Evaluation of Tourism Comfort Climate in Mazandaran Province Using PMV Model

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The purpose of this paper is setting out the situation of thermal comfort climate in Mazandaran province in relation to attracting tourists. The method in this research is descriptive-analytic and the instruments for gathering data are PMV model and Rayman software through using synoptic station (1980-2010) in a 31-year-old period. The result of the study shows that Mazandaran province has the best conditions for attracting tourists to the province during the month of May, June, September, and August, and the months of January, February, and December are not good for tourists due to very severe cold stress sensitivity and severe cold stress climatic conditions.

ABSTRACT

Research Background:

Mazandaran Province is the most prone area for tourism in Iran for its climatic condition, vegetation, forests, beautiful seacoasts, and plenty of beaches. Environmental conditions influence tourists’ perceptions and impressions, levels of comfort, well-being, and health. The human body is constantly affected by the weather. Thus, tourists are always looking for a climate which increases their comfort and is not any threat to their health. Climate and weather affect tourists’ satisfaction and make it possible for them to enjoy and take advantage of entertaining and recreational activities in perfect excellent health and comfort, and thus their the level of satisfaction is enhanced (Tavalaee, 2006). Meanwhile, the combined indexes of temperature-physiology which are based on the energy balance of human body hold a special place in today's human climate biology studies. Numerous studies have been done regarding comfortable climate and the PMV index.

Basatrzadeh (1999) in his master's thesis examining the biology and climate of ChaharMahal Bakhtiar province using Terjung states that most stations in the months of May, September, and October are within the climatic comfort zone. In 2002, Karimi in his dissertation examined the relationship between climate and tourism in Tabriz using PET, SET, and PMV indexes and reached the conclusion that July and August are the best months for tourists regarding the comfort climatic conditions, and the worst months are November, December, January, February, and March.

In an article, Zolfaghari (2007) has attempted to determine an appropriate time calendar for tourism in Tabriz using physiological equivalent temperature index (PET) and the predicted mean vote (PMV) and concluded that the climate comfort period is limited and is only for 45 days from early June to mid-July. Moreover, Mohammadi et al. (2008) investigated human comfort and environment in a case study in Ghom city and concluded that the studied area has a range of hot to very cool condition bio-climatically during the year. EsmaeNejad (2009) also in an article entitled investigating winter climate and tourism in Chahbahar province concluded that months in winter have climatic comfort.

Shayan et al. (2009) examined tourism climate index in Kish Island and concluded that January has a high potential in terms of climatic comfort. Sari Saraf et al. (2010) studied zoning climatic tourism in Arasbaran area using TCI index and concluded that June, July, August, and September with the TCI score of (90-100) have the best conditions in terms of climatic comfort and December and January have no climatic comfort for tourists in all studied stations.

Gandomkar (2010) studied applying GIS in zoning Fezeh index in Isfahan province and concluded that the October, April, and May are the best months for tourists to come to the province. Farhoodi et al. (2010) evaluated the impact of seasonal changes on tourism revenues in Anahita Temple and concluded that seasonal changes affect the number of tourists and thus the revenue from tourism and tourism planning is essentially related to summer.

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Najafi et al. (2012) examined the thermal climatic comfort in Vakil Bazaar in an article entitled studying thermal comfort using PMV, and PPD. A case study in Vakil Bazaar in Shiraz. They reached the conclusion that thermal comfort in winter terms of the degree of physiological stress is without cold stress and thermal sensitivity is in comfort degree and less than 15 percent of Bazaar users are not satisfied with these conditions.

Hemati (2013) in an article entitled studying climate and tourism comfort in Shiraz city using PMV model came to the conclusion that October without cold stress and April (Ordibehest) which is the best month for tourism in terms of thermal sensitivity with a slight cold stress and slightly cool thermal sensitivity and the months of November and March with moderate cold stress and cool thermal sensitivity, and June with low warm stress and slightly warm thermal sensitivity are suitable months for tourism.

Gandomkar and Daneshvar (2013) studied human biology climate based on DEM using predicted mean vote (PMV) index in a case study in Kohkilooye and Boyer Ahmad province. They concluded that altitude is one of the most important local factors affecting climate and comfort and comparing the obtained results fully demonstrates the effect of altitude on climatic comfort.

Matzarakis and Mayer (1997) examined the amount of heat stress in relation to bio-meteorological significance using PMV index at 12 meteorological stations in Greece during the years 1980 to 1989. Then, using a statistical model, they turned PMV values at each station into a climatology map with high precision. This map shows the average of the number of days in the year with high heat stress. Jacqueline (2004) studied the effect of climatic conditions on selecting tourism destination in Germany using some variables such as air temperature, precipitation, the number of humid days and the number of frost days.

Emmanuel (2004) in an article investigated the application of thermal comfort in hot and humid urban areas in the metropolitan area of Colombo in Sri Lanka and used bioclimatic indexes, relative stretch index (RSI), and temperature humidity index (THI) to study thermal comfort. Moreover, Hamilton et al. (2005) using a stimulated model claimed that due to the increase in the amount of carbon dioxide and climatic changes throughout the world, tourists’ travel and accommodation for have gone more towards the higher latitudes and altitudes.

Matzarakis (2007) analyzed bio-climatic information for tourism in the southeastern parts of Germany in areas where the density of meteorological stations is small. The results of these analyses are presented in the form of bioclimatic maps. Farajzadeh and Matzarakis (2009) also studied the northwestern parts of Iran using a physiology equivalent model and concluded that the best season for tourism comfort is summer. Moreno et al. (2009) studied comfort conditions and climatic changes in coasts of Europe in summer and states that for sustainable tourism in the Mediterranean Sea greater attention must be paid to climate changes such as rising of the sea level and bio-environmental quality and variety of activities and decentralization.

Moreno and Amelung (2009) studied the effects of climatic and weather changes with special attention to beach tourism in the summer especially in Mediterranean Sea and predicted that tourism in this region will be at its upper level in 50 years. Due to climate change, therefore, more attention has been paid to maintaining bio-environmental quality of the region regarding climatic changes. Also, Yu et al. (2009) studied two tourist destinations in Alaska by providing a way to identify the appropriate seasons for tourism in terms of climatic conditions. Mentioning that the climate is getting warmer and it has positive and negative impacts on tourism opportunities, they stated that although the period of skiing decreases in some parts of the region, the summit of mountains will be a suitable high quality place to ski.

The realm of the research:

Mazandaran is an area of 23756/4sq kms. The province is in 35 degrees 47 minutes latitude, 36 degrees 35 minutes north, 50 degrees 34 minutes longitude, and 54 degrees 10 minutes east. It is bordered from the north by the Caspian Sea, from the south by Alborz and Tehran provinces, from the Southeast by Semnan province, from the North and Northeast by Golestan province, from the west by Gilan province, and from the southwest by Gazvin province.

Methodology:

Each scientific research requires a methodology corresponding to its topic. Selecting an appropriate method and its continuity in the whole process of scientific research is among applied principles of a scientific research. Predicted mean vote (PMV) is among the most important indexes of temperature. It is widely used not only for studies related to urban and regional planning but also for determining thermal element of urban microclimates in studies related to tourism meteorology for investigating climatic comfort zones for tourists. PMV index can be calculated by the following equation.

1- PMV=(0.303E-0.036M+0.028){(M-W)-H-Ec-Crec-Erec-PMV=(0.303E)}

In the above equation, the values of E, Erec, Crec, and Ec are calculated as follows:

2- E=3.05 * 10-3 (526sk-3373-Pa)+Esw
3- Ec=3.05 *10-3(5733-6.99 *(M-W)-Pa)+0.42(M-W-58.15)
4- Crec=0.0014M(34-Ta)
5- Erec=1.72 *10-5M(5867-Pa)
In the above equations, H is directly measurable and can be calculated by the following equation:

\[ H = Kc_1 - tc_1/Ic_1 \]

### Table 1: Explanation of formulas (Matzarakis et al., 1999).

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>( C_{rec} )</td>
<td>Evapotranspiration convection heat exchange (W/M²)</td>
</tr>
<tr>
<td>( E_{sw} )</td>
<td>Heat losses by evapotranspiration (W/M²)</td>
</tr>
<tr>
<td>( Ic_1 )</td>
<td>Average dress radiation to the whole body (W/M²)</td>
</tr>
<tr>
<td>( tc_1 )</td>
<td>Dress surface temperature (Centigrade degree)</td>
</tr>
<tr>
<td>( W )</td>
<td>Effective mechanical force (W/M²)</td>
</tr>
<tr>
<td>( H )</td>
<td>Dry heat loss through convection, conduction and radiation (W/M²)</td>
</tr>
<tr>
<td>( E_{ec} )</td>
<td>Evaporative heat exchange at the skin surface in neutral temperature (W/M²)</td>
</tr>
<tr>
<td>( t_a )</td>
<td>Air Temperature (Centigrade degree)</td>
</tr>
<tr>
<td>( M )</td>
<td>Rate of metabolism (W/M²)</td>
</tr>
<tr>
<td>( t_{sk} )</td>
<td>The average temperature of the skin (centigrade degree)</td>
</tr>
<tr>
<td>( e )</td>
<td>Evaporative heat exchange at the skin surface (W/M²)</td>
</tr>
<tr>
<td>( P_a )</td>
<td>Humidity, slight air pressure (Pascal)</td>
</tr>
</tbody>
</table>

PMV scale is a 7-degree heat sensation segmentation and its range changes from -3 (cold) to +3 (warm). Zero on this scale indicates a neutral thermal sensation (Table 2). For easier and faster calculation of this index, software are designed, Ray Man software is one of them (Zolfaghari, 2007; Bahadorinejad & Yaghoobi, 2006).

### Table 2: Threshold values of PMV index in different degrees of human sensitivity (Matzarakis et al., 1999).

<table>
<thead>
<tr>
<th>Degree of physiological stress</th>
<th>Thermal sensitivity</th>
<th>PMV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe cold stress</td>
<td>Very cold</td>
<td>-3</td>
</tr>
<tr>
<td>cold</td>
<td></td>
<td></td>
</tr>
<tr>
<td>moderate cold stress</td>
<td>cool</td>
<td>2</td>
</tr>
<tr>
<td>slightly cold stress</td>
<td>slightly cool</td>
<td>1</td>
</tr>
<tr>
<td>without cold stress</td>
<td>comfortable</td>
<td>0</td>
</tr>
<tr>
<td>slight heat stress</td>
<td>slightly warm</td>
<td>1</td>
</tr>
<tr>
<td>moderate heat stress</td>
<td>warm</td>
<td>2</td>
</tr>
<tr>
<td>great heat stress</td>
<td>warm</td>
<td>3</td>
</tr>
<tr>
<td>Severe heat stress</td>
<td>hot</td>
<td></td>
</tr>
</tbody>
</table>

Appropriate methods for calculating the mean of radiant temperature of the environment are used and ultimately they are used to calculate PMV.

**Required variables for Ray Man model for calculating PMV:**

1. The situational variables including geographical longitude and latitude, position and altitude of a city
2. Meteorological variables including dry temperature in degrees Celsius, the vapor pressure in terms of hectopascal, relative humidity in percentage, wind speed in terms of meters per second, and the amount of cloud in octal.
3. Personal variables as physiological characteristics are influential in the model are. In this respect, individual characteristics such as height, weight, age and gender must be entered into the model.
Findings and Discussion:

Given that physiological data, coverage, and kind of activities vary a lot, according to the model’s suggestions, some items can be considered as average or standard. For example, the standard mean of men’s height, weight, and age variables can be considered in the society. The figures 9/0 kg for coverage and 80 watts for a moderate activity like driving can be considered for either male or female. It is can be said that there is a slight difference in this regard between men and women which is mostly negligible in many cases (Zolfaghari, 2007).

According to the studies that have been carried out and using PMV model and Rayman’s software, the maps of different months in Mazandaran Province were prepared which show the thermal comfort climatic situation of each month in a year.

Fig. 1: PMV Map for January.

Fig. 2: PMV Map for February.

Fig. 3: PMV Map for March.

Fig. 4: PMV Map for April.
Fig. 5: PMV Map for May.

Fig. 6: PMV Map for June.

Fig. 7: PMV Map for July.

Fig. 8: PMV Map for August.
**Conclusion:**

Based on PMV model and conducted studies of statistics of the synoptic meteorology station, the best months for tourists are May, June, December, and August which have a cool, a little cool and comfortable climate in May, and slightly cool, comfortable, and a little bit warm climate in June and September, and slightly cool, comfortable, slightly warm and somewhat warm climate in August. Tourists would feel comfortable if they travel in these months. The rest of the months are either warmer or colder than the desired level and bring about tourists’ dissatisfaction.

**REFERENCES**


