

Climatic Comfort Potentials in the View of Tourism in Ilam Province Using Equivalent Temperature Index (ETI) and Discomfort Index (DI)

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Abstract

The purpose of present research is to assess Ilam provincial climate in the view of tourism using Equivalent Temperature Index Discomfort Index. In this regard, it was used dataset of National Meteorology Organization and statistics of General planning and management Department, Ilam provincial stations (& stations) from the date of their opening to the end of 2016. Then, collected data were considered by two respective indices. Discomfort Index will calculate the rate of human discomfort in relation to thermal factor using air temperature, relative humidity (RH) and wind rate. Equivalent Temperature Index will assess common effects of temperature on living organism in relation to air temperature and evaporation. Results obtained from Ilam provincial tourism climate by means of Equivalent Temperature Index showed that the lowest and highest annual scores were related to Ilam and Dehloran cities, respectively. Results of Discomfort Index (DI) showed that the lowest and highest DI scores related to Ilam city in January and Dehloran city in July were 614 and 28.8, respectively. Based on obtained results, Ilam province had two different spatial and temporal spans for tourism. Tow that, in regard to tourist attraction, if northern region has optimal conditions in one season, at the same time, there is no optimal conditions in southern regions.

Keywords: Tourism; Discomfort index; Equivalent Temperature; The province of Ilam; GIS.



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1. Introduction

Tourism is considered as one of emergent activities of modern human with so many effects on different economic, social, cultural and political sectors to every community. This industry is developing to one of main remunerative industries at the whole world. Its GDP and global occupation rates have been 10% and 10%, respectively (UNWTO, 2008). As such, most researchers believed that tourism could act as the main basis of sustainable development also as an effective factor to improve economic status of countries, including third world ones.

Weather, climate and tourism have been three main interrelated parameters effective on environmental development in both local and global scales. Actually, weather as one of environmental factors plays main role in human daily activities, especially tourism, as such, having optimal climate is regarded as a potential regional advantage for tourism (Esmaeili *et al.*, 2010). Because, in most cases, tourists would select their traveling based on weather conditions (De Freitas, 2001). For human, it is of high importance to being located in climatic or weather comfort range, it means, condition in which at least 80% of individuals feel comfort. In such conditions, individuals feel neither hot nor cold weather (Jahanbakhsh Asl, 1999). In the view of tourism, climatic comfort is calculated by various experimental and theoretical indices, such as regions' tourism climate conditions. Besides informing tourists about the conditions of their destination, it is necessary to determine tourism climatic potentials of different regions. In this regard, so many studies were done, including:

- Assessment of resort climatology of Arizona, United states of America Hartz *et al.* (2006).
- Determination of bioclimatic comfort in Erzurum-Rize expressway corridor using Geographic Information System (GIS) (Zengin *et al.*, 2009).
- Estimation of climate tourism of Iran by Tourism climate Index (TCI) (Farajzadeh and Ahmad, 2010).
- A human thermal climatology of subtropical Sydney (Spagnolo and De Dear, 2003).
- Predicting urban outdoor thermal comfort by Universal Thermal Climate Index (UTCI) (Brode *et al.*, 2011).
- Studying physiological comfort by bioclimatic humidity temperature index in Nigeria (Oyenike, 2015).
- Considering climatic comfort of South Africa by TCI Fichett *et al.* (2016).
- Assessment of tourism industry in china using TCI (Yan and Jie, 2015).
- Considering serbia's climatic comfort using Tourism Climate Comfort Index (TCCI) (Andelković *et al.*, 2016), finally
- Studying climate comfort using bioclimatic indices in European (Scott *et al.*, 2016). Some indices mainly indicate individual response to weather conditions. By means of these indices, it has been more practical the effects

of atmospheric elements on human comfort also it is possible to compare regions in various times of year in regard to comfortable climate for tourism. Among them, we could refer to equivalent thermal and discomfort indices, considered the effects of air temperature, evaporation and humidity on human comfort. Up until now, frequent studies have been done by these indices in different parts of the world (Avtandil *et al.*, 2016; Balafoutis *et al.*, 2004; Bartzokas *et al.*, 2013; McGregor *et al.*, 2002; Tawhida and Hisham, 2013; Xu Hanqiu *et al.*, 2017). Ilam province is located in the west of Iran. Regardless of high tourism potentials with regard to weather and natural environmental diversity, this province is deprived from appropriate economic status therefore, the purpose of present research is to assess and zone climate conditions of tourism in relation to human comfort using Discomfort Index (DI) and Equivalent Temperature Index (ETI) also Geographic Information System (GIS) in order to collect tourism calendar with the purpose of planning for providing necessary foundations of tourism.

2. A Review of Literature of Region

Ilam province with geographic situation $31^{\circ} 58'$ to $34^{\circ} 15'$ Northern latitude and $45^{\circ} 24'$ to $48^{\circ} 10'$ Eastern Longitude has been located in the most western part of Iran. Westward, it has 425 k.m mutual border to Iraq (Fig 1).

Fig-1. The Geographic Location of Ilam Province



As observed in fig 2, Northern and East northern regions were covered by high mountains, in contrary, western and South Western regions were location with low elevation with westward slope, consisting expanded tropical plains of Mehran, Dehloran and DashteAbbas regions. The elevation of these plains is less than 300m. The existence of unevenness in neighboring low lands caused difference between elevation about 3000m in both regions. Also, the existence of low lands, high land and Zagros mountain chains resulted in the appearance of microclimates with different conditions, as such hot and cool even cold weather were experienced simultaneously. Northern region has and elevated mountains covered by oak trees, whereas, southern regions have been mainly expanded plains with scarce vegetation, sometimes, deserts with hot weather. Climatically, Ilam province is divided to three cold regions, including: Northern and Northeastern mountainous regions, Tropical South and South western regions and Central Temperate regions (Fig 3). Also, different atmospheric systems effective on this province caused precipitation during autumn, winter, and spring, sometimes summer (Fig 4). In addition to external factors, local or regional factors such as topology, unevenness or roughness, distance from or proximity to moisture resources... play important roles in climate conditions, spatio- temporal distribution and emergence of various climate types.

Fig-2. Topography of Ilam Province

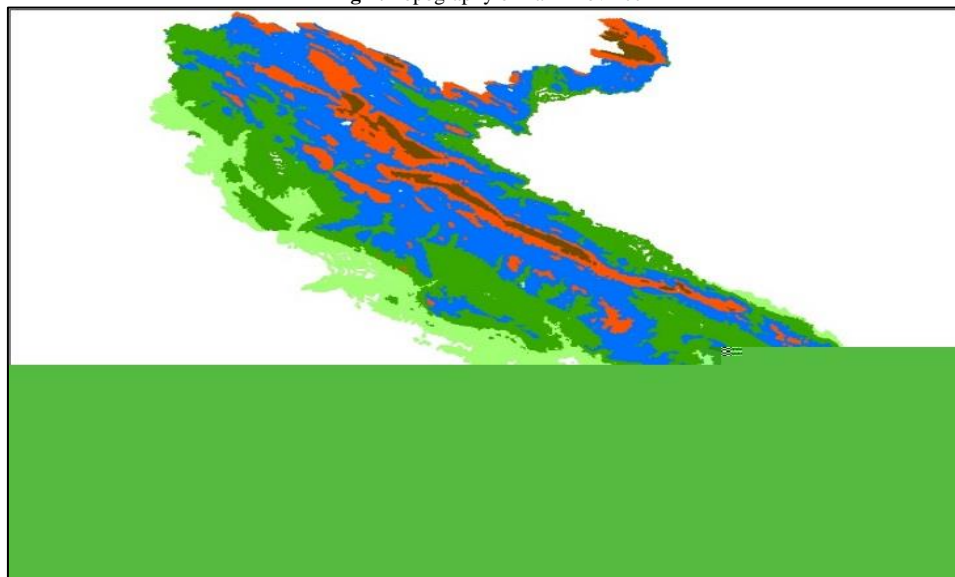
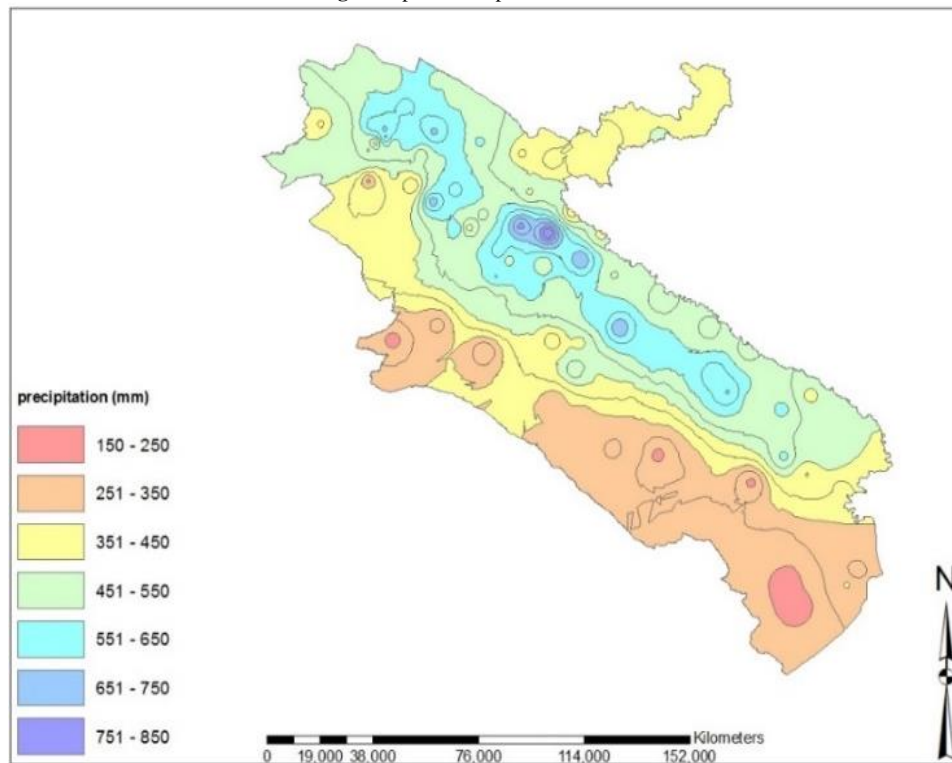
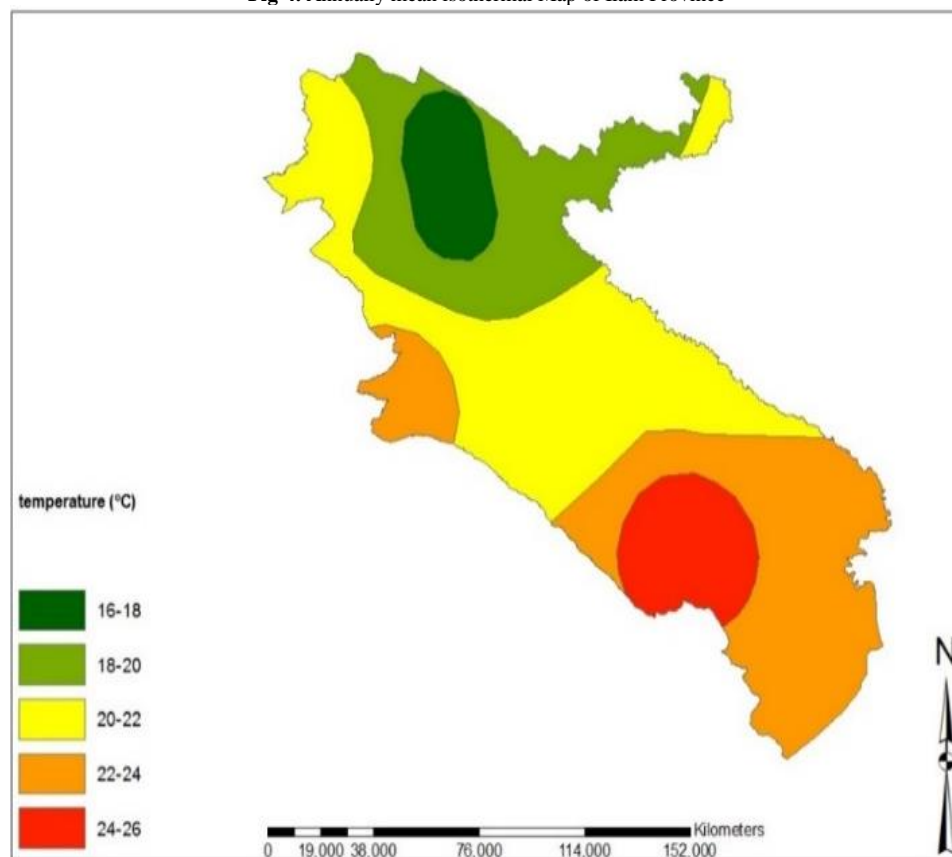


Fig-3. Isopluvial Map of Ilam Province**Fig-4.** Annually mean isothermal Map of Ilam Province

3. Data and Methodology

In this research, to assess tourism potential in Ilam region, it was used available statistical data in such a way that covered max spatio- temporal span. Therefore, it was used data to National Weather Organization and statistical data of Planning and Management Department from the data of its opening to December 2016 for eight Provincial Stations. Then, gathered data were estimated by two Discomfort Index and Equivalent Temperature Index.

The primarily used criteria was Equivalent Temperature Index which assessed common effects of temperature on living organisms in relation to air temperature and evaporation. *7* TEK Index is defined as an air temperature with regard to constant air pressure while its vapor is compressed totally. The Average Equivalent Temperature

assessed common effects of temperature on living organism, in relation to temperature and evaporation (Hegazizadeh and Alireza, 2016). This Index is calculated by equations (1). Table 1 shows the gradation of comfort coefficient obtained from Equivalent Temperature Index on the humans.

$$TEK = T + 1.5e \quad (1)$$

Here

T= Temperature (°C)

E= Evaporation

In order to calculate evaporation, it was used equation (2):

$$E = 60.112 \times 10 \left[\frac{7.5 \times T}{273 + T} \right] \times \frac{RH}{100} \quad (2)$$

Here

RH= Relative Humidity

T= Temperature

Table-1. Obtained Thresholds for Equivalent Temperature Index (°C)

Range	Climate
under 18 °C	cold
18-24 °C	cool
24-32 °C	relatively cool
32-44 °C	comfort
44-56 °C	sultry- hot
above 56 °C	very hot, humid and sultry

Discomfort Index (DI) is another factor to assess climate conditions in regard to comfort. As determined, higher temperature caused human discomfort, planning in the context of tourism necessitates having knowledge about human discomfort able conditions. The most common method to estimate DI is Tom Formulas. These values were calculated based on temperature and humidity also, by means of equation (3) and (4). Table 2 shows DI values.

$$DI = T - 0.55 \left(1 - \frac{RH}{100} \right) (T - 14.4) \quad (3)$$

Here

DI= Discomfort Index

T= Temperature (°C)

RH= Relative Humidity (degree)

$$DI = 0.4 - (td - tw) = 14.8 \quad (4)$$

Here

TD= Temperature Dry (°C)

TW= Temperature Wet (°C)

Table-2. Bioclimatic Condition of Discomfort Index (DI)

DI value	Bioclimatic condition of DI
> 21	No one feels discomfort
21-24	A few individuals feel discomfort
24	50% of feel discomfort
24-30	Most individual feel discomfort
< 30	Whole population feel discomfort
35	In some countries, it is announced public recess (holding)

GIS is software with the capability to restore, analyze, retrieve and display geographic data or information. The capability of this system is approved to apply in whole cases related to management and decision making in regard to activities related to geographic information directly or indirectly (Zare *et al.*, 2006). Tourism is an industry that used geographical spaces and their related factors. As mentioned previously, weather or climate is one of main elements in the development of tourism. Representing general features of local (destination) weather, also daily, monthly and seasonal changes of temperature, humidity precipitation have been considered as, important information for applicants to plan their schedule in regard to traveling date, necessary wears and equipment.

In this research, after performing essential computation and obtaining index values for eight respective stations, GIS data bank was established in order to zone tourism bio climate of Ilam province. For this purpose, it was used Arc GIS 10.1 software and provincial maps prepared by National Topographic Center of Ilam (scale 1: 25000). Then, obtained values, after creating stations- oriented dot layer in Arc Map, were restored in data bank, next, by interpolation, they were transferred to a counter in GIS. Finally, respective maps were extracted.

Then, based on temperature threshold of indices in GIS, maps related to every index were prepared monthly. Raster model is the most appropriate method to integrate geographical data in different layers, by analyzing obtained results, it was prepared general map of tourism climate of Ilam province.

4. Findings

Here, after estimating statistical domain for all stations, it was determined climate data for Discomfort Index and Equivalent Temperature Index. These indices were calculated on monthly scale. Results obtained from tourism climate of Ilam province using ETI (table 3) showed that the lowest annual score was related to Ilam city with cold climate with 11.46 and the highest score during all months except April, is related to Dehloran city with very hot and sultry climate with 56.76. In January, February and March, i.e. in winter, all parts of this province were cold to cool. In April, i.e. the beginning of spring, most regions except northern parts, - Ilam and Eyvan- also parts of Sirvan and Chardavol cities, have comfortable climate. Totally, ETI scores were incremental or ascending from January to July and most regions, except Dehloran have experienced very hot and humid climate. In July and August, Dehloran city was very hot and humid with max index in July (56.76). Index score in all cities was descending from August to the end of December. Also, Index score for all northern regions was less than southern regions.

Figs 3, 4 showed tourism climate zoning using GIS based on equivalent thermal index. According to these maps, in habitants in northern parts would experience rarely cool condition and in southern parts comfort condition. May onwards, hot and sultry condition dominated on southern regions, i.e. Dehloran, Abadan, Darrehshahr, also Mehran, but comfortable climate dominated on northern regions. During warm months, Dehloran had hot, wet and sultry weather. This weather is dominated on the other parts except small parts of Ilam and Eyvan cities. In September, comfortable domain is expanded once again. By reducing temperature, comfortable climate is replaced to cool and cold weather, in contrary, in hot and sultry regions, comfortable climate is being expanded.

Table-3. Results obtained from considering tourism climate in Ilam province based on Equivalent Temperature Index

Month	Ilam	Eyvan	Abadan	Darrehshahr	Dehloran	Chardavol	Sirvan	Mehran
January	11.46	12.72	19.45	19.31	24.61	14.76	16.35	21.74
February	1.63	15.62	22.57	22.79	27.57	18.35	20.27	26.02
March	18.5	20.81	28.45	28.92	32.85	23.93	26.13	31.8
April	26.18	28	31.06	36.8	42.84	32.27	33.79	44.79
May	33.4	35.26	46.67	47.67	51.22	42.86	42.92	48.37
June	36.64	38.62	46.85	49.24	54.73	46.4	45.83	50.32
July	39.44	41.93	51.29	52.75	56.76	48.21	49.09	53.66
August	38.99	41.4	48.7	51.53	56.22	46.92	48.63	54.09
September	32.92	34.92	42.97	44.52	49.48	40.5	42.15	47.26
October	26.87	29.18	38.51	36.19	41.46	33.09	33.34	38.99
November	19.87	21.05	31.42	27.93	32.9	24.77	25.7	29.64
December	14.17	16.08	25.6	21.62	26.62	17.75	19.15	23.74

Fig-5. Zoning the tourism climate in Ilam province based on equivalent temperature index in first semester A) January, B) February, C) March, D) April, E) May, F) June

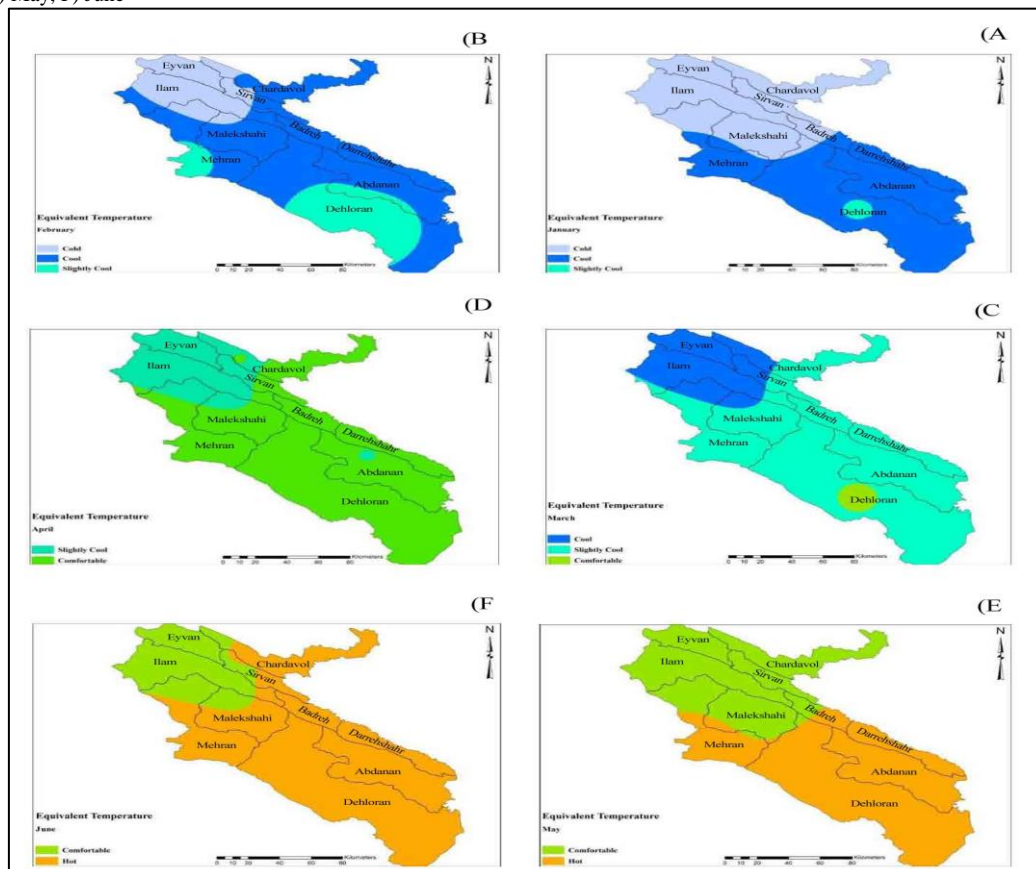
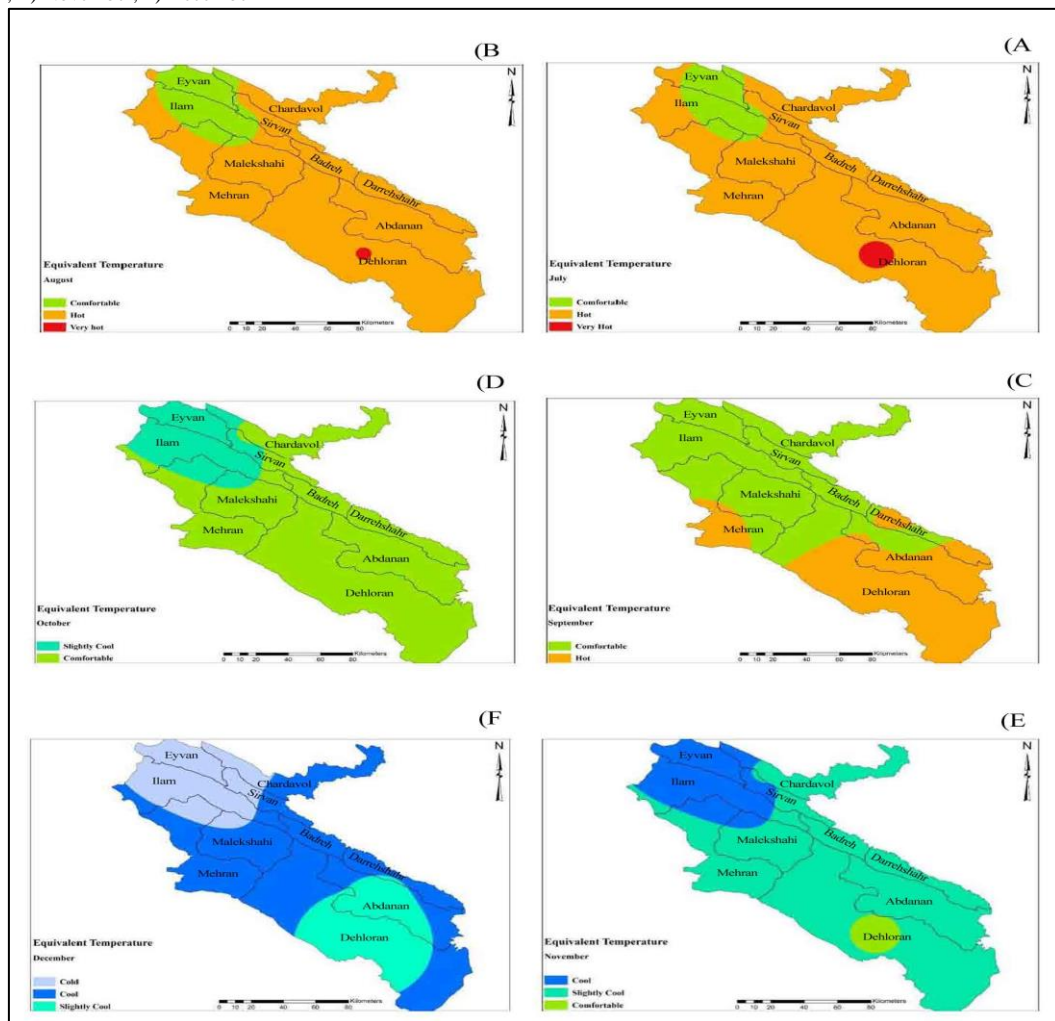


Fig-6. Zoning the tourism climate in Ilam province based on equivalent temperature index in second semester A) July, B) August, C) September, D) October, E) November, F) December



On the basis of obtained results using Discomfort Index (table 4), lowest DI score was related to Ilam city in July (6.4) and highest to Dehloran city in July (28.8). Generally, DI score for all cities, except Dehloran, was less than 21, then increased gradually. In July this score was maximum for all cities. At following, this score descended and reach min value in December.

Table-4. Results obtained from considering tourism climate in Ilam province based on Discomfort Index

Month	Ilam	Eyvan	Abdanan	Darrehshahr	Dehloran	Chardavol	Sirvan	Mehran
January	6.4	7.8	10.9	19.7	12.8	7.6	8.9	11.6
February	7.5	8.9	12	11.6	14.6	9.5	10.9	13.8
March	10.7	12.5	15.3	15.3	17.8	13.1	14.7	17.4
April	14.9	15.9	19.4	18.9	22.2	16.9	18.3	21.4
May	18.9	19.6	23.6	23.6	25.9	21.6	22.4	24.9
June	21.6	22.3	25.6	26.1	27.9	24.5	25.1	26.8
July	23.	23.8	27.2	27.4	28.8	25.7	26.6	27.9
August	22.8	23.8	26.6	27.1	28.7	25.4	26.3	28
September	20.4	21.2	24.4	24.5	26.8	22.9	24.8	25.5
October	17.2	18.3	21.4	20.7	23.1	19	19.9	22.1
November	12.1	12.8	16.1	15.03	18.2	13.5	14.4	16.8
December	8.6	9.7	12.7	11.1	14.3	9.5	10.6	13.1

Fig-7. Zoning the tourism climate in Ilam province based on Discomfort Index in the first semester A) January B) February C) March D) April E) May F) June

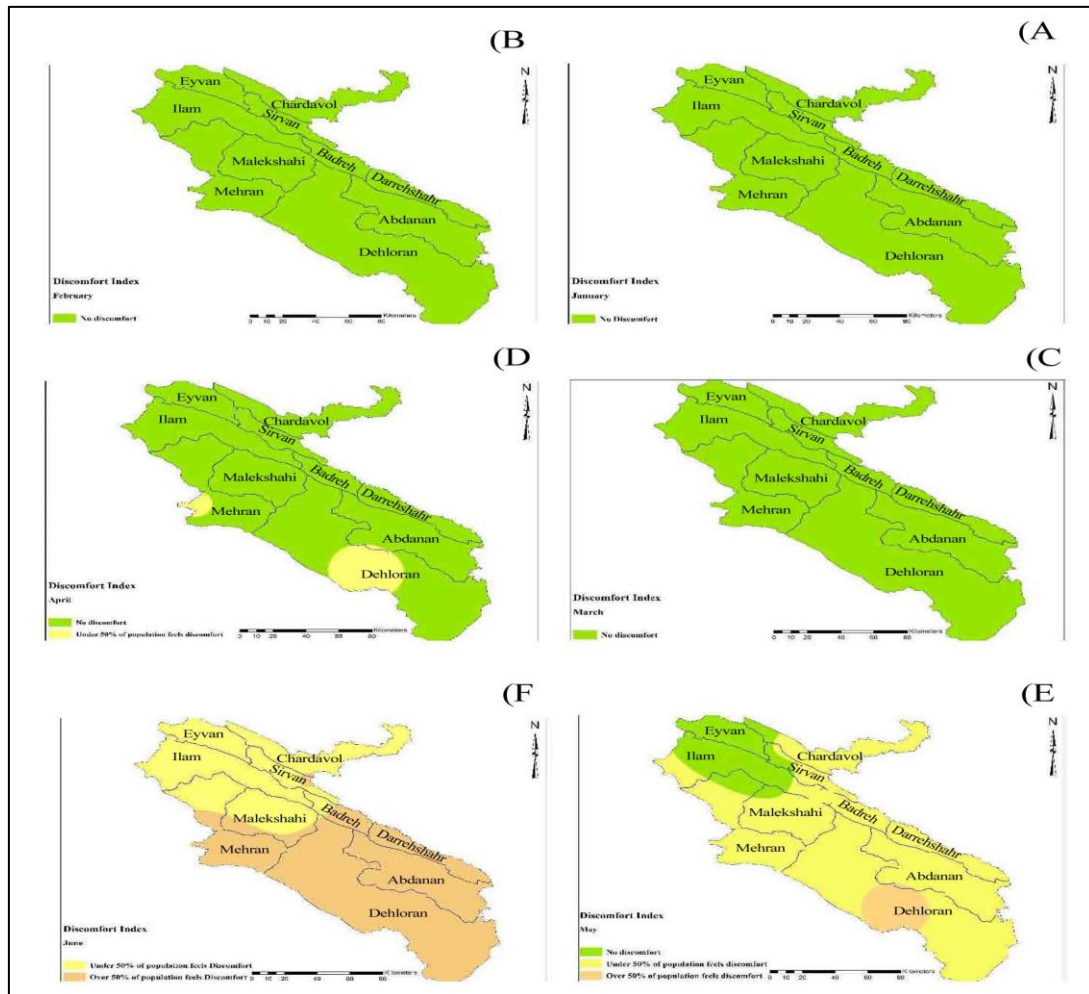
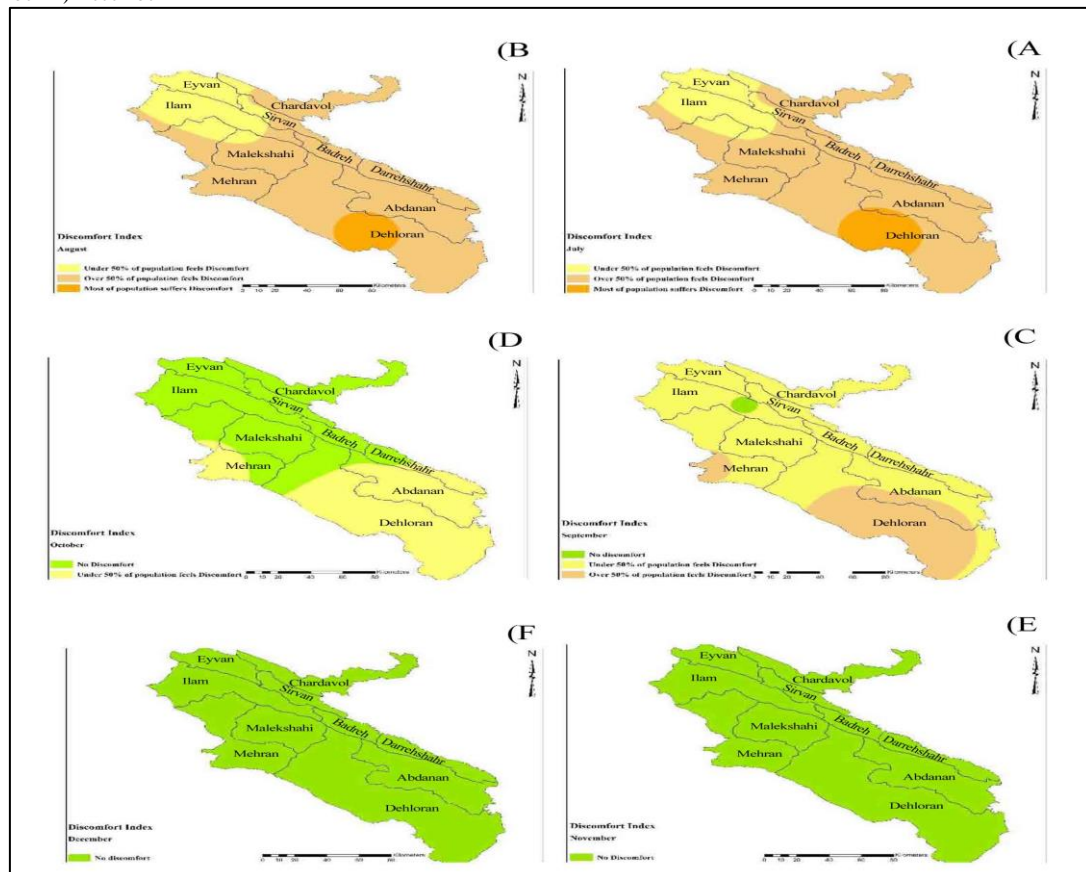


Fig-8. Zoning the tourism climate in Ilam province based on Discomfort Index in the first semester A) July B) August C) September D) October E) November F) December **



Maps related to zoning the tourism climate in Ilam province based on discomfort index (figs 7, 8) suggested that as in April most regions, except small parts of Mehran and Dehloran, will experience comfortable climate, by approaching to warm months, discomfortable climate has increased less than 50% and gradually is replaced with discomfortable feeling in 50% of population. In July and August, most population of Dehloran experienced discomfort. Also, in Autumn and winter, northern regions with colder weather have no discomfortable climate.

5. Discussion and Conclusion

Tourism as a dynamic and universal industry encompassed all foundations of every community and global systems. As cultural and social development is of high importance the same as paying attention to remuneration and job making, tourism could act as an important element in the field of development and job making.

Weather- transient atmospheric condition-, and climate- a dominant regional weather as natural environmental factors play main roles in most of human activities. Climate plays an important role in tourism activity at different levels.

Ilam province has so many potentials to attract internal and external (foreign) tourists also, to perform tourism activities, both naturally and historically. By having mutual border with Iraq, Ilam province is known as the corridor of Attabāt-e-Alyyat that plays an important role as an assisting factor to development of tourism industry.

With regard to its unevenness in different region, also, its influence from different air masses during a year (annually), latitude, elevations, Saudi Arabia deserts, Khoozestan plain, Iraq plains and local winds, there is a high diversity of climate and weather in different regions of this province. Having weather and environmental diversities is considered as one of prominent characteristics to attract tourists, solely by means of proper planning and providing necessary substructures.

To assess climate in the context of tourism activities also spending leisure time during whole year, it was used two important indices: Discomfort Index (DI) and Equivalent Temperature Index (ETI).

Studies performed by two above- mentioned indices showed that Equivalent Temperature Index has classified Northern regions in the range of having comfortable climate during warm months, southern region, especially Dehloran city, in the range of having comfortable climate in April, October, November and March. In December, January and February these regions were relatively cool. These parts were hot and sultry during May, June, July, August and September. Small regions of Dehloran city were classified as very hot, wet and sultry. Therefore, according to this index, Northern regions obtained rank 1 to attract tourists during May, June, July, August and September. In contrast, Southern regions obtained this rank in April, October, November and March. In regard to Discomfort Index, Ilam province has no optimal conditions for tourist attraction in May, June, July, August and September. In contrary, this region has optimal conditions for tourist attraction in October, November, December, January, February, March and April.

With regard to weather diversity, Equivalent Temperature Index is the most optimal index to estimate tourism climate in Ilam province. Also, Discomfort Index has described total region with no discomfortable climate during autumn and winter. In regard to tourism index, DI couldn't provide better description.

Generally, on the basis of results obtained from two indices Ilam province has two different interchangeable spatio- temporal spans for tourism, as such, if Northern regions have optimal climate to attract tourists in one season, at the same time, there is no optimal climate in southern regions. For example, during cold seasons, northern regions have no optimal climate for tourism, southern regions have an optimal weather and climate. Of course, it is necessary to pay attention to this fact that the above- mentioned indices will assess optimal climate for tourism activities such as looking landscapes and outlooks. If it is possible to apply these indices for sports tourism and mountain tourism some changes must be performed with regard to tourist needing. In regard to sports tourism, mountain tourism and ecotourism, its regions may be divided into two sections: mountainous regions mainly optimal for mountain tourism and ecotourism, and southern regions proper for other ecotourism activities such as desert tourism. Weather and tourism have been interrelated from various aspects. This interrelationship is of high importance both locally and globally. Tourists pay special attention to weather data. With regard to research results, Ilam province has great potentials for tourism and spending leisure time during different time of a year.

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