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ORIGINAL ARTICLE

Evaluation and zoning of environmental climatic parameters for tourism feasibility in northwestern Iran, located on the western border of Turkey

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Abstract
The purpose of this study is to evaluate and seasonally map the tourism climate of northwestern Iran using the Tourism Climate Index (TCI). In this study, climate data from 22 synoptic stations of northwestern Iran during 26 years (1993–2018) were prepared to evaluate climate comfort from a tourism perspective. In this system model, seven parameters were used: mean maximum temperature, mean temperature, mean minimum relative humidity, average relative humidity, monthly precipitation, daily mean sunshine and wind speed. For data processing, the TCI index was used to map the tourism climate map for four seasons using ArcGIS. The TCI index was used to process the data and the tourist climate map was drawn up using GIS for 12 months. The results showed that the TCI of the northwest is varied due to topography contrast throughout the year. The months of April, May, June, July, August, September and October have good to ideal conditions with a rating of 60–99 for climatic comfort. The months of November, December, January, February, and March provide inappropriate conditions with a range of 24–52. The areas (Parsabad Moughan and Jolfa) have a favourable climate in the cold months of the year and there is an inappropriate condition for tourism during the warm months. September is the most favourable month with ratings from 78 to 99 and journey is the most inappropriate month for tourism in the northwest with the rank of 24–52. Northwest of Iran, having plenty of tourist attractions, can be a source of domestic and foreign tourists. In addition to the introduction of this region to attract tourists, employment can also be achieved by the planning and management of tourism.

Keywords Modeling · Climate comfort · Zoning · Tourism Climate Index · Climatic parameters · Iran

Introduction

Climatic parameters affect different parts of human life, one of these parts is tourism (Sobhani and Safarian 2019; Mieczkowski 1985). In recent years the rise in temperature has been clearly visible and it can be said that climate change in the tourism sector has both negative and positive effects (Sobhani et al. 2019b; Dominique et al. 2016; Manolis et al. 2016). Among environmental factors, climate parameters such as temperature and precipitation in tourism are important (Andrea et al. 2019; Olya and Alipour 2015; Sobhani et al. 2019a). Tourism is highly dependent on the climate of an area. Humans usually choose areas for tourism that are more climatically comfortable (Daniel et al. 2019, 2016; Ghislain et al. 2016). Climate and tourism affect each other as one of the main components of a system in different ways, and they interact with each other in a new discussion as tourism climatology (Matzarakis 2014; WTO 1998). Increasing temperature in recent years in the study area has been approved by most researchers. The climate is very important from the point of view of tourism planning, and tourists are usually looking for a favourable climate or climate of comfort (in which the person has no discomfort and the lack of thermal and climatic comfort (Scott et al. 2007; Safarianzengir et al. 2019; Amelung and Viner 2006; Sobhani et al. 2018).

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Several studies have been carried out on the application of the TCI index in tourism planning, some of them are mentioned: Fang and Yin (2015) conducted the tourism climate assessment with the TCI in China for 4 years, and the results showed that Tibet Province has favourable tourism conditions one month a year and Yunnan province 10 months a year. Endler et al. (2010) studied horizontal slope changes of air and impact on the climate of the tourism of lush forests. Katerushak and Matzarakis (2016) studied the Thermal Bioclimatic Index and TCI in the Black Sea Coast of Odesa region. Kulendran and Dwyer (2012) examined the study of seasonal change in tourism with the climate index and the results showed that it was suitable for tourism at an optimum temperature. Nicholls and Amelung (2015) examined the application of climate change in the rural areas of the Nordic. Tzu and Liu (2016) studied the impact of climate change on Taiwan's National Park tourism. Zhang and Kulendran (2016) studied the impact of climate change on tourism seasonal changes in Hong Kong. Ahmadi (2012) evaluated the comfort of the tourism climate of Sanandaj city and the results showed that the best time of tourism in Sanandaj is from late May to late October. Gandomkar (2010) studied the comfort of the tourist climate in Semirom and concluded that the city is suited to tourists in September and May, respectively. Astani and Sobhaniardakani (2012), in the evaluation of the TCI for the International Lagoon of Shadegan, concluded that June and August are the best climatic conditions for tourism. Esmaili et al. (2012) evaluated the comfort climate of some of Iran's main tourism cities using the physiological equivalent temperature index and concluded that among the studied cities, Kish Island, Mashhad, Isfahan, and Rasht are the best destinations for Nowruz travels. The second priority of the Nowruz trips belongs to the city of Rasht. The cities of Mashhad and Isfahan have the limitations of cold stress during the Nowruz holiday. Asadollahi et al. (2012) in a study on the climate comfort of Cheghakhor Lagoon using the TCI method concluded that May and June are the best climates for tourists, and the months of December, January and February have inappropriate climates for tourists. Mohammadi et al. (2013) in a study titled "Determine the comfort index of the tourism climate in East Azarbaijan province using the TCI" concluded that the months of June, July, August, and September provide the best conditions for the tourists in the province. Yazdanpanah et al. (2013) studied the climatic conditions for the development of tourism using the TCI index for nine synoptic stations in East Azarbaijan province for a period of 20 years (1990–2010) and the results were entered into the GIS. Then, the zoning of the tourism climate conditions of the province was carried out using the GIS in different months, and it was concluded that the May, June, June, August, and September months have the best conditions for the climatic comfort of tourists. The months of December, January, February, and March are the worst conditions. Hassanpour (2012) in the evaluation of the climatic conditions of Bandar Anzali in terms of tourism based on the TCI showed that July and May months are most suitable for the presence of tourists in the city due to the favourable heat situation and lower rainfall. Jafari et al. (2014) determined the climate of tourism comfort of the Sarab Gian Nahavand with the TCI. The results showed that in the months of September and June, the climate comfort of the region has ideal conditions for the presence of tourists. Salmanimoghadam and Jafari (2015) evaluated the tourism comfort climate of Zanjan province using the TCI. The results showed that the months of May, June, August, September, and October are excellent and ideal for the presence of tourists in the province, and November, December, January, February, March, and April are not suitable for tourists. Astani and Sobhaniardakani (2011) evaluated the climate tourism index of tourism in Hamedan and the results showed that June and September are ideal for tourism.

Therefore, knowledge of climate conditions and its application can be very valuable and useful for tourism designers. The northwest regions of the country have high potential in the tourist climate, due to attractive nature and diverse climate. Nevertheless, it is possible to plan for attracting tourists using the climate comfort index and identifying the climatic conditions and the potential of the region's bioclimatic.

Materials and methods

Study area

The study area is located in the northwest of Iran, including the provinces of Ardabil, East Azerbaijan, and West Azarbaijan in geographical coordinates between 35 ° 58′ and 39 ◦ 46′ N latitude and 44 ◦ 3′–48 ◦ 55′ E longitude. The required climatic information was provided from 22 synoptic stations during the 26-year statistical period (1993–2018). Figure 1 shows the location of the study area.

Research methodology

The research approach is descriptive-analytic, due to components examined and the nature of the subject. In this research, the TCI and the climatic data of 22 synoptic stations of the province have been used in to evaluate the conditions of the tourism climate and northwest climate attractions from the point of view of tourism. At first, seven climatic parameters were extracted monthly from synoptic stations in the northwest during the 26 years (1993–2018). Then, the relevant database was formed and processed using the TCI. After calculating the TCI for each month of the

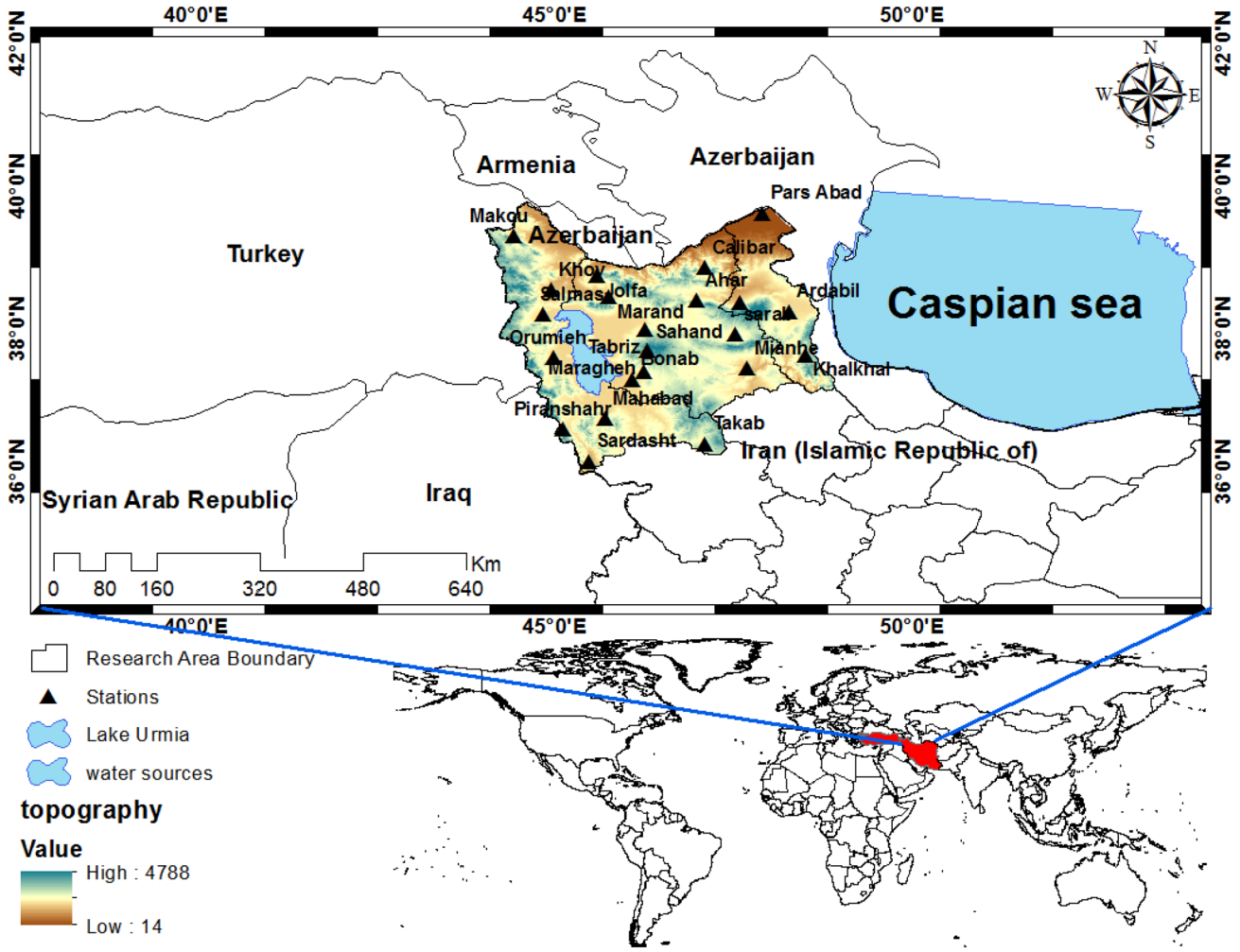

Fig. 1 Location of the study area

year, given the results obtained as a point, the inverse-distance weighing method (IDW) was used to zone the regional tourism climate conditions and convert the point data from the stations to the surface information, and finally the map TCI was obtained for the northwest.

Introducing TCI

Tourism Climate Comfort Index (TCI) was introduced in 1985 by Mieczkowski. In fact, it is a combination of climatic factors affecting the tourist's comfort. The advantage of the TCI than other indicators is more because it uses all the important climate variables, such as temperature, humidity, precipitation, wind and sunny hours in tourism, which control the human body's thermal conditions (Mieczkowski 1985; Farajzadeh and Ahmadabadi 2010). There are seven variables used in this index (Mieczkowski 1985; Saeedi et al. 2012): (1) average daily maximum temperature, (2) average daily temperature, (3) average daily minimum relative humidity, (4) average daily relative humidity, (5) total monthly precipitation, (6) total sunny hours, and (7) average wind speed. These seven variables make up five sub-indicators in TCI, which are:

Daily Comfort Index (CID)

Includes maximum daily temperature and average daily relative humidity. This index shows the thermal comfort conditions at the maximum of tourism activity (Fig. 2) and its share is 40% in TCI.

Temperature and humidity variables are based on the graph (comfort factor) used to measure the thermal comfort which expresses individual physiological and psychological sensation. It is obtained from the intersection of temperature and relative humidity. In the comfort index, the most favourable and optimal area for thermal comfort is between 20 and 27 °C and relative humidity of 70–30%. This area

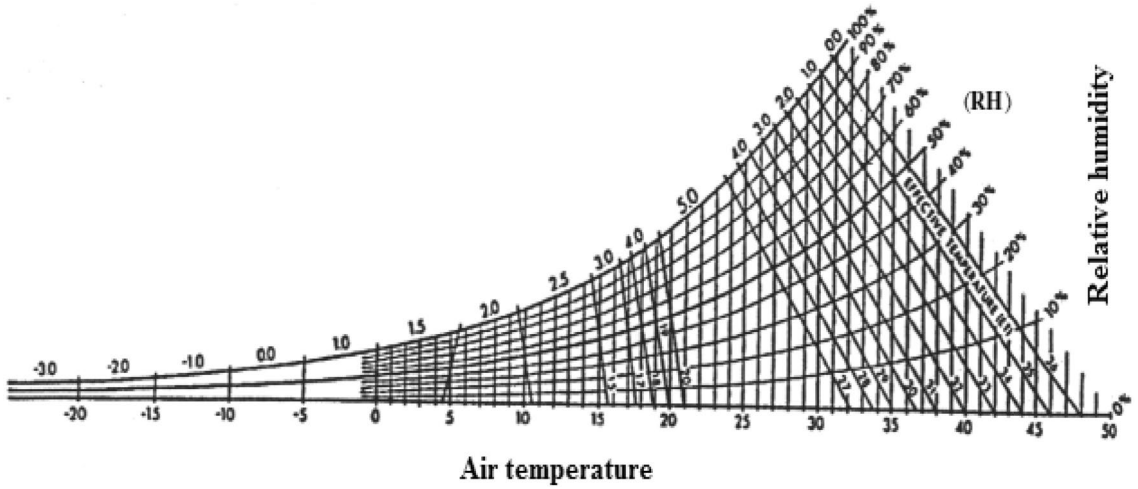

Fig. 2 Determination of the values of thermal indicators. Mieczkowski (1985)

has optimum conditions for thermal comfort (Mieczkowski 1985; Jafari et al. 2014).

24-hour Comfort Index (CIA)

Includes daily average temperature and daily average humidity. This index shows the thermal comfort all day and night, and its share is 10% in the TCI. We used from the corresponding figure to calculate the Daily Comfort Index (CID) and the 24-h Comfort Index (CIA), the share of both indicators is 50% in the TCI, (CID is 40% and CIA is 10%). The CID is derived from the maximum daily temperature and minimum relative humidity variables (Mieczkowski 1985; Asadollahi et al. 2012).

Precipitation (P): in general, rainfall has a negative effect on recreational activities and tourism. The share of the sub-index is 20% in the TCI. The value of the precipitation rank is obtained using Table 1. In this system, precipitation ranking decreases with increasing precipitation, which shows the negative effect of precipitation on the pleasure, recreation, and comfort of the tourists.

Sunny hours (S): sunlight is considered as a positive factor in climatic comfort. The sunlight parameter, like rainfall, has a weight of 20% in TCI. This variable is obtained by dividing the average monthly hours of sunshine by the number of days in each month and we used Table 2 to determine the ranking.

Average wind speed: the effect of this variable depends on the air temperature. It has a positive effect in the hot climate, due to evaporation and cooling, but it has a negative effect on human comfort in a cold climate, due to the wind cooling effect. Also, increasing the wind speed will increase uncomfortable, as a result, it is considered a negative factor and its rank in the TCI index is lowered. Four types of wind speed ranking systems are considered for the TCI formula. In the normal system, the lowest average monthly wind

Table 1 Monthly precipitation index (*P*), Mieczkowski (1985)

Total monthly precipitation	Precipitation ranking
0 to 5.14	5
15 to 29.9	4.5
30 to 44.9	4
45 to 59.9	3.5
60 to 74.9	3
75 to 89.9	2.5
90 to 104.9	2
105 to 119.9	1.5
120 to 134.9	1
135 to149.9	0.5
150 or more	0

Table 2 Sunny hours' index (*S*), Mieczkowski (1985)

Number of sunny hours per day	Radiation ranking
10 h or more	5
9 to 9.59	4.5
8 to 8.59	4
7 to 7.59	3.5
6 to 6.59	3
5 to 5.59	2.5
4 to 4.59	2
3 to 3.59	1.5
2 to 2.59	1
1 to 1.59	0.5
< 1	0

speed has the highest rank and indicates its desirability for climatic comfort. The normal system is used when the average temperature is between 15 and 24 °C (Table 3).

The above variables are weighed and ranked according to their relative importance in the comfort of tourism to calculate the tourism climate index and give the sub-indicators, and finally, the TCI is obtained based on the following equation:

$$\mathrm{TCI} = 2(4\mathrm{CID} + \mathrm{CIA} + 2P + 2S + W). \quad (1)$$

In this formula, the CID is a 24-h comfort index, P monthly precipitation, S sunny hours and W is the wind variable (Table 4). The ranking of each of the above variables should be placed in the formula to obtain the TCI value. The daily comfort index and the 24-h comfort index are obtained from the Michalowski index graph using maximum daily temperature and minimum relative humidity, daily average and average relative humidity. Further values represent ideal conditions. Also, dissatisfaction and unfavourable climatic conditions increase for tourists towards fewer values. The resulting number with the final table (Table 5) checks the quality of the tourism climate, and finally, the characteristic of the tourism climate of the region is obtained at that time (Mieczkowski 1985).

Table 3 Wind speed index, km/h (W), Mieczkowski (1985)

Wind speed (km/h)	Normal system	Elisa system	Hot climate system
< 88.2	5	2	2
2.88 to 5.75	4.5	2.5	1.5
5.76 to 9.03	4	3	0.5
9.04 to 23.12	3.5	4	0
12.24 to 79.19	3	5	0
19.80 to 29.24	2.5	4	0
24.30 to 79.28	2	3	0
28.80 to 52.38	1	2	0
> 52.38	0	0	0

Results and discussion

After calculating the five components based on Eq. (1), the numerical value of the TCI for each point was estimated and the numerical values of the tourism climate index and related climatic clusters were determined using Table 5. In the following, the maps were drawn using ArcGIS software for each month and based on the climate tourism index.

Maps of the northwest tourism climate in different months

The tourism climate in January (Fig. 3) showed that the northern regions (the southern range of the Aras River) around Lake Urmia and the Mianeh city are in a desirable

Table 5 Final coefficient and quality of climate conditions for tourists, Mieczkowski (1985)

Climatic group	Rank	The range of TCI index
Ideal	9	90 to100
Excellent	8	80 to 89
Very good	7	70 to 79
Good	6	60 to 69
Acceptable	5	50 to 59
Little-marginal	4	40 to 49
Inappropriate	3	30 to 39
Very inappropriate	2	20 to 29
Extremely unpleasant	1	10 to 19
Impossible	< 0	9 to − 30

Table 4 Indicators effective on tourism, Mieczkowski (1985)

Sub-indicator	Monthly climate variable	Impact on tourism	Score in model
CID	Average maximum daily temperature and average minimum relative humidity	Indicates the thermal comfort when the tourists have maximum activity	40
CIA	Average daily temperature and average relative humidity	Shows the thermal comfort of the 24-h, including sleeping hours	10
P	Total precipitation	Reflects the negative effect this element on holiday	20
S	Total sunny hours	It is positively evaluated for tourism and has a negative impact in hot days due to the risk of sunburn and discomfort	20
W	Average wind speed	The effect of this element depends on the temperature. The effect of wind cooling is evaluated positively in the warm climate, while the effect of wind cooling is evaluated negatively in cold climates	10

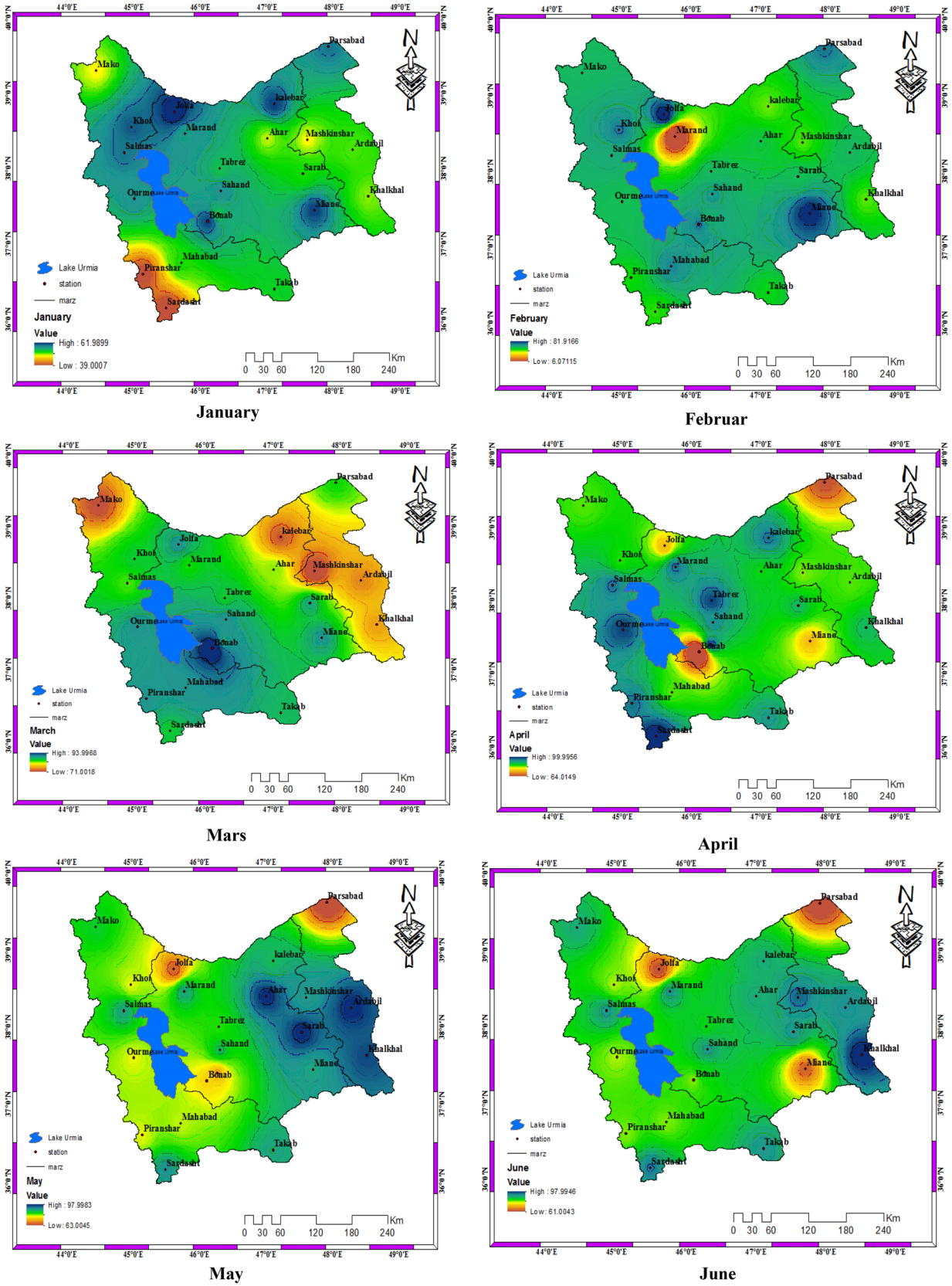

Fig. 3 Climatic zonation of the northwestern of Iran, monthly, using the tourism climate index (TCI)

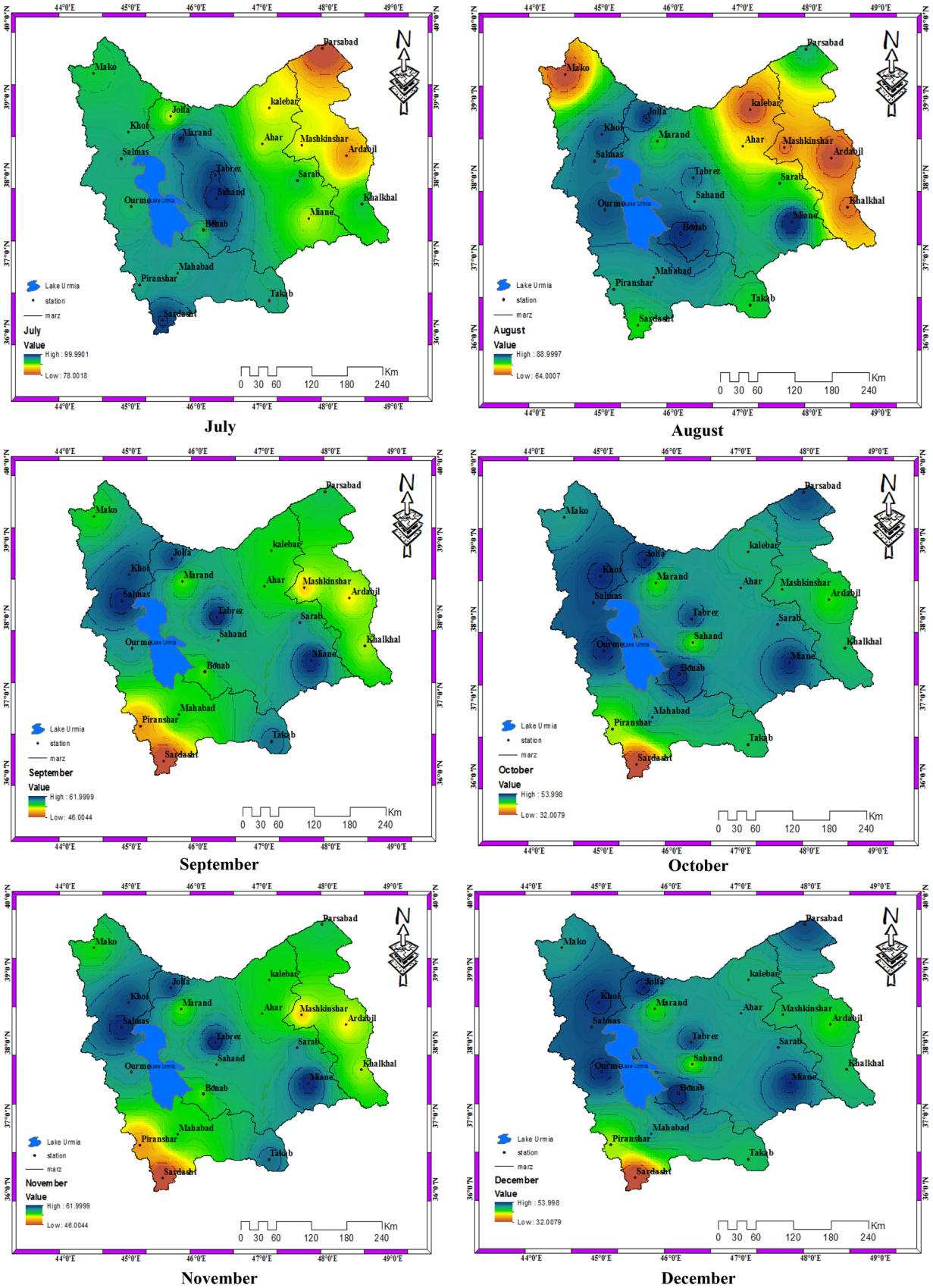

Fig. 3 (continued)

Table 6 Iran's Northwest Tourism Calendar for 22 stations based on the TCI

Row	Stations	January	Descriptive	February	Descriptive	March	Descriptive	April	Descriptive	May	Descriptive	June	Descriptive
1	Ardabil	42	Low marginal	48	Low marginal	51	Acceptable	62	Good	76	Very good	88	Excellent
2	Khalkhal	45	Low marginal	42	Low marginal	50	Acceptable	52	Acceptable	77	Very good	92	Ideal
3	Meshkin	44	Low marginal	45	Low marginal	48	Low marginal	52	Acceptable	71	Very good	87	Excellent
4	Parsabad	53	Acceptable	53	Acceptable	58	Acceptable	71	Very good	84	Excellent	76	Very good
5	Tabriz	48	Low marginal	42	Low marginal	54	Acceptable	62	Good	85	Excellent	98	Ideal
6	Ahar	44	Low marginal	44	Low marginal	49	Low marginal	60	Good	82	Excellent	90	Ideal
7	Bonab	47	Low marginal	55	Acceptable	60	Good	71	Very good	94	Ideal	64	Good
8	Jolfa	49	Low marginal	55	Acceptable	62	Good	82	Excellent	88	Excellent	82	Excellent
9	Sahad	38	Inappropriate	52	Acceptable	57	Acceptable	67	Good	88	Excellent	95	Ideal
10	Kaleybar	47	Low marginal	50	Acceptable	60	Good	51	Acceptable	74	Very good	96	Ideal
11	Maragheh	49	Low marginal	50	Acceptable	54	Acceptable	63	Good	87	Excellent	98	Ideal
12	Marand	45	Low marginal	51	Acceptable	56	Acceptable	6	Good	84	Excellent	96	Ideal
13	Mianeh	48	Low marginal	55	Acceptable	60	Good	81	Excellent	88	Excellent	82	Excellent
14	Sarab	42	Low marginal	32	Inappropriate	52	Acceptable	61	Good	87	Excellent	92	Ideal
15	Khoy	47	Low marginal	53	Acceptable	59	Acceptable	71	Very good	85	Excellent	89	Excellent
16	Urmia	49	Low marginal	49	Low marginal	57	Acceptable	61	Good	88	Excellent	98	Ideal
17	Mashabad	45	Low marginal	45	Low marginal	52	Acceptable	70	Very good	88	Excellent	88	Excellent
18	Maku	47	Low marginal	49	Low marginal	48	Low marginal	62	Good	73	Very good	88	Excellent
19	Salmas	46	Low marginal	54	Acceptable	58	Acceptable	64	Good	83	Excellent	96	Ideal
20	Piranshahr	3	Inappropriate	38	Inappropriate	39	Inappropriate	56	Acceptable	88	Excellent	96	Ideal
21	Sardasht	24	Very inappropriate	36	Inappropriate	39	Inappropriate	54	Acceptable	85	Excellent	100	Ideal
22	Takab	43	Low marginal	49	Low marginal	53	Acceptable	57	Acceptable	86	Excellent	94	Ideal
Row	Stations	July	Descriptive	August	Descriptive	September	Descriptive	October	Descriptive	November	Descriptive	December	Descriptive
1	Ardabil	98	Ideal	91	Ideal	83	Excellent	94	Good	53	Acceptable	45	Low marginal
2	Khalkhal	96	Ideal	98	Ideal	92	Ideal	67	Good	54	Acceptable	47	Low marginal
3	Meshkin	91	Ideal	93	Ideal	87	Excellent	67	Good	52	Acceptable	47	Low marginal
4	Parsabad	63	Good	61	Good	78	Very good	81	Excellent	57	Acceptable	52	Acceptable
5	Tabriz	84	Excellent	84	Excellent	98	Ideal	85	Excellent	62	Good	52	Acceptable
6	Ahar	98	Ideal	88	Excellent	88	Excellent	73	Very good	56	Acceptable	49	Low marginal
7	Bonab	76	Very good	80	Excellent	92	Ideal	88	Excellent	55	Acceptable	54	Acceptable
8	Jolfa	68	Excellent	64	Good	88	Excellent	87	Excellent	61	Good	53	Acceptable
9	Sahad	88	Excellent	90	Excellent	100	Ideal	83	Excellent	58	Acceptable	44	Low marginal
10	Kaleybar	88	Excellent	88	Excellent	87	Excellent	64	Good	56	Acceptable	48	Low marginal
11	Maragheh	74	Very good	84	Excellent	98	Ideal	87	Excellent	58	Acceptable	51	Acceptable
12	Marand	90	Excellent	90	Excellent	98	Ideal	79	Very good	55	Acceptable	45	Low marginal

Table 6 (continued)

Row	Stations	July	Descriptive	August	Descriptive	September	Descriptive	October	Descriptive	November	Descriptive	December	Descriptive
13	Mianeh	90	Ideal	66	Good	88	Excellent	89	Excellent	62	Good	53	Acceptable
14	Sarab	98	Ideal	90	Excellent	92	Ideal	79	Very good	59	Acceptable	50	Acceptable
15	Khoy	79	Very good	79	Very good	93	Ideal	86	Excellent	61	Good	53	Acceptable
16	Urmia	79	Very good	79	Very good	93	Ideal	86	Excellent	59	Acceptable	53	Acceptable
17	Mahabad	80	Excellent	80	Excellent	94	Ideal	83	Excellent	56	Acceptable	49	Low marginal
18	Maku	86	Excellent	88	Excellent	92	Ideal	63	Good	56	Acceptable	49	Low marginal
19	Salmas	90	Ideal	90	Ideal	94	Ideal	85	Excellent	62	Good	52	Acceptable
20	Piranshahr	79	Very good	80	Excellent	94	Ideal	82	Excellent	50	Acceptable	43	Low marginal
21	Sardasht	92	Ideal	92	Ideal	98	Ideal	78	Very good	46	Low marginal	32	Inappropriate
22	Takab	90	Excellent	90	Excellent	94	Ideal	79	Very good	60	Good	47	Low marginal

condition with a numerical index of 30–52. Southwestern regions of West Azarbaijan Province, East Azarbaijan Province (Sahand Mountain), and Ardabil Province (around Sabalan Mountain) have unfavourable conditions and an index of less than 30, due to the presence of snow and cold in the region, which has lowered the tourism climate index in these areas. Farajzadeh and Ahmadabadi (2010) have introduced cold weather in the northwest region in January–February, causing the tourist undesirability. The tourism climate conditions in February (Fig. 3) showed that the southwestern parts of West Azerbaijan, centre and south of Ardebil province, the slope around Sabalan Mountain and north of Sahand Mountain have unsuitable climatic conditions with a numerical index of 32–40, and the south of the Aras River, around Lake Urmia and the Mianeh city shows an acceptable status with a numerical index of 40–45. The tourism climate situation in March (Fig. 3) shows that northern regions, except the Maku town, around Lake Urmia, the central, southern and northern parts of East Azerbaijan, are in an acceptable condition with a numerical index of 50–61. In the central and southern regions of the province of Ardabil and East Azarbaijan (the Sabalan and Sahand mountains), southwest and northwest of West Azarbaijan are in the marginal condition with rank 39–49, which includes most of the highland and mountainous parts (Rordeh et al. 2014) that have expressed the height factor in increasing and decreasing the TCI.

The tourism climate in April (Fig. 3) shows that the northern regions of East Azerbaijan and the south of Ardabil and the south of West Azerbaijan province are in good condition with a numerical index of 60–69 and in other areas such as the Mianeh city, south of Lake Urmia, Moghan plain and the north of West Azarbaijan are in very good condition with index 70–80 (Hassanvand et al. 2011). April is the most suitable month with the ideal and excellent conditions, and January and February are the most unsuitable months for tourism in Lorestan province with the marginal conditions. The climate of comfort in May (Fig. 3) shows that the province of Ardabil and the northeast and northwest of the West Azarbaijan are in a very good condition with a numerical index of 71–80. The East and West Azerbaijan regions are in excellent condition with an index of 80–93. In Isfahan province (Gandomkar 2010), the May and April months have offered the best conditions for the presence of tourists based on the TCI.

Climatic comfort conditions in June (Fig. 3) show that Moghan plain (Parsabad, Bileh Savar and Germi), Mianeh and Bonab cities are in good condition with a numerical index of 64–75. The central parts of Ardabil province, north of West Azarbaijan have very good conditions with a numerical index of 70–79, northeast of East Azarbaijan and the south of Ardabil province are excellent with an index of 80–89, and the west and south of West Azerbaijan

is ideal with a numerical index of 90–100. Sarisaraf et al. (2010) showed that June, July, August, and October are the most suitable months in the Arasbaran region with rank 90–100. Climate conditions (Fig. 3) in Parsabad Moghan, Jolfa and Bonab are good with a numerical index of 60–69. West Azarbaijan and the west of East Azarbaijan are in good conditions, Sardasht, Salmas, Marand, Kaleybar, and Mianeh have excellent conditions with a numerical index of 90–99, and the centre and south of Ardabil and Sarab have an ideal condition for the tourism climate with an index of 90–100.

Climatic conditions (Fig. 3) Parsabad, Moghan, Mianeh, Jolfa is good with numerical index 60–69 in August, around the Lake Urmia and Khoy are very good with a numerical index of 70–79. Maku town, Tabriz, and Salmas are excellent with a numerical index of 80–89 and centre and south of Ardabil province, the east of East Azarbaijan, Marand, Sardasht, Salmas and Sahand cities are ideal for tourism with a numerical index of 90–100. September climate conditions (Fig. 3) in Ardabil province and the east of East Azerbaijan was excellent with a numerical index of 78–90, and West Azerbaijan and the west of East Azarbaijan have ideal conditions for tourism with a numerical index of 90–100.

October climate conditions (Fig. 3) in Ardabil and Northeast of East Azarbaijan and Maku city are good with a numerical index of 60–69, Parsabad Moghan, Marand, Takab and Sardasht cities have a very good conditions with a 70–79 index, and the parts of West Azerbaijan and East Azarbaijan have excellent conditions with the index of 80–89 for the tourism climate. Gandomkar (2010) stated October, April, and May months are the most suitable months for the tourists, according to the TCI. November climate conditions (Fig. 3) of Ardabil province and southwest of Urmia and Maku are marginal with a numerical index of 44–54 and the climate conditions in the north of West Azerbaijan and north, northwest and south of East Azerbaijan are poor and good with the index from 55 to 65 for tourism.

Climate comfort conditions in December (Fig. 3) in the south of West Azerbaijan, south and centre and south of Ardabil province showed an inappropriate condition with the numerical index of 30–39. The northern and central parts of the East Azarbaijan Ahar and Parsabad have a marginal condition with the numerical index of 40–53. On the contrary, in Ilam province, November and December, and the southern regions of Iran are most suitable for tourists, according to the TCI.

Calendar of tourism climate in the northwest based on the TCI

The final coefficient of the tourism climate is presented monthly for each of the studied stations in the northwest of Iran (Table 6). This table is a tourism calendar that is presented based on the analysis of climatological data of the TCI for the northwest as follows: (1) in January only Parsabad Moghan station is acceptable with a numerical index of 50–59 for tourism. Other northwest regions are inappropriate for tourism, due to cold weather. (2) Parsabad, Kaleybar, Jolfa, Sahand, Maragheh, Marand, Mianeh and Salmas stations are acceptable for tourism in February, and other stations are unsuitable for tourism. (3) Meshkinshahr, Ahar, Maku, Piranshahr and Sardasht stations are inappropriate and other stations are acceptable and good for tourism in March. (4) Jolfa Station is in excellent condition and Parsabad, Bonab, Khoy, Mahabad are in very good conditions in April and other stations are in good and acceptable conditions. (5) The conditions are ideal to very good in June, July, August, September, and October months, for all the stations, and the Parsabad, Jolfa and Mianeh stations are in the good conditions for tourism in the summer months, due to the increase in the temperature. (6) Except for the station of Piranshahr, other stations are in good condition for the tourism climate in November. (7) Tourism climate in December is similar to April.

Conclusions

Northwest of Iran, with plenty of tourist attractions, can be the reason for the presence of domestic and foreign tourists. Beautiful and unique landscapes and diverse weather conditions in all seasons can be a step towards the development of this industry. Based on the climate comfort index of tourism (TCI) and the use of ArcGIS in the northwest, stations in which the tourism climate conditions are good and acceptable in the cold months (January, February, and March), the conditions are inappropriate in the warm months (June, July, August), due to the increase in temperature at those stations. Except for Parsabad Moghan station with rank 53 and acceptable for tourist climate, the rest of the stations are inappropriate for tourism in January. In other words, in the northwest, the most unfavourable month is January based on the TCI for the tourism climate. The most suitable month in September for the northwest tourism climate based on the TCI that its climate condition is very good to ideal with the numerical index of 78–100 in all stations. The cold months (December to March) on the South coast of Aras on the Iran border, especially in the Moghan plain, show the most favourable conditions for tourism according to the TCI. Mai station, which is located on the slopes of Sabalan, Sahand, Bozgush, Qarrah Dagh, Misho and western highlands of Urmia from mid-spring to mid-autumn (from May to November) have relatively good conditions for the presence of tourists.

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Compliance with ethical standards

Conflict of interest The author declares that there is no conflict of interests regarding the publication of this manuscript.

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