considered as the most pleasant period of the year for tourism activity. A 'winter peak' would occur in the more equatorial and lower-latitude locations where cooler and/or lower humidity conditions in winter make conditions more comfortable for tourists compared to hot and/or humid summer weather. Where spring and fall months were more suitable for tourist activity a 'bimodal' or 'shoulder peak' distribution was shown. The tourism climate resource in regions with distinct wet and dry seasons were mostly dependent on precipitation. The TCI in these regions displayed a dry season peak, when the climate was most conducive to tourism activity (Scott et al. 2004).

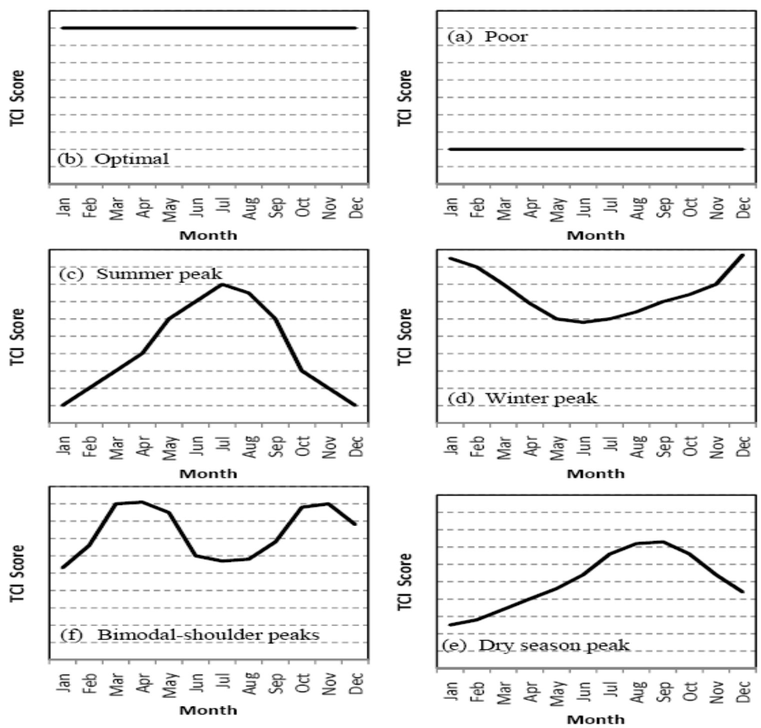

Fig. 2. Conceptual annual tourism climate distributions (Scott and McBoyle 2001)

3. Results

The tourism climate resource of every destination can be classified into one of six annual TCI distributions (Figure 2). Using the sample of 12 synoptic weather stations, three of them were found to be among destinations in southeastern Iran included in this study of current climate (summer peak, bimodal-shoulder peaks and winter peak). The cities of Anar, Bam, Rafsanjan, Zarand, Sirjan, Shahdad, Shahre-Babak and Kerman had a bimodal-shoulder peaks distribution (Figure 3). The TCI maximum values were found in April, May, October and November. In these areas spring and autumn seasons were determined as having a comfortable climate for tourism activity, especially for ecotourism and agritourism. In these cities, heat made the summer climate uncomfortable for tourists while winters were considered cool.

The cities of Baft and Lalehzar had summer peak distribution (Figure 4). Each of these areas had a TCI scores above 90, evaluations that describe an 'ideal' tourism climate for the summer months. Baft was evaluated as having the most favorable climatic conditions for attracting tourism in the summer because of its location in the upper latitudes of Kerman province. The conceptual winter peak TCI distribution represented by Kahnouj and Jiroft is shown in figure 5. Both cities had four months with a TCI over 80 and as such they were classified as having an 'excellent' tourism climate. Furthermore, these cities were determined as having an 'ideal' tourism climate (TCI scores of over 90) for November. Summer TCI scores in these two cities were lower because of the human discomfort caused by temperatures that often exceeded 44°C. Table 3 shows the five sub-indices of the TCI that contributed to the TCI score of each area and in different seasons. For example Figure 6 (a, b and c) illustrates how contributions of the sub-indices changed from season to season in Kerman, Baft and Jiroft and the disparate climatic strengths of the three cities. Kerman, at 30.25°N latitude and 1753.8 m high from sea level was predominantly classified as having bimodal TCI distribution. Here the thermal sub-indices contributed maximum values in March, April, May, September and October and little during the summer and winter months because of the high and low heat indexes in summer and winter, respectively. While the cooling effect of the wind was an asset during January to May and September to December and contributed to the TCI score, it was detrimental to the TCI score for Kerman in June, July and August when it contributed to a high evaluation for wind chill and thus was absent from the TCI score. Jiroft city located in the south of Kerman province has lower elevation and was on different latitude so it fell into the winter peak class. Like Kerman, wind had a detrimental effect on the TCI score for Jiroft' in the summer months. The city of Baft (western Kerman) was determined as having the most suitable months for tourism activities in the TCI descriptive categories 'excellent' (80<TCI<90) and 'ideal' (90<TCI<100) climatic conditions were from April to October (Figure 6, b). Wind was determined as a climatic asset in Baft all year-around. Similarly, sunshine had a relatively stable positive contribution to TCI throughout the year.

TCI scores for all months in Kerman province were transferred into Geographic Information system (GIS) using Arc GIS 9.3 software. The interpolation process used the Inverse Distance Weighting (IDW) model in ArcMap. This is a method of interpolation that estimates cell values by averaging the values of sample data points in the neighborhood of each processing cell. The closer a point to the center of a cell that is being estimated, the more influence, or weight it has in the averaging process. The IDW technique estimates values using a mathematical function to create a line of best fit that minimizes overall curvature between data intervals. The most suitable areas and months for tourism activities in Kerman province were determined and are shown in Figure 8.

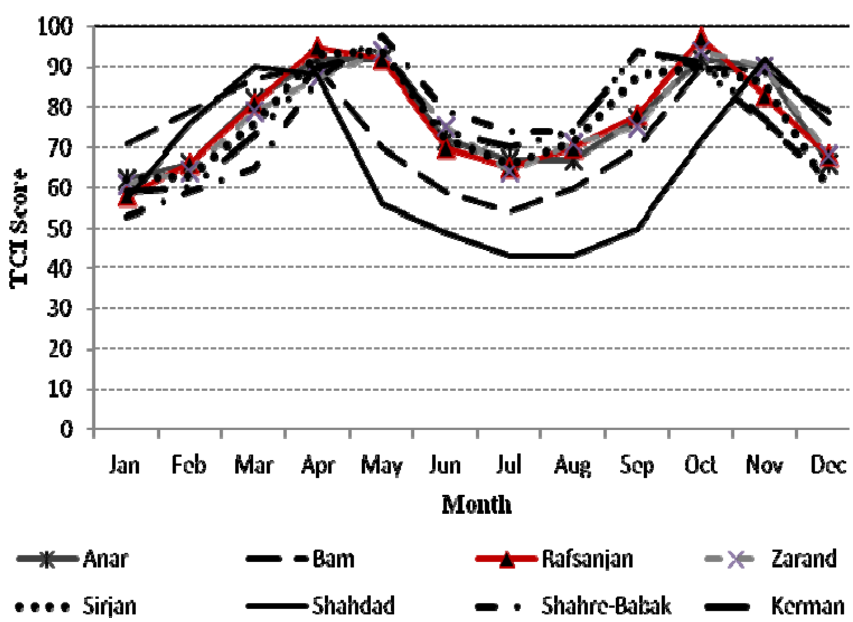

Fig. 3. Cities with bi-modal shoulder peak on the Tourism Climate Index (TCI) distribution in Kerman province (southeastern Iran)

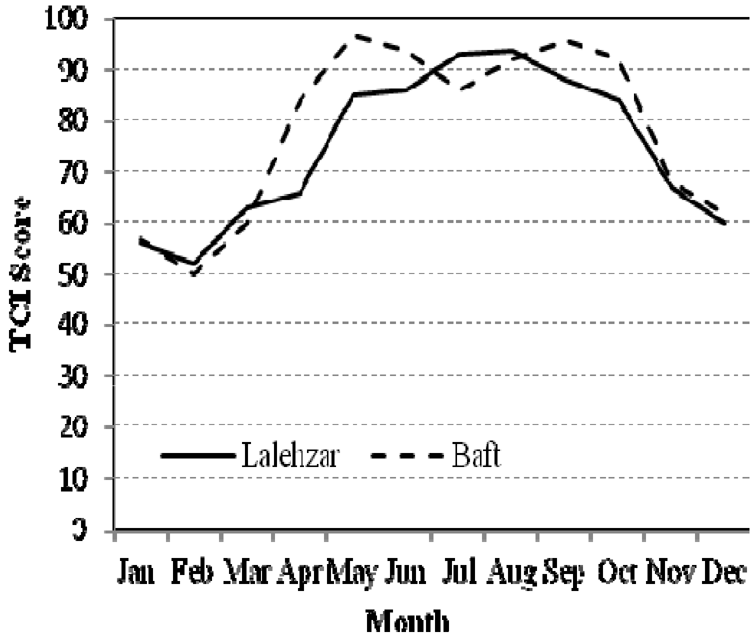

Fig. 4. Cities with summer peak on the Tourism Climate Index (TCI) distribution in Kerman province (southeastern Iran)

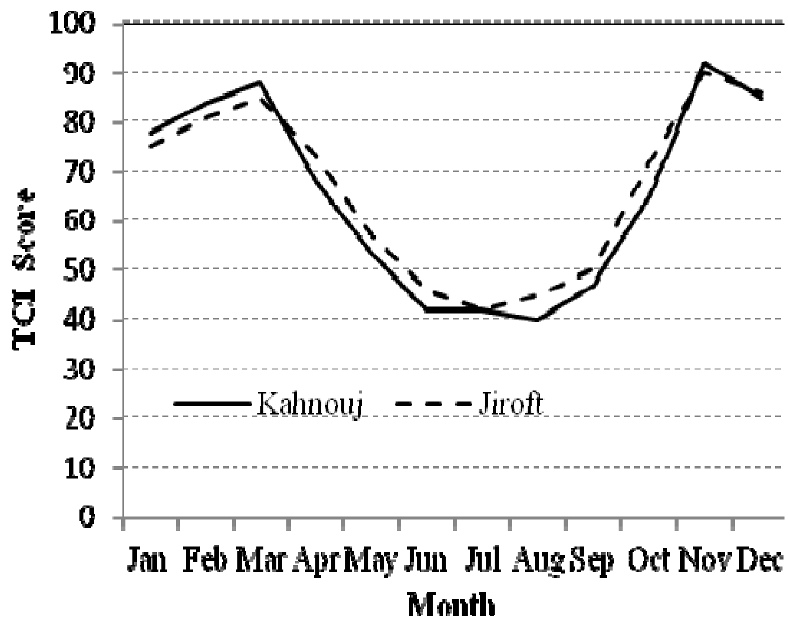

Fig. 5. Cities with winter peak on the Tourism Climate Index (TCI) distribution in Kerman province (southeastern Iran)

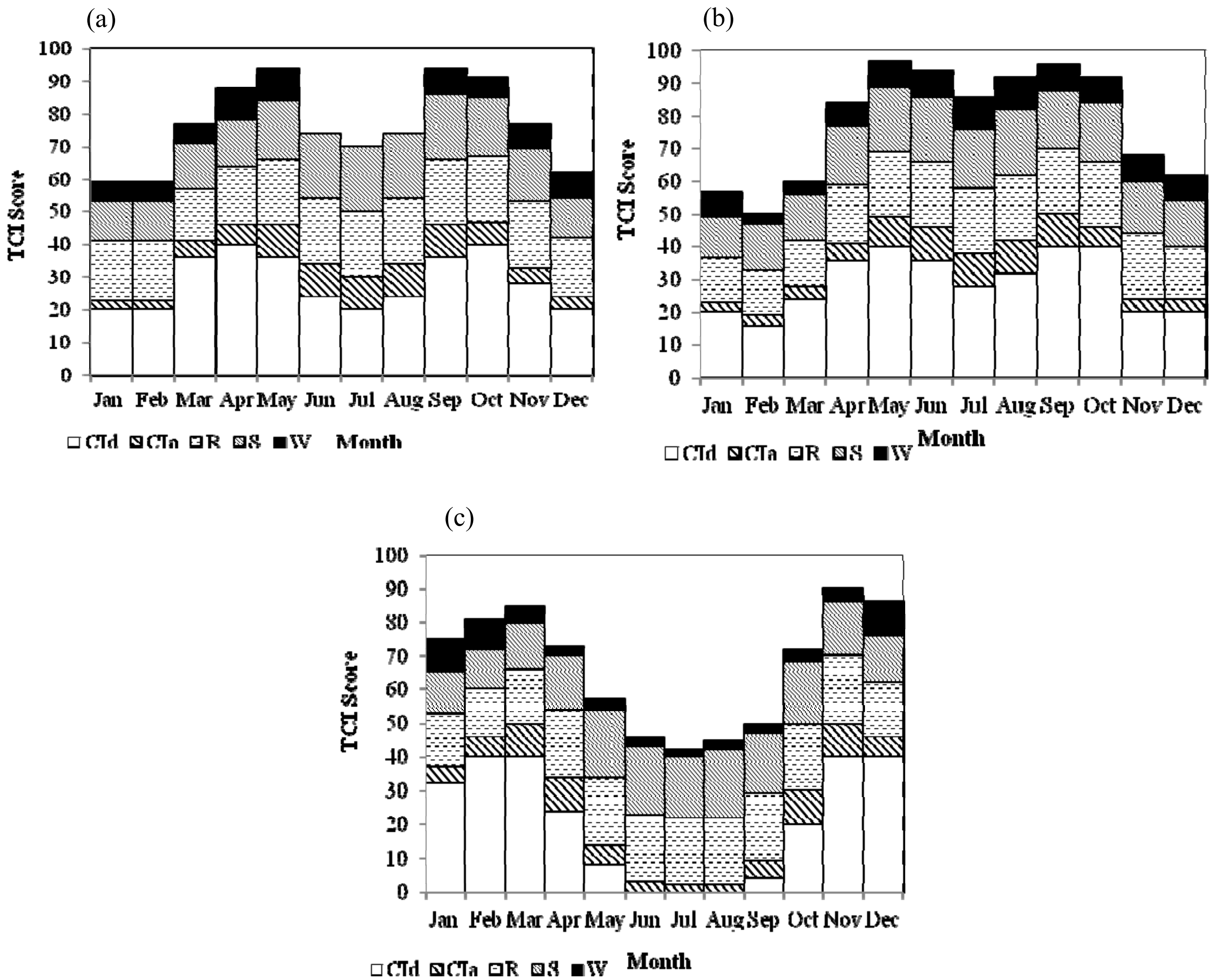

Fig. 6. Seasonal Tourism Climate Index (TCI) sub-indices rating in (a) Kerman, (b) Baft and (c) Jiroft (CId, daytime comfort index; CIa, daily comfort index; R, total precipitation; S, sunshine hours; W, average wind speed)

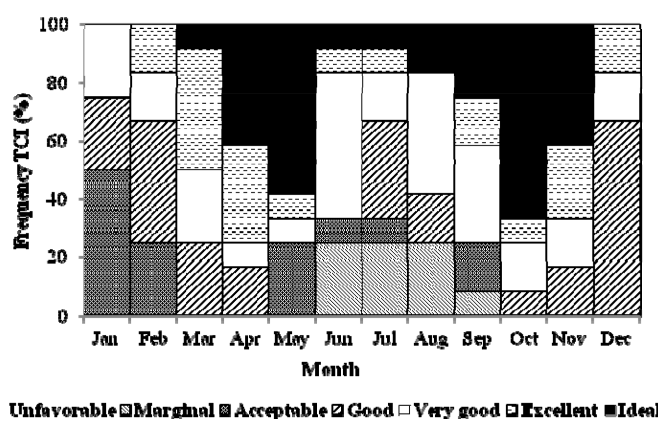

Fig. 7. Frequency diagram of Tourism Climate Index (TCI) classes of Kerman province-Southeast of Iran

4. Discussion

The results of this study are valuable for both domestic and international tourism activities, especially for agritourism and ecotourism in Kerman province, located in southeastern Iran. The most suitable regions in summer, in terms of bioclimatic comfort conditions were located in the southwest of Kerman (Baft and Lalehzar). The cities of Anar, Bam, Rafsanjan, Zarand, Sirjan, Shahdad, Shahre-Babak and Kerman had evaluations showing bimodal-shoulder peak distribution. In these cities spring and autumn weather made them climatically comfortable for tourists. In Kerman province, the most suitable months for tourism activities in the TCI descriptive category 'excellent' climatic conditions (TCI>80) were evaluated for March, April, May, September, October and November (Figure 7). Relevant TCI scores made in April, May, October and November in all of the northwest cities were evaluated in the 'ideal' rating from 40% to 67%. Figure 8 shows that the best regions for tourism activities in March were those in the eastern and southeastern parts of the province. In April the central and northern areas of the province were considered as excellent for tourism activity. But the TCI evaluation was greater than 80 in May in the northwest of Kerman. As shown in Figure 6, the 'marginal' score (40<TCI<50) for the cities of Shahdad, Jiroft and Kahnouj were determined for June (25%), July (25%), August (25%) and September (8.3%).

The result of this study shows that the TCI calculations were consistent with results of related research. Farajzadeh and Matzarakis (2009) showed that in northwestern Iran, cities such as Maku, Ardabli and Takab had 'ideal' tourism climates for the summer months as did Baft and Lalehzar in southeastern Iran. Also, the cities of Mahabad, Jolfa, Marageh, Sagez and Parsabad were determined as having bimodal-shoulder peak distribution in northeastern Iran as did cities of Baft and Lalehzar in Kerman province in the southeast. Human biometeorological results based on combined indices (e.g. TCI) can be used at local and global scales for current and future climatic conditions. This information can be applied to planning and construction in relation to areas of tourism. A range of climate information is needed for tourism climatology, but single meteorological variables in the form of means, extremes, frequencies and probabilities may be less relevant on their own (Lin and Matrazakis 2008). Data analyses were used to calculate TCI because records of daily data were unavailable.

5. Conclusions

Weather and climate can affect visitors' experiences to a destination in physical, psychological and aesthetic terms.

So, it is important to consider these variables in combination in the climatic information available for tourism. Climate information has to be computed and provided for the tourism industry and tourism planning using mean values, extremes and probabilities with some indication of their possible effects and implications. Single parameters such as air temperature or precipitation are inadequate for tourism climatology. The impact of climate and climate information can also be assessed from the perspective of human-biometeorology. TCI is a useful index because uses climatic variables in relation to biometeorological studies on a single index that is readily interpretable by the travelling public. An additional advantage of TCI is its widespread applicability, as the climatological data required for the TCI are generally available for most locations. Also, TCI curves appear to reflect tourism demand as general information. The monthly period used in recent TCIs can be replaced by a timeframe that better resembles the length of most visitors' vacation (7 or 10 days), because of connection to the length of stay during vacation and the availability of data.

The TCI provides a sufficient measure of climate for the average tourist, and may be used to evaluate the appropriateness of sub-index rating systems and weightings in the TCI against stated visitor preferences. Furthermore, validation of the still used index and new developments are needed in order to further assess the value of weather and climate in tourism research, especially for agritourism and ecotourism sectors. The method presented here can be applied for any other climate region of Iran.

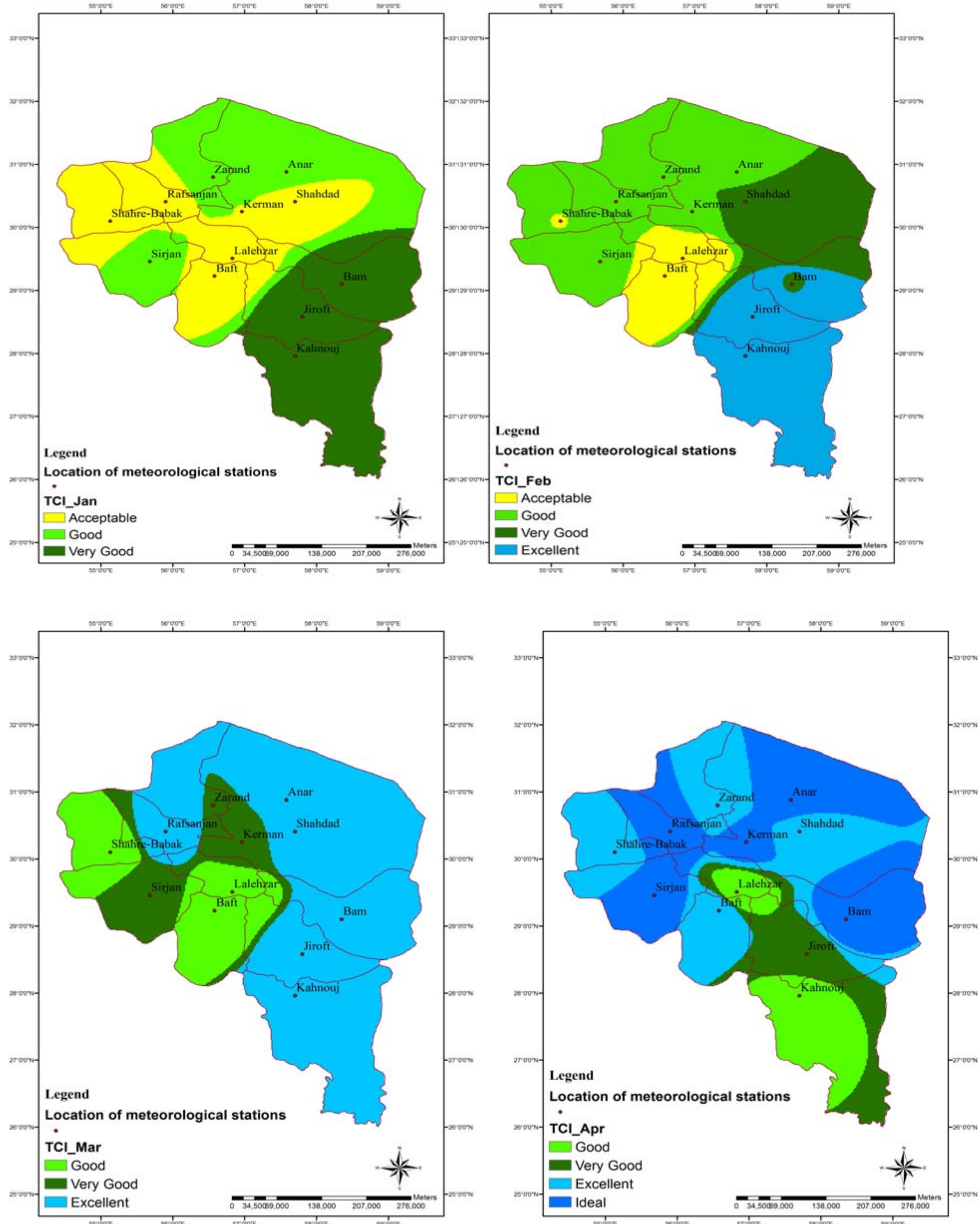

Fig. 8. Geographical distribution of Tourism Climate Index (TCI) scores in different months for Kerman province, southeastern Iran

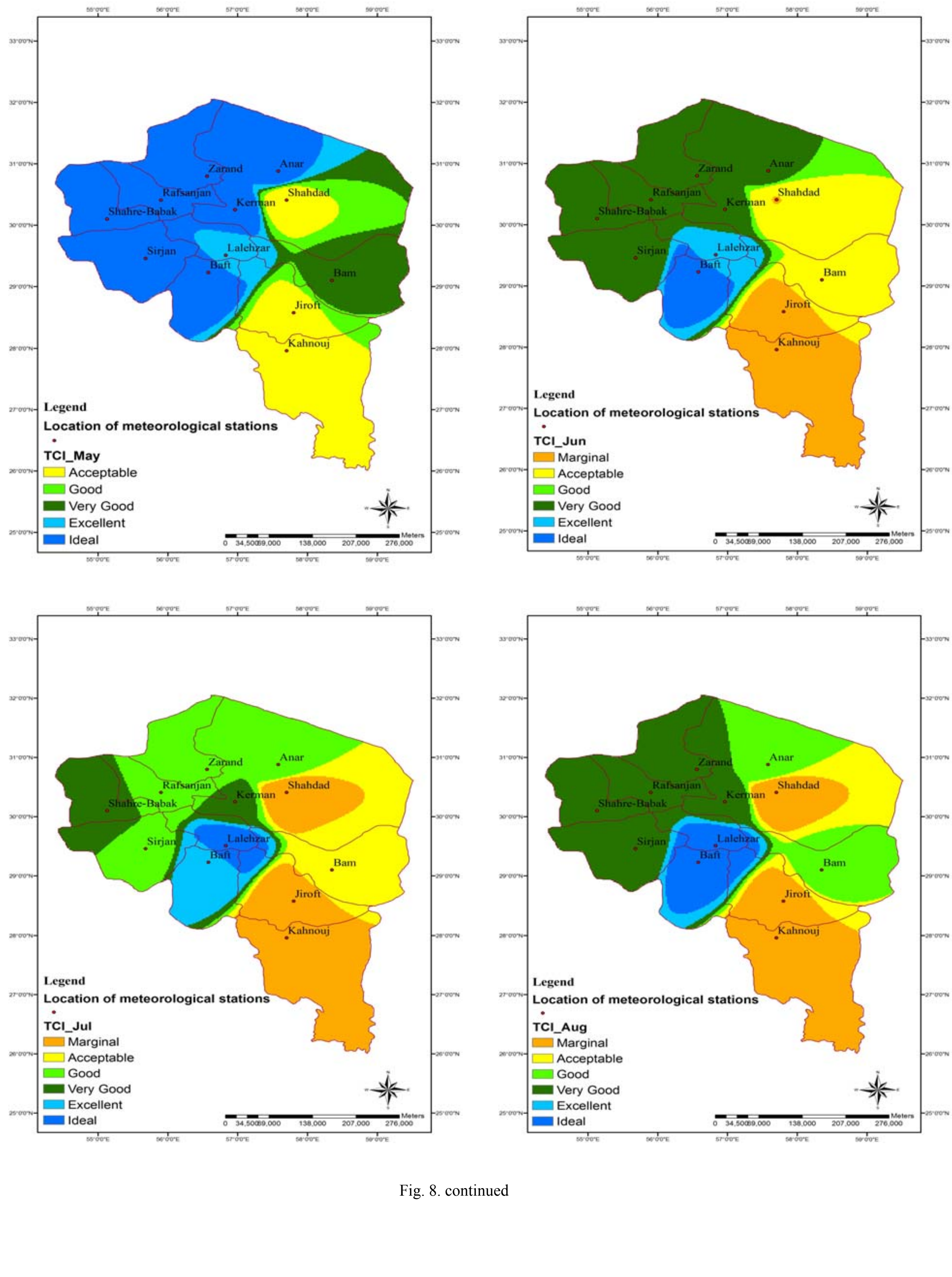

Fig. 8. continued

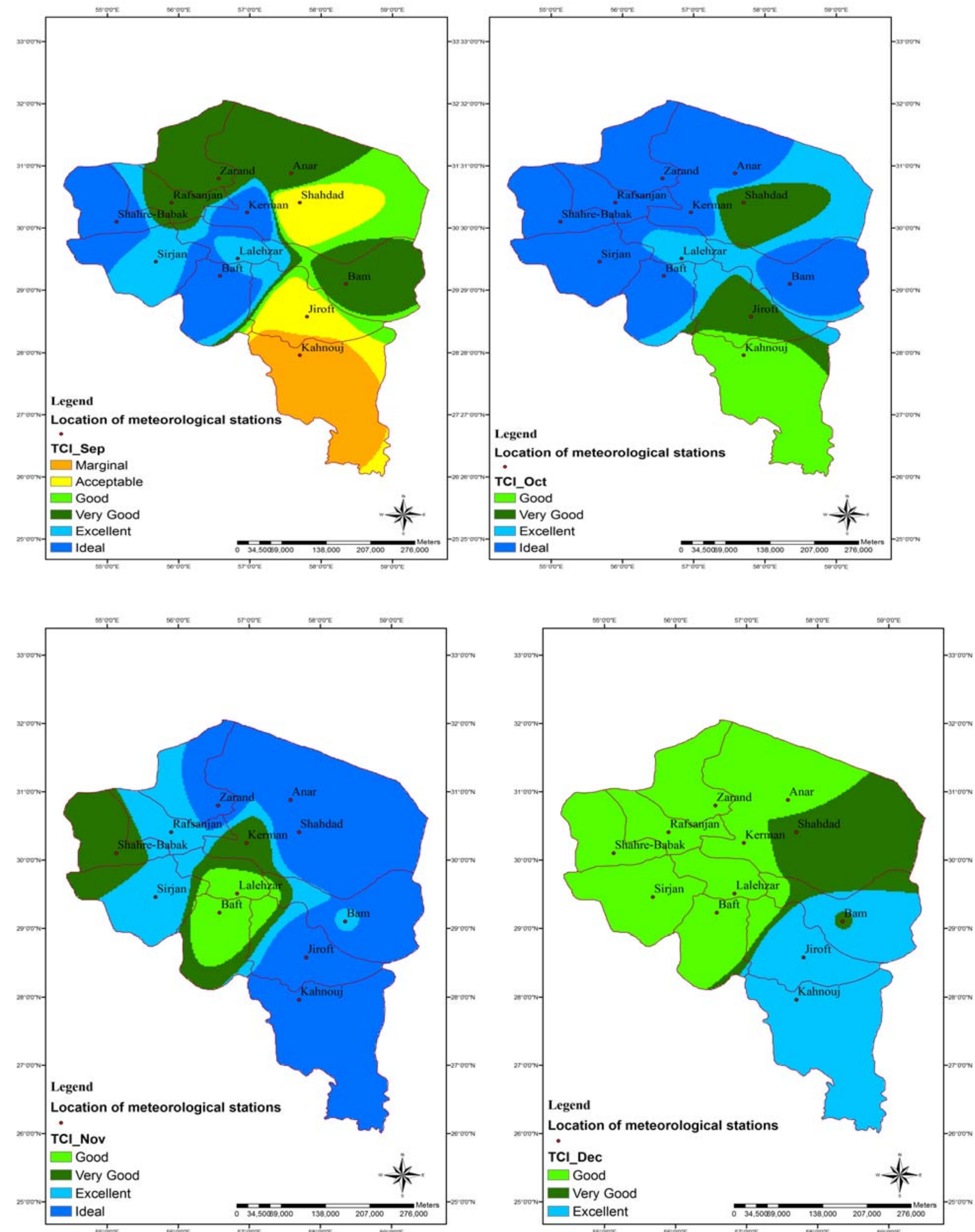

Fig. 8. continued

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