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ORIGINAL ARTICLE

An Assessment of Bioclimatic Conditions for Tourists In the Southwest of Iran

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ABSTRACT
Tourism, as a major sector of the global economy, is influenced by weather and climate. At several travel destinations, climate represents a natural resource on which the tourism industry is predicated. Today, several indicators have been suggested by scientists for ecological climatology study that are used specifically in tourism meteorological study. Among them, composite indicators of temperature physiology can be named that are based on energy balance of human body and have more credibility. The purpose of this study is to assessment the most suitable months for human thermal comfort and tourism activities in the Southwest of Iran by using Physiological Equivalent Temperature (PET).The data, which covering the period 1991–2010, from a dense network of 13 meteorological stations was used to compute the PET. Monthly mean air temperature, relative humidity, vapor pressure, wind velocity, and cloud cover data were obtained from the bureau of meteorology.Rayman model was used to calculate the PET index. Based on the calculations of PET in the region, it is shown that months of March and December in the Khuzestan province and the month ofApril, May and October in the Ilam and Lorestsn province are laying in the comfortable class representing the most suitable months for tourism and tourist activities .In elevated cities like Aligoodarz and Borojerd ,the months of May, June, September and April are the most suitable months for tourist activities.
Key words: Tourism; physiologically equivalent temperature (PET); climatic comfort; southwest of Iran

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INTRODUCTION

Tourism industry is one of the most important economic parts in the world that has increasingly developed in the recent years. International tourism organization has said that from 1950 to 2007 the number of international travelers increased from 25 million to 903 million and the resultant income surged to 865 billion and has predicted that the population of tourists in the world will be 1 billion by 2020 and the earned income will be 1.6 billion $ [1]. Many factors affect the tourism industry, one of them is climate. Along with geographical position, landscape, vegetation, animal diversity; climate as one of the most important sources of local base play a role in development of tourism industry. So, it can be said that the impact of climate controls duration, tourism quality, tourists' health and even tourists' personal experiences [2, 3].Tourism highly depends on weather and climate in such a way that fair weather and climate knowledge of destination play a key role in tourism industry and they can be attracting or off putting factors for tourists [4].Humans have always been aware that weather and climate affect their health and well being. Fevers vary seasonally and so do people's moods and various psychological disturbances. Aches and pains in joints flare up in winter, while in summer heat waves debilitate and kill [5].

Climate and tourism are closely related and the relationship between these two is indicated whereby "Climate Comfort Index". The *physiologically equivalent temperature* (PET) is a thermal index derived from the human energy balance. It is well suited to the evaluation of the thermal component 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 units (°C), which make results more comprehensible to urban or regional planners, for example, who are not so familiar with modern human biometeorological terminology. PET results can be presented graphically or as bioclimatic maps. Graphs

mostly display the temporal behavior of PET, whereas spatial distribution is specified in bioclimatic maps [6]. In this regard Rayman, which is an improved model, calculates the average radiant temperature and thermal indexes in simple and complex environments based on the data from weather stations and climatic elements such as temperature, humidity and wind speed [7]. This model can be used to evaluate urban bioclimatic and thermal indexes including PET, *Standard Effective Temperature* (SET), and *PredictedMean Vote* (PMV). The model has been developed in Germany according to international guidelines between atmosphere and short-and-long-wave fluxes. Rayman model is a manned model for evaluation of biometeorological weather quality, urban and regional planning at micro and macro level [8].

Matzarakis and Mayer have discussed the various applications of PET for the evaluation of the thermal component of urban microclimates. Gulyas[9] analyzed the complex surface structure of urban areas by using PET. The study examined outdoor thermal comfort conditions through field surveys in Szeged, Hungary. Ranjbar [10] studied the relation between climatic conditions and annual tourism trend in the city of Marvdasht. Farajzadeh and Matzarakis[11]introduced the weather elements in north-west Iran. They concluded that all the stations in northwest of Iran have a month with TCI over 80 which can be considered as an ideal index.Ataei[12] determined a suitable calendar for tourism in Ahwaz using PET and Concluded that Ahwaz has comfortable and suitable conditions during the cold seasons of the year and is the best destination for tourists in the winter. The purpose of this paper is to determine Bioclimatic Conditions and the most suitable months for tourist activities in the southwest of Iran.

METHODLOGY

Study Area

In general, the southwest of Iran has plentiful cultural, historical and environmental attractions (ecotourism) consideringas one of the most potential spots for tourist capacity. The study area is located between 29° 58′ to 34° 30′ latitude and 44° 03′ to 50° 30′ longitude. More than 50 tourism landmarks, plentiful cultural, historical and natural attractions (ecotourism and geotourism) and variety of climates can be found in the region and are mostly visited by the domestic and foreign tourists.Lorestan, Ilam and Khuzestan provinces are located in this region, (Figure 1). Falalolaflak castle, GaharLakeand Bishe waterfall palace in Lorestan province, Bahramchubin canyon, QaliqirqnMountain and Vali castle in Ilam, choghaz anbilshrine, Gondi Shapur University and Shadegan pond in Khuzestan are also interesting locations for visitors.

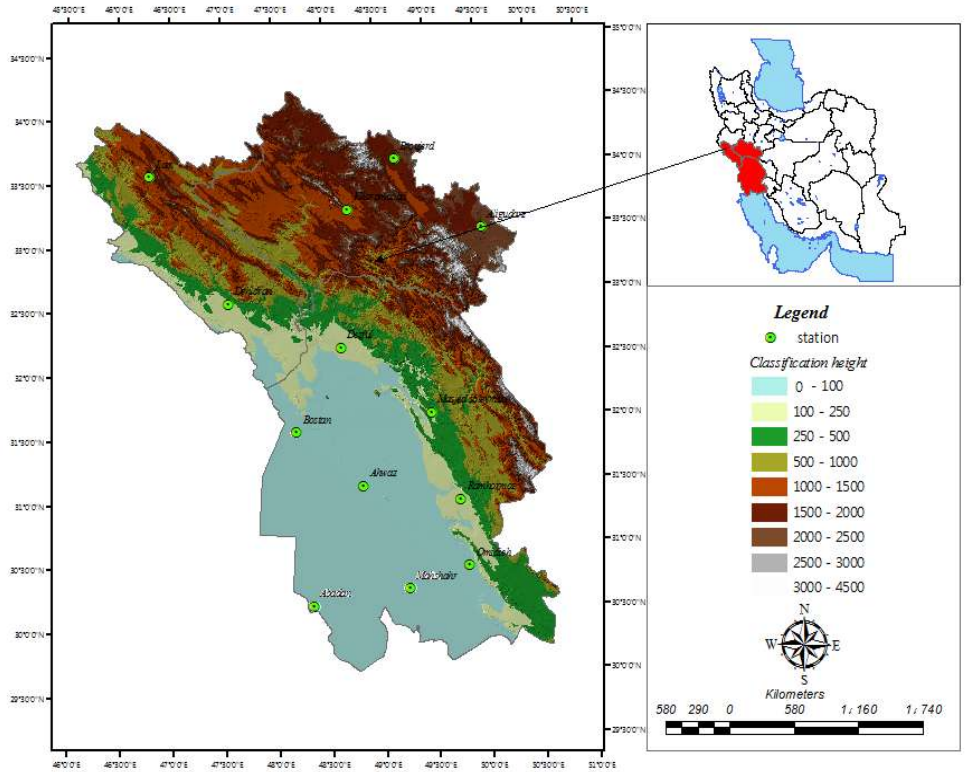

Figure 1 Topographic map, weather stations and geographical location of the study area

DATA AND METHODS

In the first part, the data from 13 meteorological stations over 20 years (1991-2010) and climatic parameters of average dry temperature in Celsius, average humidity in percent, average wind speed in meter per second, average of vapor pressure in hPa, the cloud amount in Octa were obtained from the*I. R. of Iran Meteorological Organization* (IRIMO). Then the obtained data were fed into Excel program. Next, considering compatibility with (PET) method they were fed into Rayman and finally the outputs were analyzed. The biometeorological conditions are analyzed by means of 20day mean values of thermal sensation measured at 7am, 2pm and 9pm during the year.

The role of thermal indices in the concrete explanation of bioclimatic conditions and thus the understanding of human reactions to meteorological variables has long been known [13]. The term "thermal comfort" refers to human satisfaction with environments that are conducive to dispersing heat produced by human metabolism, thus providing a thermal balance between humans and the environment [14].The thermal sensation is defined by means of physiologically equivalent temperature PET as the physiologically significant assessment of the thermal environment derived from the human energy balance [15, 16]. The Munich energy balance model for individuals" (MEMI) is such a thermo-physiological heat balance model. It is the basis for the calculation of the *Physiologically Equivalent Temperature* (PET). In this study, the PET index was used. It is equal to the reaction of the body thermal balance of a 35-year-old, 175-cm-tall male involved in an 80 W activity and wearing clothing with a 0.9 clo heat resistance, to the conditions in a typical indoor area. Outdoor meteorological conditions are calculated by taking into account the human heat balance. PET allows the evaluation of thermal conditions in a physiologically significant manner, too. With respect to this,Matzarakis and Mayer [17] transferred ranges of PMV for thermal perception and grade of physiological stress on human beings [18] into corresponding PET ranges (Table 1). They are valid only for the assumed values of internal heat production and thermal resistance of the clothing.

Table 1Ranges of the physiological equivalent temperature (PET) for different grades Of thermal perception by human beings and physiological stress on human beings[17, 19]

PET	Thermal Perception	Grade of Physiological Stress
4 °C	very cold	extreme cold stress
8 °C	cold	strong cold stress
13 °C	cool	moderate cold stress
18 °C	slightly cool	slight cold stress
23 °C	Comfortable	no thermal stress
29 °C	slightly warm	slight heat stress
35 °C	warm	moderate heat stress
41 °C	hot	strong heat stress
	very hot	extreme heat stress

Ray Man software which was designed by Dr. Andreas Matzarakis to calculate radiative fluxes is one of the most appropriate methods for calculation of mean radiation temperature and finally calculating PET and PMV (figure-2). Ray Man model estimates radiative fluxes, clouds effects and solid barriers by effects of shortwave solar radiation. Final output of this model is calculation of mean radiation temperature that needs to be used in energy balance model for human, and its result is for evaluation required in urban climates and several thermal indicators including Predicted Mean Vote (PMV), Physiological Equivalent Temperature (PET) and Standard effective temperature (SET) [20].

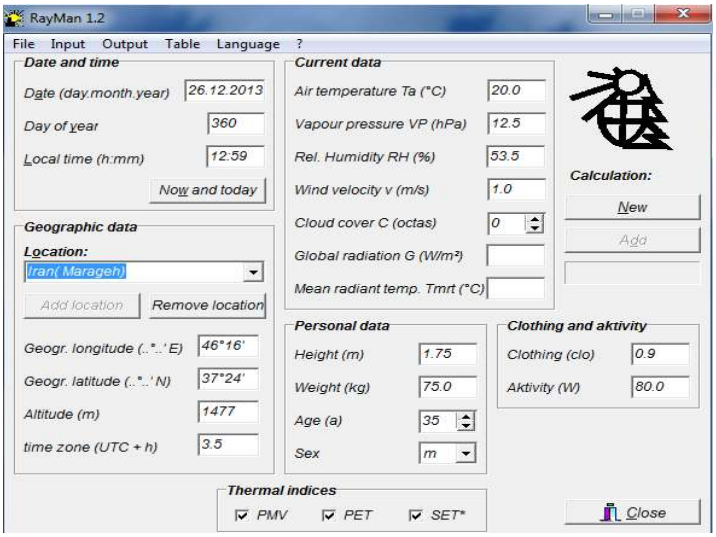

Fig. 2 Input windows of Ray Man 1.2 and the relevant values for the calculation of thermal indices

RESULTS AND DISCUSSION

Choosing a travel time and destination in terms of climate comfort can positively affect the quality of tourism. Enjoying a fair weather while travelling will increase the tendency to stay longer and coming back to the same spot. In contrast an unfavorable climatic condition enhances a negative experience. According to the PET index (table 1), the numerical value of 18-23 range shows a comfort condition without the warm or cold tensions. In this classification, the numerical values of 23- 29 and 13-18 indicate a slightly warm and cool stresses that can wear light or heavy clothes to bring the comfort condition. In order to obtain an overview of PET changes in the region, three stations of Ahwaz, Ilam and Khorramabad were selected from different geographic regions and the biometeorological conditions are analyzed by means of ten-day mean values of thermal sensation during the year. By means of the probability of occurrence of different thermal sensations that enable more detail information about bioclimate.The relative frequencies for PET values divided in to9 classes in order to evaluate the thermal stress for the Period from 1991 until 2010.

Figure 3 shows the relative frequencies for PET in Ahwaz station. In this station, thermal comfort occurs from January to April and October to December, with highest Probability (>30 %) in the months March and November and minimum frequency in June to September (0 %). Cold stress (<4 °C) can be observed from December to February with a frequency of less than (3%). Days with strong heat stress, defined as PET values >35 °C, can be observed from May to October with maximum frequencies (Nearly100%) during June until August.

The relative frequencies for PET in Ilam station is shown in Figure 4. In Ilam station, thermal comfort occurs from March to June and September to November, with highest Probability (>30 %) in the months May and October and minimum frequency in July to August (about 0 %). Cold stress (<4 °C) can be observed from November to March with highest Probability (>50 %) in the months January and February. Days with strong heat stress, can be observed from June to October with maximum frequencies (Morethan45%) in the months July and August. Figure 5 shows the relative frequencies for PET in Khorramabad station. In this station, thermal comfort occurs from March to June and September to November, with maximum frequencies (>30 %) from 1st to 30th of May and 20th of September to 20st of October and minimum frequency in December to February, July and August (about 0%). Cold stress (<4 °C) can be observed from November to April with highest Probability (>50 %) in the months January and February. Days with strong heat stress, can be observed from June to September with maximum frequencies (Morethan40%) in the months July and August.

Figure 6 shows the mean daily changes in the PET for Khorramabad, Aligudarz, Ilam and Ahwaz stations in the period 1991–2010. The comfort zone (the numerical value of 18 to 23 degrees) is marked on the charts.

Ahwaz station has been selected as samples in Khuzestan province. Based on PET of Ahwaz station, there is slightly cold stress from 1st of December to 15th of February. From 16st February to 31st march and 20th of October to 30th of November the physiological stress is zero and there is a climate comfort condition. From 1st of April to 20th of October there is a physiological stress from slight heat to extreme heat.

Ilam station has been selected as a sample in Ilam province. Based on PET of Ilam station, there is a cold physiological stress with different intensities from 1st of November to 15th of April. From 16th of April to

30th of May and 15th of September to 20th of October the physiological stress is zero and there is a climate comfort condition. There is a warm physiological stress with different intensities from 1th of June to 15th of September. Khorramabad station has been selected as an example in Lorestan province. Based on PET index of Khorramabad station, there is a cold physiological stress with different intensities from 1st of January to 30th of March and 1th of November to 31st of December. From 1st of April to 20th of May and 25th of September to 30th of October the physiological stress is zero and there is a climate comfort condition. There is a warm physiological stress with different intensities from 20th of May to 25th of September. Aligudarz station has been selected as another example in Lorestan province due to varying climatic conditions. Based on PET of Aligudarz station, there is a cold physiological stress with different intensities from 1st of January to 30th of April and 10th of October to 31st of December. From 1th of May to 30th of June and 15th of August to 10th of October the physiological stress is zero and there is a climate comfort condition. There is a warm physiological stress with slight intense from 1th of July.

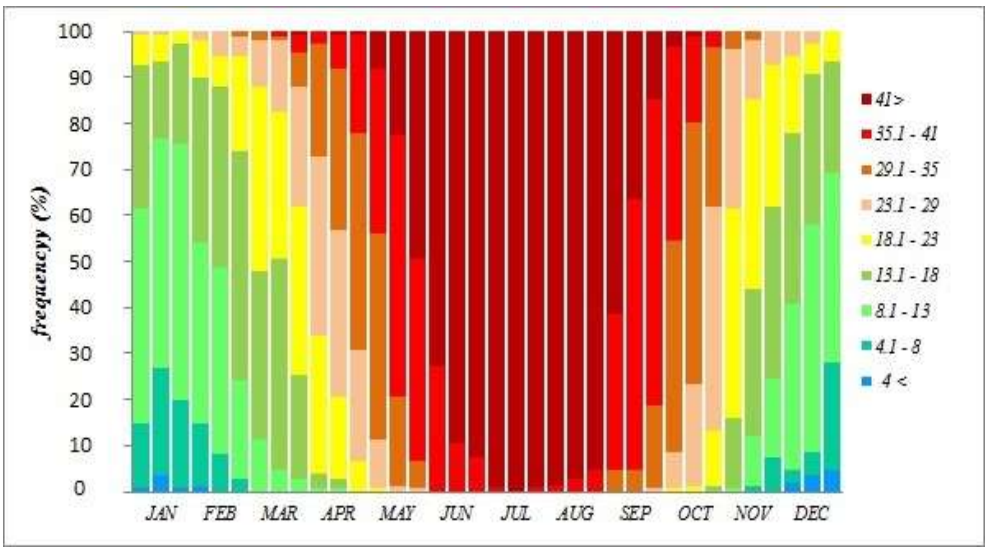

Fig 3 Probability of occurrence of different PET classes for the meteorological station Ahwaz.

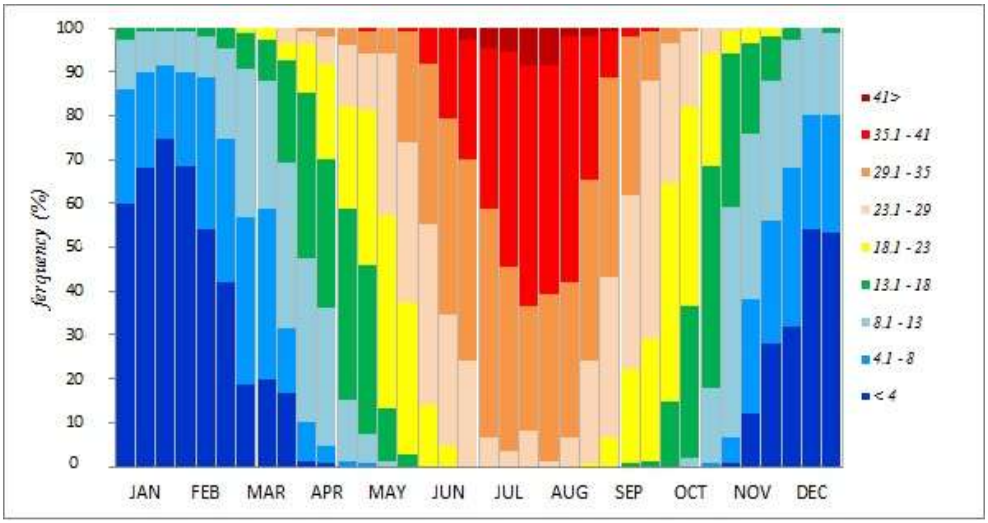

Fig 4 Probability of occurrence of different PET classes for the meteorological station Ilam

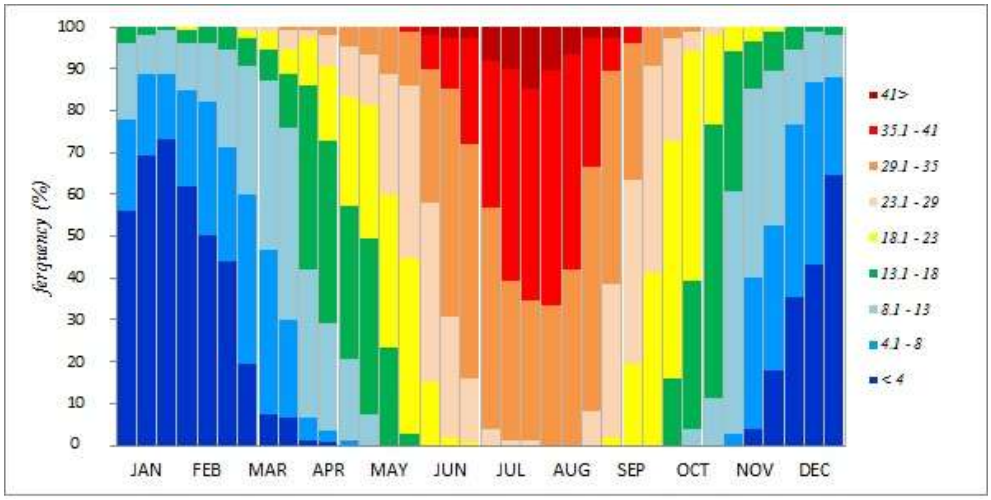

Fig 5Probability of occurrence of different PET classes for the meteorological station Khoramabad

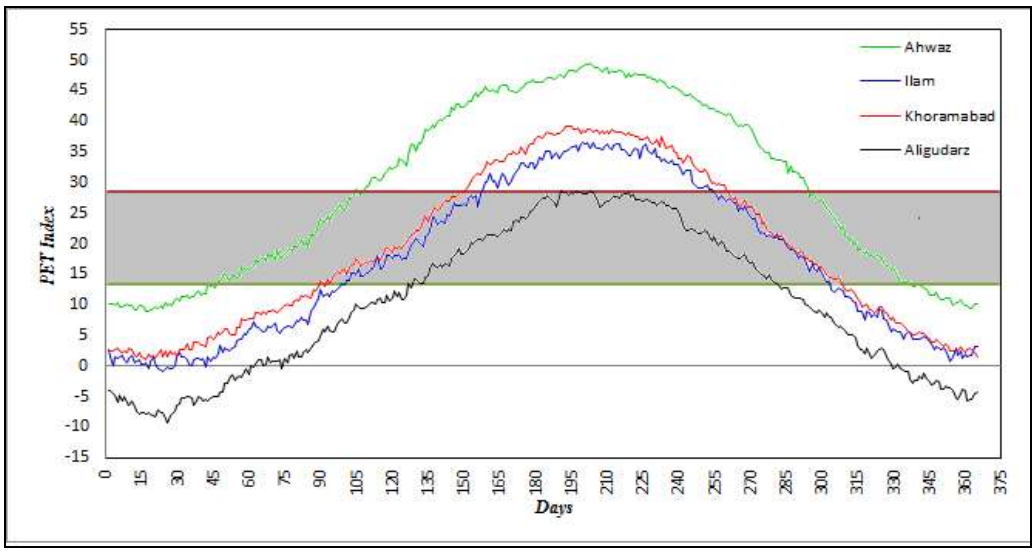

Fig 6 PET variations and comfort range at selected stations for 1985–2010

In order to study the temporal and spatial changes in climatic comfort, the monthly maps predicted and evaluated. Figure 7 shows the PET conditions for January. In this month, a very high cold stress dominates in the north parts of region such as Aligudarz,Borujerd, Khoramabad and Ilam stations, while there is a little cold stress in the provinces of Khuzestan and south of Ilam province. The PET condition for February is the same as January. There is an extreme and strong cold stress in the Aligudarz, Borujerd and Ilam stations, while a slightly cold stress is dominant in the southern areas such as Khuzestan and south of Ilam province (Fig. 8).In March, the amount of cold stress compared with the months of January and February have been reduced. There is an extreme and strong cold stress in Aligudarz, Borujerd and Ilam stations, a moderate cold stress in Khorramabad and a slightly cold stress to comfortable perception in Khuzestan province (Fig. 9).In April, the southern partsi.e.Khuzestan and south of Ilamare associated with slightly heat stress while there is a slightly cold to comfortable perception in the northern areas such as Aligudarz, Borujerd ,Ilam and Khorramabad stations (Fig. 10).The PET condition for May indicates an moderate to strong heat stress in the southern parts of the region (such as Khuzestan and southern parts of Ilam), while a slightly cold stress to comfortable perception is dominant in the southern areas such as Aligudarz, Borujerd and Ilam stations (Fig. 11).The PET condition forJune indicates an extreme to strong heat stress in the southern parts of the region (such as Khuzestan and southern parts of Ilam), a moderate heat stress in Ilam and Khorramabad stations and a slightly heat stress to climatic comfort conditions in Aligudarz and Borujerd stations (Fig. 12). July is the hottest month in the study area. The PET condition for July represents an extreme heat stress in the southern parts of the region (such as Khuzestan and southern parts of Ilam), a strong heat stress in Ilam and Khorramabad stations and a moderate heat stress in Aligudarz and Borujerd stations(Fig. 13).Physiological equivalent temperature in August is also similar to July, so that the PET condition shows an extreme heat stress in the southern parts of the region and a

strong to moderate heat stress in the northern sections of the region (Fig. 14).In September, the intensity of the heat stress compared to the months of July and August have been reduced. There is a strong heat stress in the southern parts of the study area (Khuzestan and southern parts of Ilam), a slight heat stress in Ilam and Khorramabad stations and a comfortable perception in Aligudarz and Borujerd stations (Fig. 15).In October, the amount of heat stress reduced and cold stress has started in the northern parts of study area such as Aligudarz and Borujerd stations. The PET condition for October indicates a moderate and slight heat stress in the southern parts of the region (Khuzestan and southern parts of Ilam), a climatic comfort conditions in Khorramabad station and a slight cold stress in Aligudarz,Borujerd and Ilam stations (Fig. 16).The physiological equivalent temperature condition in November represents a comfortable condition to slight cold stress in the southern parts (Khuzestan and southern parts of Ilam), a moderate cold stress in Khorramabad and Ilam stations and a strong cold stress in Aligudarz and Borujerd stations (Fig. 17).In December, the intensity of cold stress has increased. The PET condition in December represents a slight to moderate cold stress in the southern parts (Khuzestan and southern parts of Ilam) and a strong to extreme cold stress in the northern regions such as Khorramabad, Ilam, Aligudarz and Borujerd stations (Fig. 18).

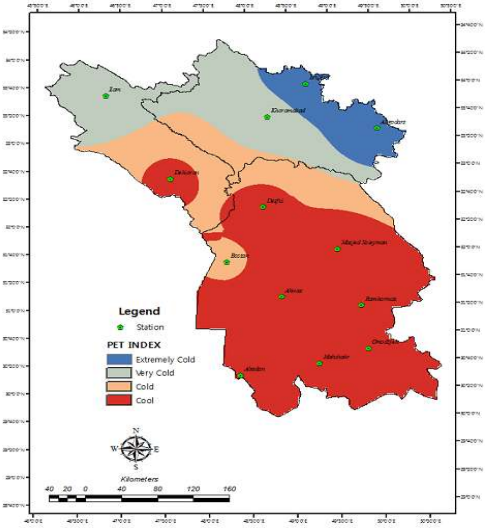

Fig (7) Geographical distribution of PETin January

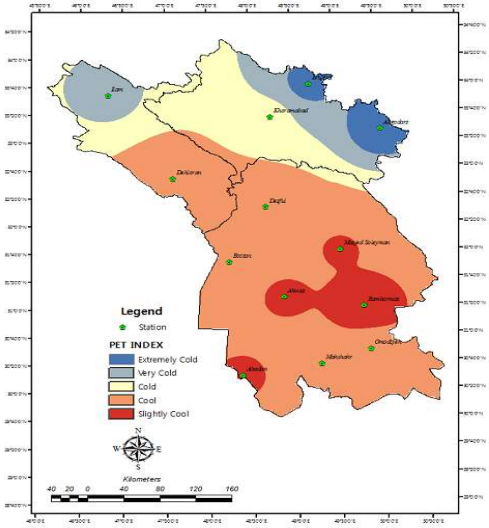

Fig (8): Geographical distribution of PET in February

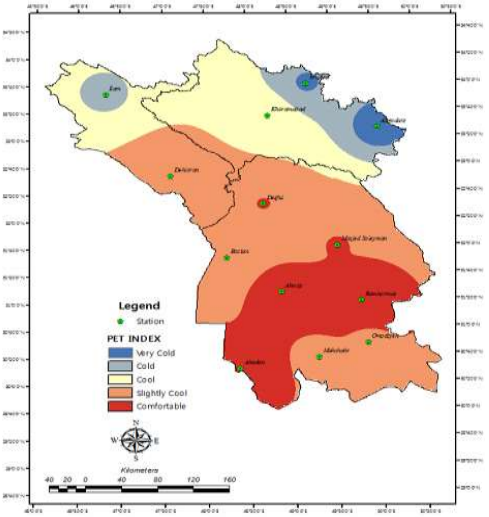

Fig (9) Geographical distribution of PET in March

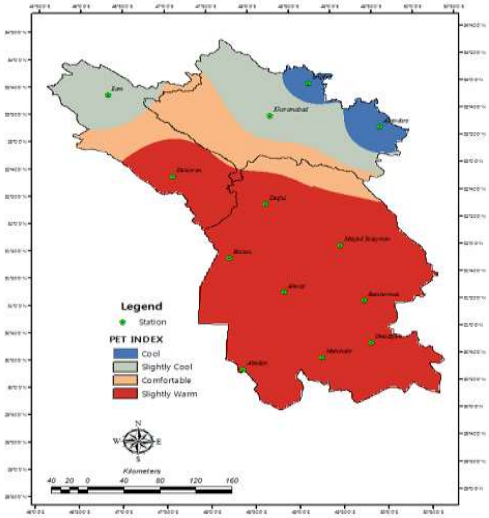

Fig (10): Geographical distribution of PET in April

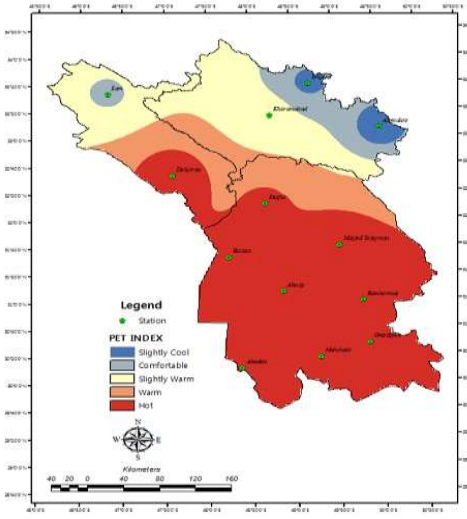

Fig (11) Geographical distribution of PET in May

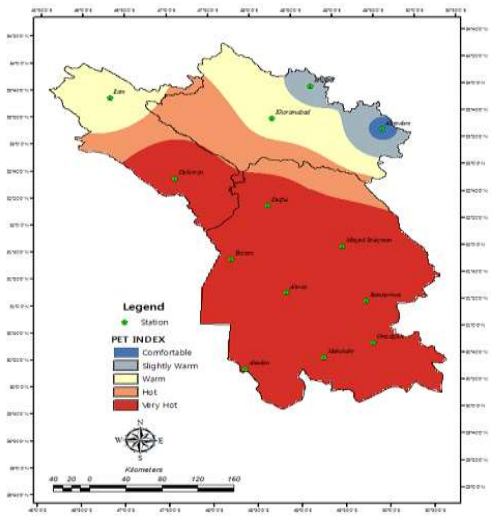

Fig (12): Geographical distribution of PET in June

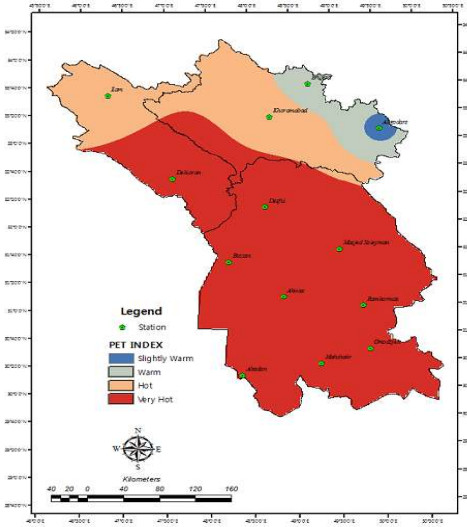

Fig (13) Geographical distribution of PET in July

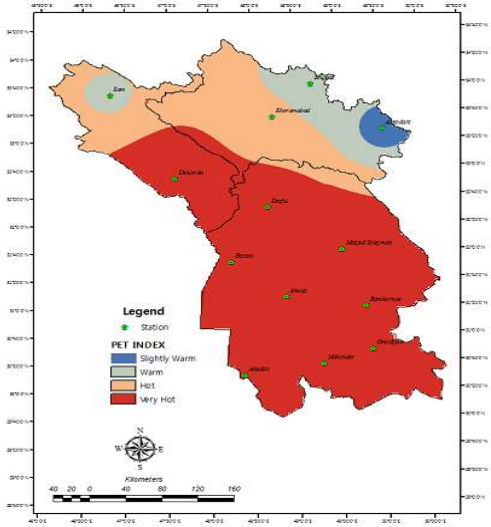

Fig (14): Geographical distribution of PET in August

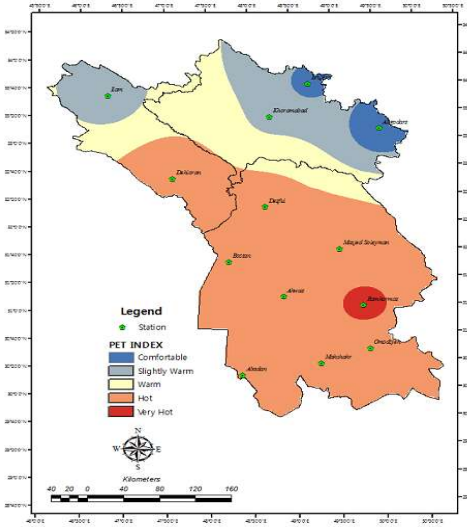

Fig (15) Geographical distribution of PET in September

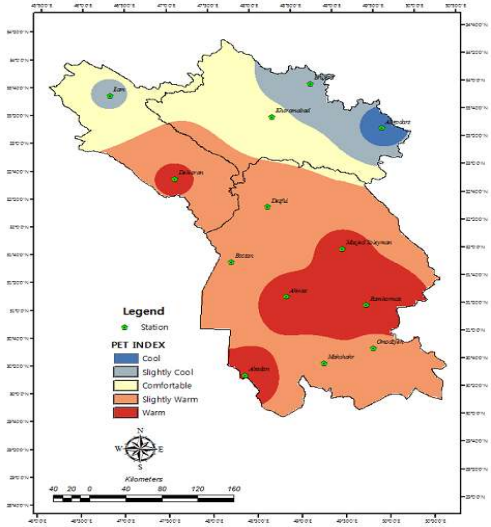

Fig (16): Geographical distribution of PET in October

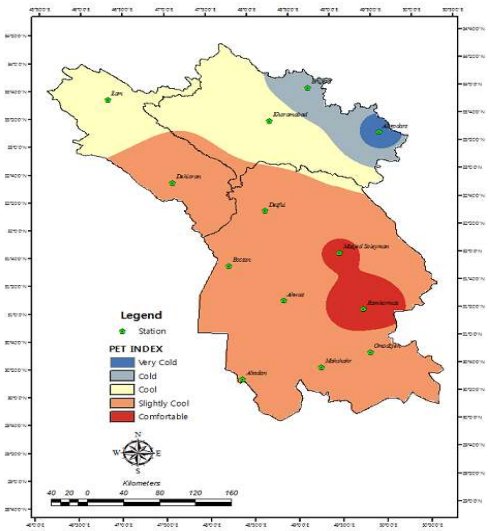

Fig (17) Geographical distribution of PET in November

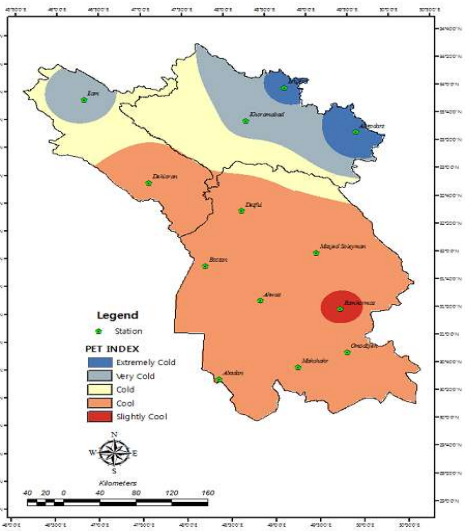

Fig (18): Geographical distribution of PET in December

CONCLUSIONS

In this paper, we analyzed the thermal comfort conditions for southwest of Iran. The data for 13 meteorological stations wereusedfortheperiod1991–2010. The finding of this study can be valuable for tourism in the region. The analysis of climate and bioclimate, especially if presented in a clear and simple way to be understandable for everyone, provides a basis for the promotion of tourism destinations. The information can be used by tourist managers in advertising, by tourists who want to decide when to take their holidays and by physicians to warn their patients for the periods that are unsuitable for health therapy. For example, the people who have difficulty tolerating thesummer heat, such as the elderlies, should choose the best period of biometeorological conditions to take their vacations, which prevail in the southern parts of region such as Khuzestan and southern parts of Ilamin March and November, in the northern parts such as Khorramabad and Ilam stations in April, May and October and in Aligudarz and Borujerd stations in June and September. For sportsmen who prefer an active and dynamic vacation, pleasant or even cool conditions would be more convenient than summer heat, when the body has to uses the energy for defense from heat.

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