J. Appl. Environ. Biol. Sci., 3(11)57-67, 2013

ISSN: 2090-4274
Journal of Applied Environmental and Biological Sciences
www.textroad.com

Determination of Comfort Temporal Calendar for Touristic Activity in Khuzestan (Using PMV and PET Indices)

Ali Asghar Roshan[1], Seyyed Foad Alavinia[2], Mohammad Raza Ziraki[3]

[1,2] Department of Military Geography, University of Imam Hossein (AS), Tehran, Iran.
[3]Researcher and Master Degree of Geography, Department of Geography, University of Imam Hossein (AS), Tehran, Iran.

Received: September 2 2013
Accepted: October 10 2013

ABSTRACT

Many climatic indices have been presented for investigation of comfort and its impact on human tourism activity which are used in bio-climatic studies. Temperature-physiologic combinational indices which are based upon human body energy balance are more valid than other indices. In the present research, synoptic and climatic stations were used inside and outside Khuzestan province over 1991-2008 and were obtained from irimo.ir. data was obtained from 23 synoptic stations and mean of each of the factors was calculated and PET index and PMT index were used to investigate appropriate time for tourists visit to Khuzestan province. Results showed that climatic comfort period in Khuzestan province is in November and March and March has a more ideal condition than November.

KEYWORDS: PET and PMT indices, Khuzestan province, tourists

INTRODUCTION

Climate is the most important element of our surroundings and is one of the main factors of changing earth face. Floods, slow rivers, jungles, dry areas, and generally all life symbols like water supply, buildings shape, agricultural activities, lifestyle and thousands of other items are directly related to climate and its elements. Therefore, identification of climatic elements and factors is very important in regional planning and the first step for human planning. Today, investigation of regions touristic attractions through increasing welfare, comfort and security is the key to many plans. Therefore, investigation and identification bio-climatic potentials can be helpful in different tourists activities like displacement, toleration, medical issues, resources management and so on. Two important points in bio-climate investigation are as follows: determination of necessary criteria and determination of boundaries between climatic regions. The present research tries to evaluate climates in terms of comfort and discomfort of tourists in different points of Khuzestan province. In spite of this, considering the absence of scientific studies in the field of bio-climate importance for tourism in Khuzestan province, the present research which makes use of new methodologies is considered as an important study. Zolfaghari (2007) conducted a research and determined an appropriate temporal calendar for tourists in Tabriz using PET and PMV indices and concluded that climatic comfort period is limited in Tabriz to 45 days from early Khordad till middle Tir (Zolfaghari, 2007, 141-129). Basatzadeh (2008) investigated bio-climate in Chahar Mahal O Bakhtiari Province in Iran in his master degree thesis and stated that most stations of the province are in climatic comfort limit in Ordibehesht, Shahrivar and Mehr months (Basatzadeh, 2008). KhoshAkhlagh et al(2010) used 50 years' meteorological data (1956-2006), relative temperature and moist and EVANZ comfort climate model in Yazd city to determine favorable months for human physiological comfort in 5 10-year period and predict linear trend of these changes for 10 years later (2016) (Khosh Akhlagh et al, 2010, 167-181). Esmaeeli, Gandomkar and No Khandan (2011) conducted a research titled: "evaluation of comfort climate of several main touristic cities in Iran (Mashhad, Isfahan, Rasht and Kish) using PE index" and concluded that comfort period of these cities is very short and is in the form of two separate periods at the beginning of autumn and spring. The main touristic limitation of Mashhad and Isfahan and Rasht cities are intense cold conditions during Azar, Dey and Bahman and the main limitation in Kish is related to intense heat in summer. Afroushteh (2011) investigated the influence of climatic elements on military activities in Eastern Azarbayjan Province using PMV, PET and Misezkofski indices in his thesis and concluded that most of the stations can be considered as comfort months (Afroushteh, 2011, 144).

Bio-climatic studies in other countries are as follows:

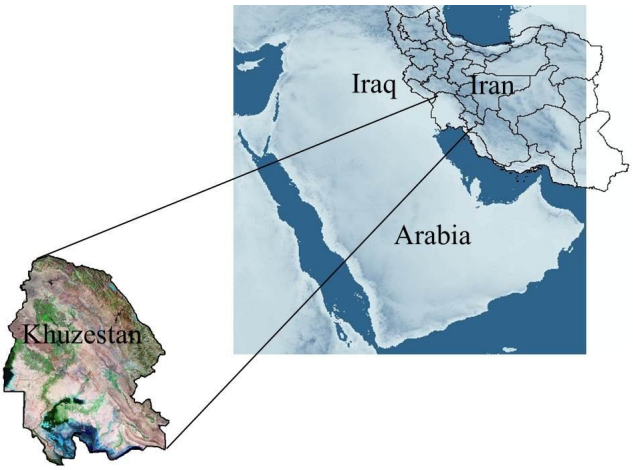
Giuni (1997) emphasized on temperature and relative humidity as the main parameters in determination of bio-climatic regions(Giuni, 1997). Zein Ahamid et al (1998) used Mahouti graph and Pschrometric table in Klang darreh in Malysia and investigated thermal comfort of employees for achieving comfort in humid areas

***Corresponding Author:** Seyyed Foad Alavinia, Researcher and Master Degree of Military Geography, Department of Military Geography, University of Imam Hossein(AS), Tehran, Iran.
Email: Seadfoadalave@yahioo.com, Tel: (++98)21-73828937

buildings (Zein Ahamid et al, 440-437, 1998). S becker (2000) investigated bio-climate in 31 cities and resorts in South Africa in order to determine and recognize necessary temperature for people comfort in South Africa using Fanger equation (S. Becker, 2000). Emanuel (2005) investigated the application of thermal comfort in warm and humid urban areas in Colombo metropolitan in Serilanka. He used bio-climatic indices, relative elasticity (R.C.I) and thermal humidity index (T.H.C) (Emanuel, 1591-1601, 2005). Hin (2009) used TCI method in investigation of tourism comfort condition in Spain and concluded that summer is the best season for tourists comfort (Hin, 2009, 170-178). Falk Martin (2010) used Dynamic Panel Data model and analysis of snow depth to investigate its relationship with winter tourism in Ostria for a period of 1986/87-2005/06 (Falk Martin, 2010, 912-924).

Khuzestan province has 24 cities and an area equal to 64236 squared meters and is situated between 47 degrees and 41 minutes and 50 degrees and 39 minutes of eastern longitude and 29 degrees and 58 minutes to 33 degrees and 4 minutes of northern latitude in south east of Iran.

Map 1: Khuzestan province situation in Iran



Methods and data

Necessary climatic data was obtained from synoptic and climatic stations inside and outside Khuzestan province during 1991-2008 and through irimo.ir depending on the type of model. This statistics were obtained from 23 synoptic stations including: Abadan, Omidiyeh, Izeh, Ahvaz, Bostan, Behbahan, Dezfoul, Ramhormoz, Shoushtar, Safi Abad Dezfoul, Mahshahr, Masjid-e-Soleiman, Hendijan, Aligoudarz, Kuhrang, Daran, Dogonbadan, Lordegan, Dehloran, Doroud, Khorram Abad, Pol Dokhtar, Boushehr and 8 climatological stations including : Mazou, Karoun Kesht o Sanat, Sardasht Dezfoul, Hamidiyyeh, Bagh Malek, Haft Tappeh, Bagh Malek and Deilam and mean of each of the factors was calculated. Situation of the mentioned meterological stations with respect to the region under study has been shown in map 2. Statistics of these stations shows that various conditions exist inside and around the region in terms of climatic condition in a way that climatic conditions of northern and north-eastern stations are different from southern areas. Therefore, it can be said that indices of investigation will also be different. Data of each index was summarized in Excel and inserted into GIS software and then monthly maps were sketched.

PMV index

PMV index and PET are among the most important Physiologic-temperature indices which are used in determination of thermal component of urban micro-climates as well as meteorological tourism studies and investigation of climatic comfort environments for tourists. The PMV index calculation:

PMV= (0.303 e -0.036M + 0.028)[(M-W) -H - Ec- Crec -Erec]

E=3.05×10-3 (256 tsk -3373 -Pa) + Esw

Ec=3.05×10-3 [5733 – 6.99 × (M-W) - Pa] + 0.42 (M-W -58.15)

Crec = 0.0014 M (34-Ta)

Erec= 1.72 × 10-5 M (5867 - Pa)

can be directly measured and through the following equation:

H=Kcl = tsk - tcl / Icl

In the above equation:

Crec convective heat exchange, transpiration (w/m2)

= Erec heat evapotranspiration (w/m2)

= Esw heat losses by evapotranspiration (w/m2)
= Ec evaporative heat exchange at the skin surface when the thermal state is neutral (w/m2)
= Icl average radiation clothing for the whole body (w/m2)
= M rate of metabolism (w/m2)
= Tcl uniform surface temperature ° C
= Tsk mean skin temperature ° C
= W of mechanical power (w/m2)
= e evaporative heat exchange at the skin surface (w/m2)
= H dry heat loss through convection, conduction and radiation (w/m2)
= Pa water vapor pressure, partial air-Pascal
= Ta ° C temperature

PMV scale is a kind of classification of thermal feeling in 7 degrees which ranges from -3.5 (cold) to +3.5(warm). Zero shows neutral thermal feeling. Table 1 is used for simpler calculation.

Table 1. Threshold values of indices PET and PMV in different degrees of human sensitivity

Degree of physiologic tension	Thermal sensitivity	PET©	PMV
Very severe cold tension	Very cold		
Severe cold tension	Cold	4	-3.5
Moderate cold tension	Cool	8	-2.5
Insignificant cold tension	Slightly cool	13	-1.5
Without cold tension	Comfortable	18	-0.5
Insignificant heat tension	A little warm	23	0.5
Moderate heat tension	Warm	29	1.5
Severe heat tension	Very warm	35	2.5
severe heat tension	Very hot	41	3.5

Reference: Matzarakis et al, 1999)

Map 2: situation of meteorological stations in with respect to Khuzestan province

PET index is one of the important temperature-physiologic indices which have been derived from human body energy balance equation. This index can be defined for out of house situation as : in one sample room, human body thermal balance(burning rate with light work 80 watts is added to base burning rate, non-conductivity value of clothing are 0.9 cls) is in equilibrium with skin temperature and central temperature of human body outside house). Clothing non-conductivity unit is called cls. Thermal resistance of one cls is equal to 0.155 watt per centigrade degrees in squared meters. For a standing person with casual clothing on, favorable thermal comfort is achieved at a physiologic equivalent temperature about 20 centigrade degrees. In values above this index, we have heat tension and in values below this index, cold tension exists. PET values will be different for different activities and clothing. In lighter working conditions and thinner clothing, PET values will increase and in heavier working conditions and thicker clothing, values of this index will reduce. Clothing is very important in human body warmth with surroundings, because clothing covers body like a non-conductive cover and reduces body touch with surrounding environment. In table 2, different clothing non-conductivity values have been presented.

Table 2: value of non-conductivity for different clothing

row	Clothing set	Non-conductivity
1	bare	0
2	Short trousers	0.1
3	Thin cotton and short-sleeved underwear, long pants and cotton socks	0.35
4	Like above + open-collared short-sleeved shirt	0.5
5	Light pants, vest, long-sleeved shirt and coat	1
6	Like above + cotton overcoat	1.5
7	Clothing specially designed for polar areas	3.5

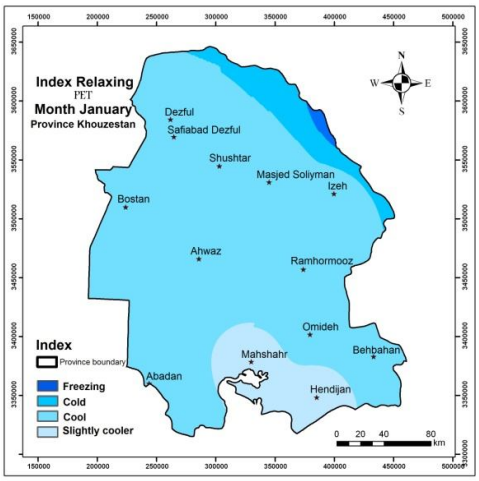
Reference: Razjouyan, 1978

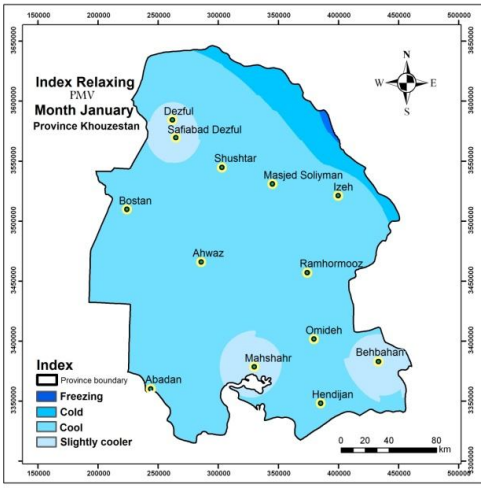
All elements of meteorology influence on human energy balance in an appropriate elevation like 1.5 meter above ground level in order to calculate PET. Parameters which are effective like whether temperature, steam pressure, wind speed are calculated through digital models depending on subject of study. Two applied and famous models which are used for investigation of PET and PMV, have been shown in the next sentences.

RESULTS

Some parameters are fixed and some of them change at different points in investigation of comfort indices like PMV and PET and using the Ray Man model and software. Height, age, weight, non-conductivity and insulation of clothing, activity level and gender were considered fixed. Of course, some factors like elevation, longitude and latitude, time, climatic parameters like temperature, steam pressure, wind speed and radiation temperature of surroundings are also important; which were calculated and inserted into Excel software and then incorporated in GIS software and monthly maps of PET and PMV were sketched.

Map 3: PET index for January in Khuzestan province
Map 4: PMV index for January in Khuzestan province

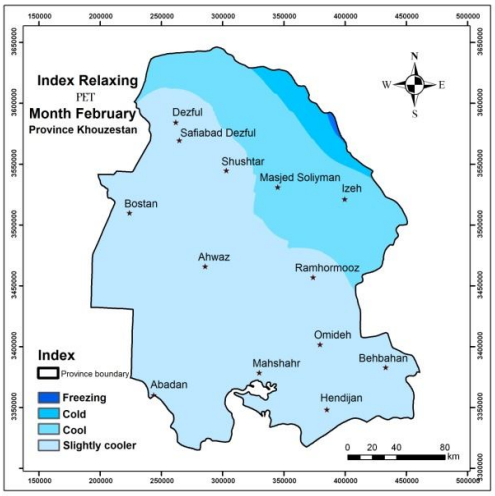


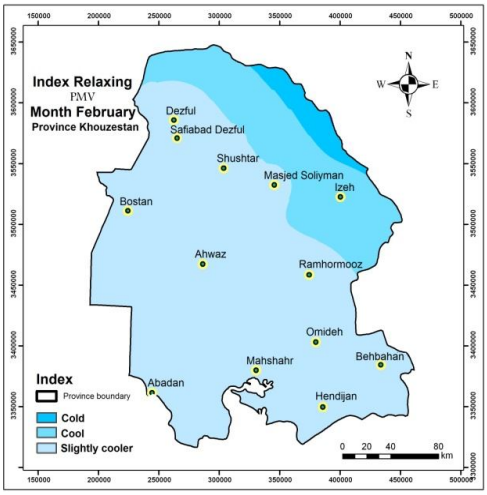


January:

PET index: in this month, PET index is such that the southern part of the province shows small cold tension and a little cool condition from 12th Dey till 12th Bahman. In central and eastern and western areas of the province, moderate cold tension makes a cool condition. In north-eastern parts of the province, severe cold tension makes cold conditions in north-eastern areas of the province and in the furthest north-eastern areas of the province, very severe cold tension brings very cold condition. PMV index: this index is completely similar to PET index from 12th of Dey till 12th of Bahman. In the southern part of the province, small cold tension shows slightly cool conditions. In central and eastern and western areas of the province, moderate cold tension brings cool conditions. In north-eastern areas of the province, severe cold tension brings cold conditions and in furthest north-eastern part of the province, very severe cold tension brings very cold conditions.

Map 5. PET index for February in Khuzestan province
Map 6. PMV index for February month in Khuzestan province

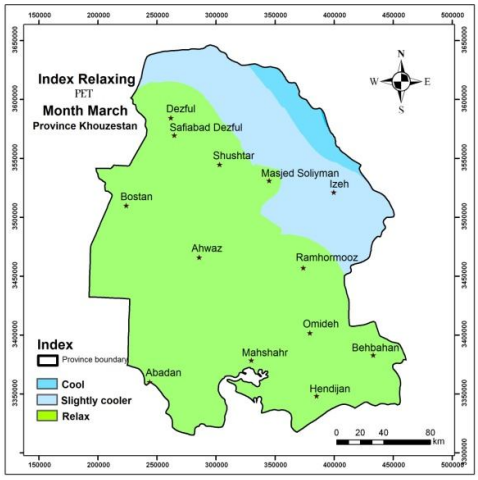


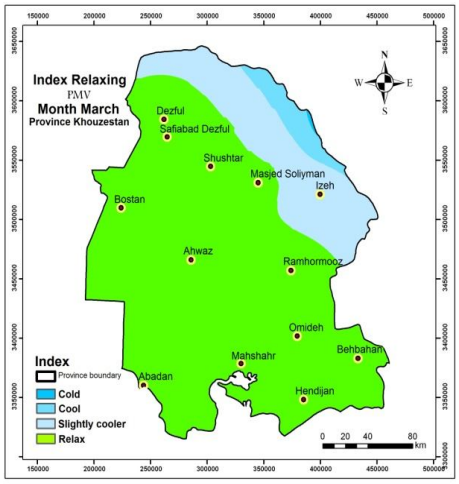


February

PET index: from 13th of Bahman to 10th of Esfand, PET index is more or less similar to the previous month so that in southern, south-eastern, central and western areas of the province, slight cold tension shows a slightly cool condition. In northern and eastern areas of the province, moderate cold tension shows cool conditions. In northe-eastern parts, severe cold tension shows cold conditions and in furthest north-eastern areas of the province, very severe cold tension shows very cold condition. PMT index: in this month, PMT index is slightly more favorable than PRT index. In southern, south-eastern, centeral and western areas of the province, slight cold tension shows slightly cool conditions. In the northern and north-eastern areas, moderate cold tension will have cool conditions and in the north-eastern areas, severe cold tension and cold condition is being observed.

Map 7: PET index for March month in Khuzestan province
Map 8: PMV for March month in Khuzestan province

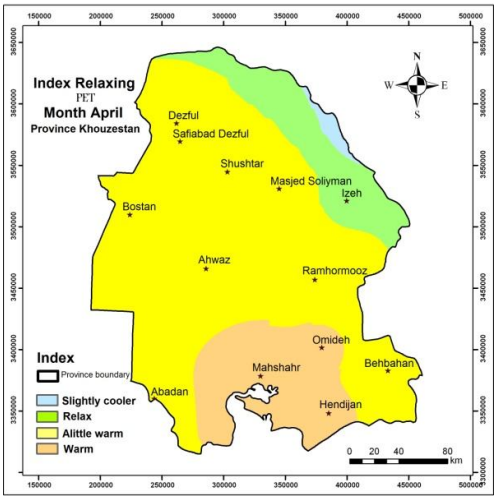


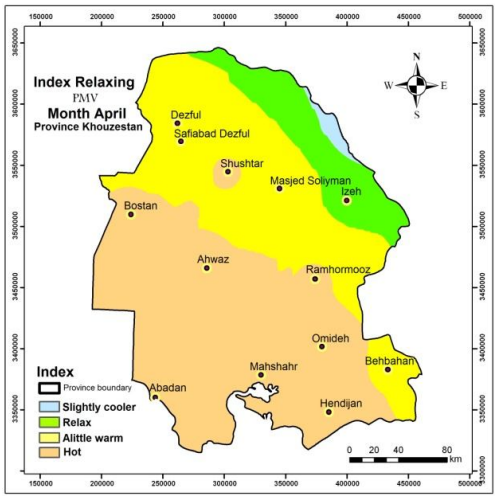


March :

PET index: climatic conditions of the area in March (11th of Esfand till 12th of Farvardin) in terms of PET index is such that in southern, south-eastern, central and western parts of the province, comfort condition exists in without tension conditions. In northern and eastern areas of the province, slight cold tension will bring slightly cool conditions. In north=eastern areas, moderate cold tension brings cool conditions. PMV index: in this month, PMV index will be similar to PET. In other words, in southern, south-eastern, central and western areas of the province, without-tension conditions bring comfortable condition. In northern and eastern areas of the province, slight cold tension and slightly cool conditions exist. In north-eastern areas, moderate cold tension and cool conditions are observed.

Map 9. PET index for April in Khuzestan province
Map 10. PMV index for April in Khuzestan province

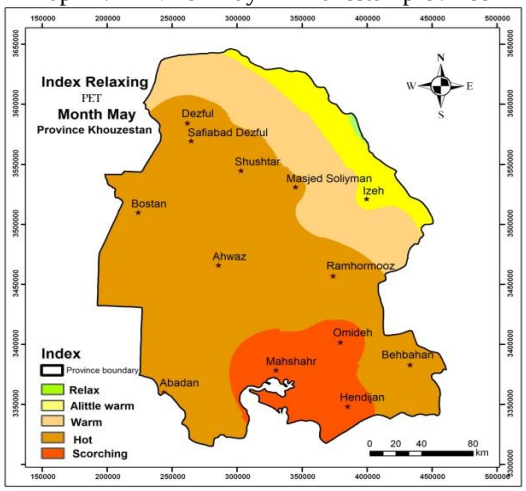


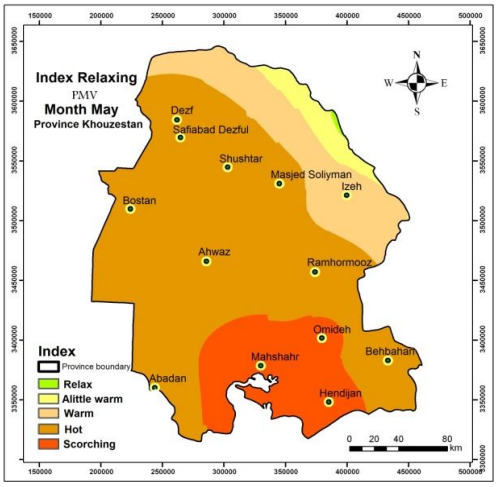


April:

PET index: PET index in this month (13th of Farvardin to 11th of Ordibehesht) in southern part of the province has warm conditions with moderate heat tension. In central, south-eastern and western parts of the province, slightly warm condition is present with slight heat tension. In north-eastern areas, there is no tension and therefore they are in comfortable conditions. In furthest north-eastern areas, slight cold tension and slightly cool condition exist. PMV index: in this month, PMV is more or less similar to PET. In southern, south-western and western parts of province will have warm conditions with moderate heat tension. In north-western to eastern parts, slightly warm conditions will be present with slight heat tension. In north-eastern areas, there is no tension and therefore comfortable conditions. In furthest north-eastern areas, slight cold tension is in slightly cool conditions.

Map 11. PET for May in Khuzestan province
Map 12. PMV for May in Khuzestan province



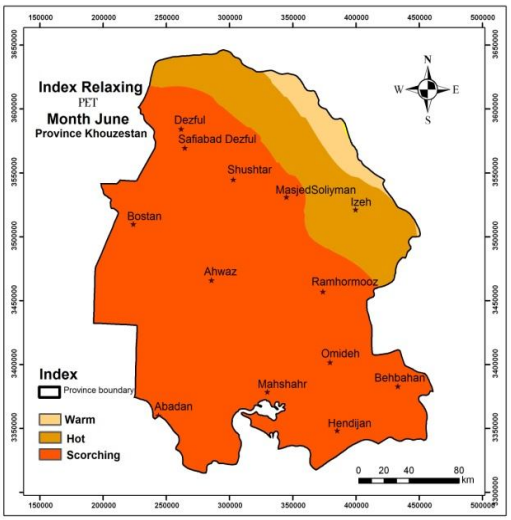


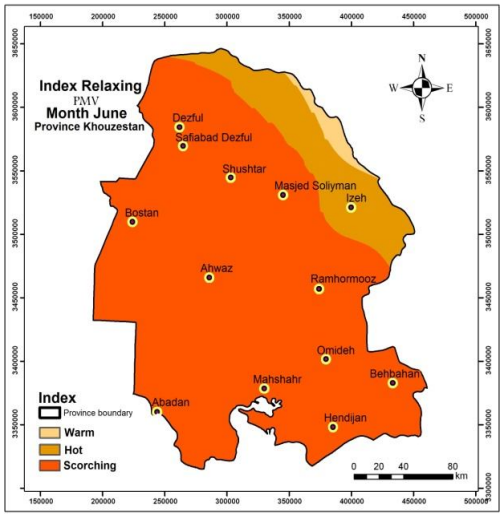
May:

PET index: in late spring in May (12th of Ordibehesht to 10th of Khordad), PET index shows hot conditions in southern area of the province with very severe heat tension. In central and south-eastern and western parts of the province with severe heat tension has very warm condition. In northern to eastern areas of the province with moderate heat tension, warm condition will exist. In north-eastern areas with slight heat tension, slightly warm conditions will exist and in the furthest north-eastern parts of the province, favorable and comfortable conditions will be present in without-tension areas. PMV index: in this month, PMV index is similar to PET. In southern part of the province with severe heat tension, hot conditions exist. In central and south-eastern and western areas of the province with severe heat tension will have very warm conditions. In northern to eastern areas of the

province with moderate heat tension will have warm conditions. In north-eastern areas, slightly warm conditions exist with slight heat tension and in furthest north-eastern areas of the province, comfortable conditions exist with without-tension conditions.

Map 13: PET for June in Khuzestan province
Map 14: PMV for June in Khuzestan province

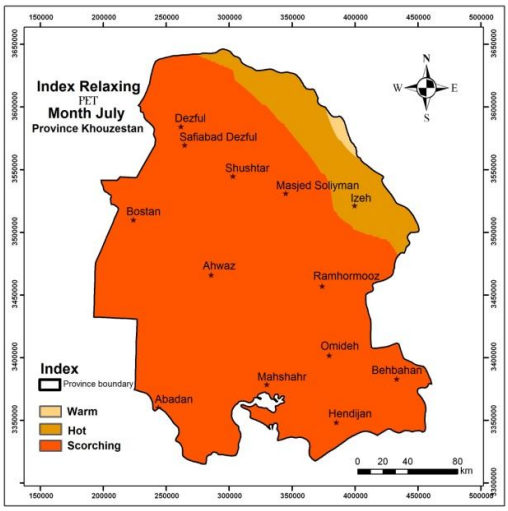


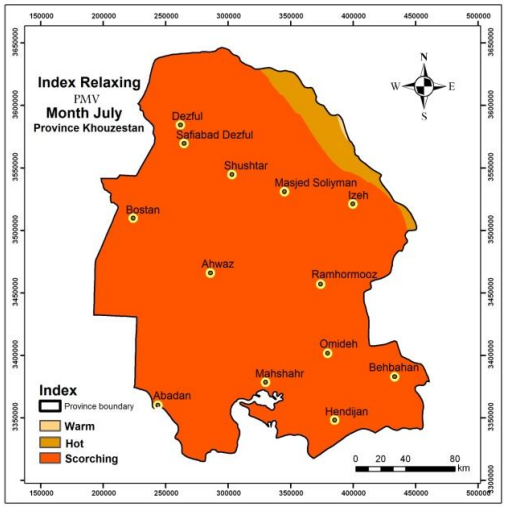


June:

PET index: according to the results in June (11th of Khordad to 10th of Tir), PET shows hot conditions in southern and central and south-eastern and westaren areas with very severe heat tension. In northern to north-eastern areas of the province with severe heat tension, very warm conditions exist. In the furthest north-eastern parts of the province with moderate heat tension conditions, warm conditions exist. PMV index: in this month, PMV is similar to PET. In southern, central, eastern and north-western areas of the province with very severe heat tension, hot conditions exist. In northern to north-eastern areas with severe heat tension, very warm conditions exist. In the furthest north-eastern part of the province with moderate heat tension conditions, warm conditions reign.

Map 15. PET index for July in Khuzestan Province
Map 16: PMV for July in Khuzestan province



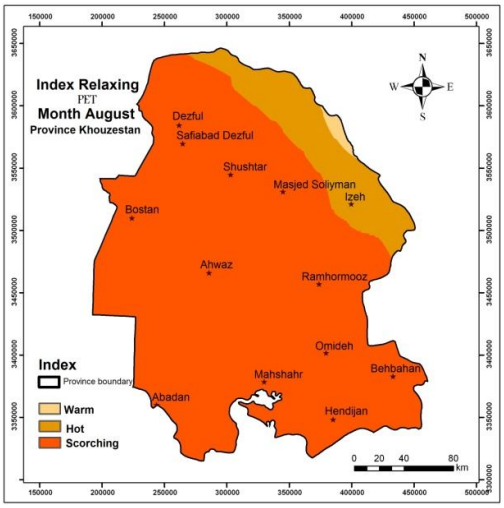


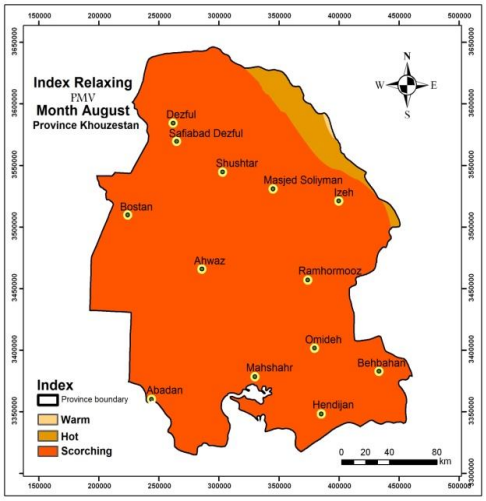
July:

PET index: in July (from 11th of Tir to 10th of Mordad), conditions of PET will be similar to the previous month so that in southern, central, south-eastern, western and north-western areas of the province with very severe heat tension, hot conditions reign. In northern to north-eastern areas of the province with severe heat

tension, very warm conditions will reign. In the furthest north-eastern area of the province with moderate heat tension conditions, warm conditions will exist. PMV index: in this month, PMV index is similar to PET index. In southern, central, south-eastern and western and north-western areas with very severe heat tension, hot conditions will exist. In the furthest north-eastern areas of the province with moderate heat tension, warm condition will reign.

Map 17: PET for August in Khuzestan province
Map 18: PMV for August in Khuzestan province

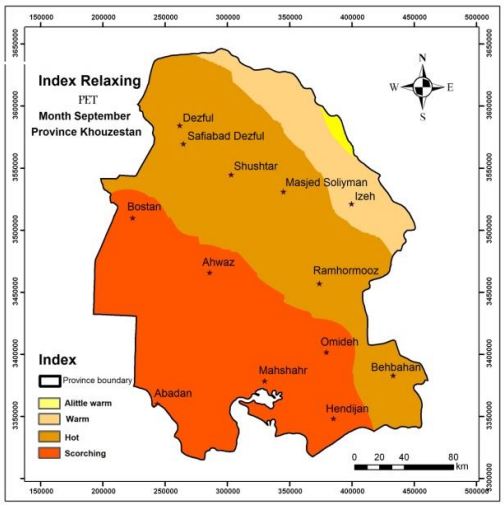


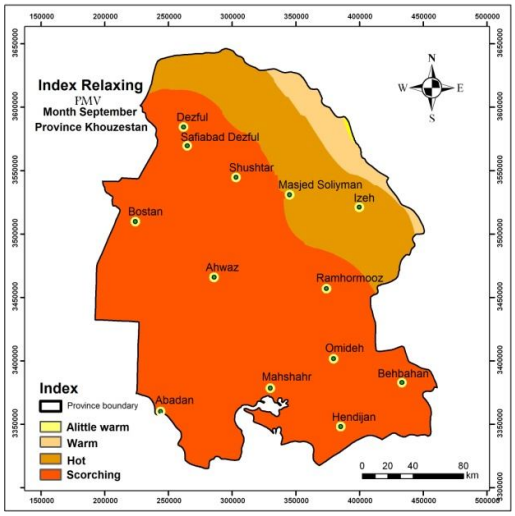


August:

PET index: in August (11th of Mordad to 10th of Shahrivar), PET index will be similar to the previous month; so that in southern, central, south-eastern, western and north-western areas of the province with very severe heat tension, hot conditions reign. In northern to north-eastern areas of the province with severe heat tension, very warm conditions will reign. In the furthest north-eastern area of the province with moderate heat tension conditions, warm conditions will exist. PMV index: in this month, PMV index is similar to PET index. In southern, central, south-eastern and western and north-western areas with very severe heat tension, hot conditions will exist. In the furthest north-eastern areas of the province with moderate heat tension, warm condition will reign.

Map 19: PET index for September in Khuzestan province
Map 20: PMV for September in Khuzestan province





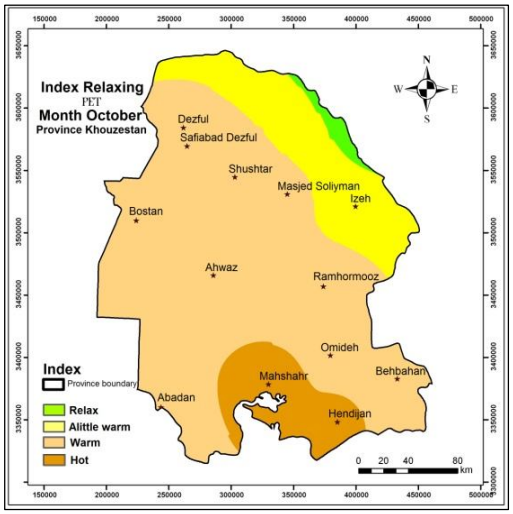
September

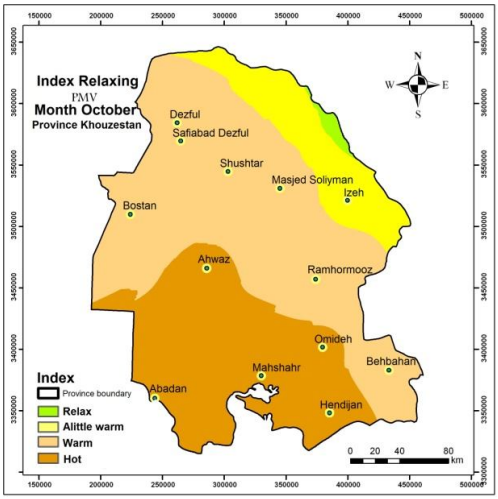
PET index: September (11th of Shahrivar to 9th of Mehr) shows hot conditions with very severe heat tension in southern, south-western, western parts of the province in terms of PET index. In central and south-

eastern areas to north-western parts with severe heat tension, very warm conditions exist. In northern to north-eastern areas of the province with moderate heat tension, warm conditions reign. In the furthest north-eastern areas of the province with slight heat tension conditions, slightly warm conditions exist.

PMV index: in this month, PMV index is similar to PET index. PMV index shows hot conditions with very severe heat tension in southern, south-western, western parts of the province in terms of PET index. In central and south-eastern areas to north-western parts with severe heat tension, very warm conditions exist. In northern to north-eastern areas of the province with moderate heat tension, warm conditions reign. In the furthest north-eastern areas of the province with slight heat tension conditions, slightly warm conditions exist.

Map 21. PET index for October in Khuzestan province
Map 22: PMV index for October in Khuzestan province

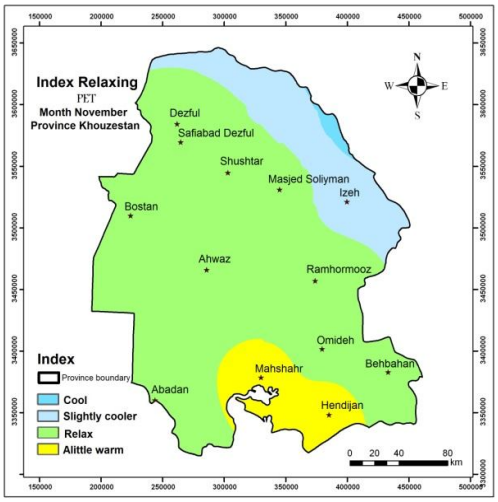


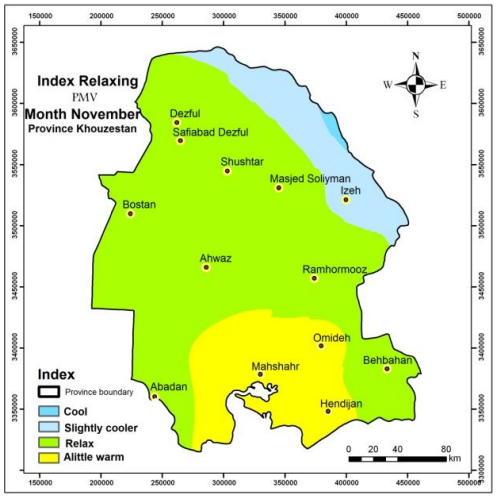


October:

PET index: in October (10th of Mehr to 11th of Aban), PET shows very warm conditions in southern parts of the province with severe heat tension. In central, south-eastern and western areas of the province, warm conditions will reign with moderate heat tension. In northern to eastern areas with slight heat tension, slightly warm conditions will reign. In north-eastern areas with without-tension conditions, comfortable conditions will reign. PMV index: in this month, PMV is slightly similar to PET index. In southern and south-western areas with severe heat tension conditions, very warm conditions will reign. In central, south-eastern and western areas of the province with moderate heat tension, warm conditions will exist and in the furthest north-eastern areas which are without tension, comfortable conditions will exist.

Map 23: PET index in November in Khuzestan province
Map 24: PMV for November in Khuzestan province

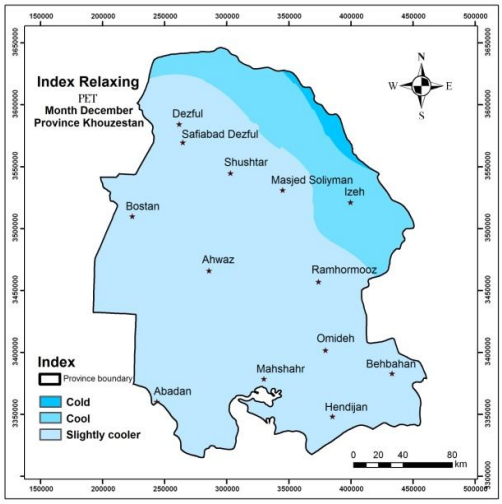


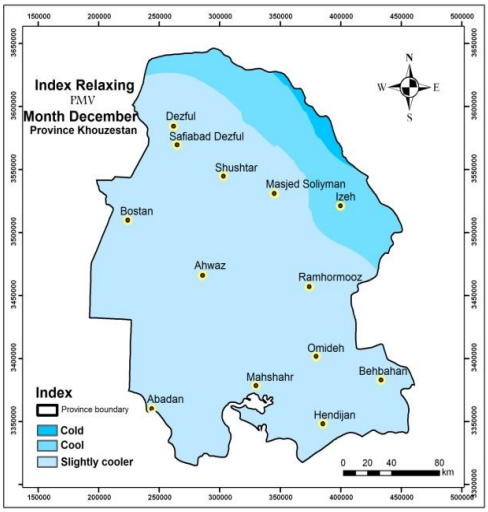


November:

PET index: in November (12th of Aban to 10th of Azar), PET shows slightly warm conditions in southern areas with slight heat tension. In central, south-eastern, western and north-eastern areas of the province without tension, comfortable conditions exist. In northern to north-eastern areas of the province with slight cold tension, slightly cool conditions exist and in the furthest north-eastern areas with moderate cold conditions, cool conditions exist. PMV index: PMV index is slightly similar to PMV so that in the southern part of the province with slight heat tension, slightly warm conditions exist. In central, south-eastern, western and north-western parts without tension, comfortable conditions exist. In northern to north-eastern areas with slight cold tension, slightly cool conditions exist and in the furthest north-eastern areas with moderate cold conditions, cool conditions will exist.

Map 25: PET for December in Khuzestan province
Map 26: PMV for December in Khuzestan province





December

PET index: PET index in December (11th of Azar to 11th of Dey) showed that in southern, south-eastern and western parts of the province with slight cold tension, slight cold conditions exist. In northern to eastern parts with moderate cold tension, cool conditions reign. In the furthest north-eastern areas of the province with severe cold tension conditions, cold conditions reign. PMV index: in this month, PMV conditions are fairly similar to PET conditions. In southern, south-eastern and western areas of the province with slight cold tension, slight cold conditions reign. In northern to eastern areas with moderate cold tension, cool conditions will exist and in the furthest north-eastern boundary of the province with severe cold tension, cold conditions reign.

Conclusion

In terms of PET index, March and November are suitable for tourists in Khuzestan, with the difference that March conditions are more ideal in comparison with November. Furthermore, PMV index showed that the two months have favorable climatic conditions. Of course, November is more favorable than March in this index. According to the means of indices PET and PMV obtained from the province meteorological stations in each month, table 4 is presented and the corresponding index changes curve was sketched during a year.

months	PET index number	Thermal sensitivity	PMV index number	Thermal sensitivity
January	12.4	Very cool	-1.6	Very cool
February	14	cool	-1.2	Very cool
March	19.3	Favorable and comfortable	-0.1	Very cool
April	27.8	warm	1.5	Cool
May	37.4	hot	3.2	Cool
June	44.2	hot	4.5	Favorable
July	46.6	hot	4.9	Warm
August	45.9	hot	4.8	favorable
September	40.8	hot	3.9	favorable
Octobr	32.4	warm	2.4	cool
November	21	favorable	0.4	Very cool
December	14.7	cool	-1	Very cool

Figure 1 was obtained from the values of monthly means of PET and PMV in Khuzestan province.

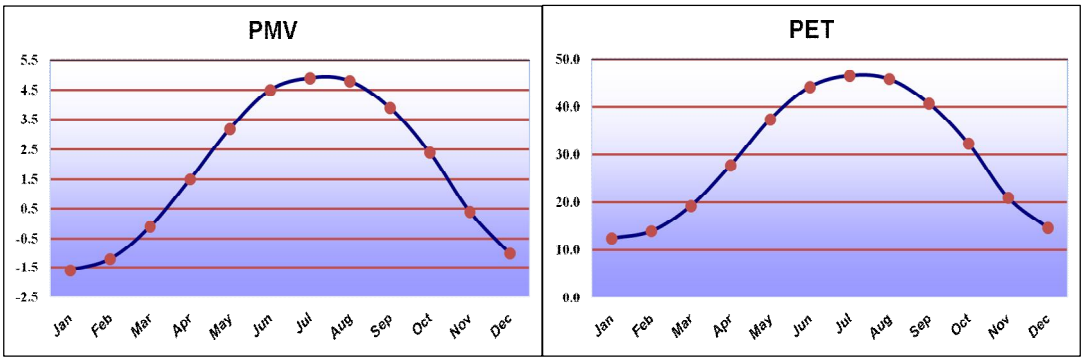


Figure 1: the quality of monthly distribution of PET and PMV in Khuzestan province

Monthly conditions of PMV index and PET index, favorability of the two indices in March and November are in ideal conditions.

Recommendations

Considering the results of the present and previous studies, the following recommendations are proposed:

- It is advised to provide necessary equipment in case of using non-local forces considering the climatic conditions of the area.
- Construction of resorts and planning for tourism activity with emphasis on the above models
- Results of the present study can be used in formulation of strategies and doctrine concerning tourism in Khuzestan.

Acknowledgment

The authors declare that they have no conflicts of interest in the research.

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