Original Article

Regional simulation model of the meteorological effects of Maharlu Lake on the human climate health of Shiraz in Iran

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Abstract

Background and purpose: Human health is affected by a variety of human and natural phenomena that surround the environment. Atmospheric pollutants and thermal comfort conditions concern the quality of surrounding air. Given the influential role of lakes on the climatic conditions of their surrounding environment, the effect of different scenarios of Maharlu Lake in the southeastern part of Shiraz on the changes of thermal comfort conditions was modeled.

Materials and Methods: In this study, cooling power index and temperature humidity index were used to explore climate comfort conditions according to the long-term observational data from 1960 to 2010.

Results: It was found that temperature humidity index has a declining trend in most months of the year. Maximum decreasing changes were observed in November and May with means of −0.31 and −0.29, respectively. However, the maximum of decade and significant changes of cooling power index belonged to April and November with means of 1.36 and 1.22, respectively.

Conclusion: Low relative humidity was seen in all the seasons; maximum decrease was observed during summer and in August with 11% decrease. Also, the dried lake outputs showed that the temperature during hot seasons increased, and the temperature during cold seasons decreased.

Keywords: Environmental Health; Thermal Comfort Modeling; Mesoclimate Models; Maharlu Lake

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1. Introduction

The first thing that comes to mind about the quality of air is air pollution and emission of aerosols and various compounds into the air. Moreover, human health is not just affected by the presence of atmospheric pollutants, but also the interaction of various climatic factors, such as temperature, humidity, wind speed, solar radiation, and so on. They can create desirable/undesirable and ideal/non-ideal environment with regard to climatic conditions in which most people do their daily activities. Also, in some areas in the country, the interaction of aforementioned climatic factors make weather conditions a challenge for people to carry out their routine activities, and thereby endanger their health (1-5). Perhaps, heat and cold waves are good examples of climatic disasters that threaten the health of people every year, and sometimes even cause death (6-8). Perceived comfortable temperature results from the energy balance of the body, which includes heat loss by convection and conduction to the surrounding air, by evaporation, and by radiation to and from neighboring surfaces. It is worth mentioning that the climatic conditions of the environment that surrounds us are dependent on two factors including local and regional factors and external and trans-regional ones. With the spread of regional climate simulation software, this possibility has arisen that various scenarios, such as the impact of mountains on adjacent lands, or the scenario of making a lake full of water, or of drying a lake and its effect on climatic conditions of the area be simulated in the virtual computer world (9-12). In this regard, some climate modeling studies have focused on modeling the lake effect on variability of climatic factors, such as temperature, humidity, rain, dust, and air quality. For example, in modeling the impact of lake on surrounding land, drying of Lake Aral was studied by (13) using MM5 Software Model. In this study, the lake was dried with three scenarios of the whole lake, half of the lake, and parts of the lake, and then based on each scenario, its effect on dust emissions and dispersion was discussed. At the same time, (14) evaluated the effect of Lake Breeze in southern Great Lakes region on air quality of adjacent areas based on the 2007 data. In one other work, (15) studied the effect of Jazmoorian Lake, located in southeastern part of Iran, on climatic conditions of adjacent areas. These researchers simulated the changes of climatic factors of temperature, relative humidity, and wind for both cold and warm periods of the year through hypothetical increase in water level and creating a virtual lake in the studied area. A similar study was done by (16) in order to model the effect of Hamoon wetland on climatic conditions of neighboring lands. Also, in another study, (17) simulated daily changes of sea breeze for southern shores of the Caspian Sea based on mesoclimate models. Investigating the effect of lake on neighboring lands showed that the thermal comfort indices could be affected by the changes in the lake. It is worth mentioning that one of the most important and influential effects of water masses similar to Maharlu Lake, is its key role in comfort climate condition of its neighboring areas. Maharlu Lake is located at an altitude of 1,490 m above sea level with a length of 35 km and 18 km in the southeastern part of Shiraz city. Being towards the east of Bakhtegan Lake, Maharlu Lake is located in the eastern part of Shiraz plain. It has very salty water, and is considered as one of the biggest salt deposits of Iran in dry seasons. One of the wonders of Maharlu Lake is the existence of numerous freshwater springs in the north and northwest margins, even in dry climatic conditions. As a result of the rainfall regime, that is, without rain, with low rainfall, and cases of heavy rainfall, there are several tiny freshwater and saltwater wetlands that depend on monthly and annual rainfall in this area, which is variable. The main objective of the present research was to study and evaluate the effect of different scenarios of drying Maharlu Lake or making it full of water on climatic conditions of comfort climate and thermal conditions of Shiraz city, which is located close to the Lake Maharlu.

2. Materials and methods

In the current study, in order to calculate the Cooling Power Index (CPI) and Temperature Humidity Index (THI), daily and hourly data of average temperature, relative humidity, and wind speed was used from 1960 to 2010. Hence, two scenarios of lake, i.e. full of water (real condition), and dried lake, were applied by using climatic software called The Air Pollution Modeling (TAPM). TAPM was prepared by Commonwealth Scientific and Industrial Research Organization in Australia. Some of the information provided in the model included ground networks, altitude, vegetation, soil types, sea surface temperature, and meteorological data in the synoptic scale. This model analyzes weather and climate components up to an altitude of 8,000 m, and it has the capacity to forecast air pollution, storms, direction, and speed of wind, and so on. TAPM is a very simple (it needs a little computation) and a relatively quick model (18-21). In this model, there is the possibility of eliminating or modifying some features of the earth's surface and simulating their effects on climatic parameters. In general, the required data in the model are divided into the following three categories (22):

(1) Data on land use and soil types.

(2) Data analysis and synoptic meteorological model.

(3) Terrain or ground elevation data extracted from the topographic map.

It should be noted that prior to using modeling data according to different scenarios, at first, the values for temperature, relative humidity, and wind speed were all modeled for actual conditions of the proposed years 2003, 2006, and 2010 using TAPM Software. Statistical methods were used to evaluate the results that were validated with real data.

The climatic effect of existence of water (being full of water), or lack of water (dry lake) on changes in the CPI and THI indices was investigated based on two scenarios. At the outset, it should be noted that in this study, only the data from 2003, 2006, and 2010 was available for TAPM Software in Iran. But the scenario number 1 was considered according to the climatic data of stations in 2003, 2006, and 2010 considering the synoptic conditions as well as all total water area of Maharlu Lake for these three aforementioned periods. It means that the most ideal circumstances were related to the scenario number 1. But in the second scenario, Maharlu Lake was considered to be completely dry, and then the values of THI and CPI indices were modeled. Moreover, Maharlu Lake is one of the salty lakes, therefore it is known as Salt Lake among its native people. Hence, after removing its water, the conditions of Salt marshlands were replaced. It must be stated that prior to the assessment of changes of CPI and THI indices of climate comfort, the overall changes of three components of temperature, wind speed, and relative humidity were evaluated. In the beginning, it is important to note that, acceptable comfort climate indicators have been introduced in the scientific community by combining components, such as relative humidity, wind speed, and temperature. To name some other indicators, one can refer to Psychological Equivalent Temperature (PET), Predicted Mean Vote index (PMV), and Predicted Percent of Dissatisfaction (PPD). But given the limitations of TAPM Model in simulating some climate components, with emphasis on simulating temperature, humidity, and wind components, two indicators of Backer climate comfort, that is, CPI (Equation 1), and THI (Equation 2) were used in the present study:

To evaluate the simulation of human bioclimate in different environments, Backer CPI can also be used. In the current study, the researchers used the climate comfort indicators which had at least a combination of two climatic components of wind, temperature, and relative humidity. Baker index formula is presented below. Also, in table 1, the qualitative and quantitative ranges are provided:

$$CPI = (0.26 + 0.34V^{0.632})36.5 - T \qquad (1)$$

According to the above equation, V is wind speed in meters per second (m/s), and T is the average daily temperature in degree Celsius (°C).

THI index that is called Discomfort Index (DI) by United States Institute of Meteorology is mostly applied in warm climate, and is suitable for evaluating warm seasons of the year for the studied area. In this regard, some researchers (25) prefer to use simple indicators called as temperature–humidity index. In comfort climate studies including comparative studies between metropolitan areas with neighboring areas, good results were presented with this formula. THI equation was presented in a way that its numerical value was shown with C unit as in equation (2) (14):

$$THI = t-(0.55-0.0055f)\,(t-14.5) \qquad (2)$$

According to equation (2), t is the average temperature in Celsius (°C), and f is the relative humidity in percent (%). In the following Table, the qualitative and quantitative ranges of THI index are also provided (1).

Table1. Climate comfort zone for CPI and THI indices (23).

THI value	Qualitative zone	CPI value	Qualitative zone
<-40	Colder than freezing	9.4-0	Hot, warm, humid, unpleasant
-20 to -39.9	Freezing	9.9-5	Warm, tolerable
-10 to -19.9	Chilly	9.19-10	Mild and pleasant
-1.8 to -9.9	Very cold	9.29-20	Cool
12.9 to -1.7	Cold	9.39-30	Cold and a little challenging
14.9 to 13	Cool	9.49-40	Very cold
19.9 to 15	Comfortable	9.59-50	Unpleasantly cold
26.4 to 20	Warm	-	-
29.9 to 26.5	Very warm	-	-
>30	Hot	-	-

3. Results

As the extracted results from figure 1 show, the trend for changes in the area of Maharlu Lake has been decreasing in recent years. Although it is possible that in some periods due to high rainfall, lake is immune from complete drying, but the outputs confirms the fact that the dry lake scenario is not unexpected. As can be seen from the map, the lake area has been 253.82 km^2 in 2000 that has reduced to 197.48 km in 2005, and it has reached to its minimum area of 55.06 km^2 in 2009. In order to properly evaluate the results of the climate models used in determining the climatic values of Shiraz station, statistical indices, such as Root Mean Square Error (RMSE), correlation coefficient (R), and Index of Agreement (IOA) were used. Therefore, after the simulation of hourly data (24 h) by TAPM Software Model, average daily data for three components, namely, temperature, relative humidity, and wind speed was calculated (Table 2). As the result of the statistical tests show, the modeled outputs have acceptable confidence level. However, with these interpretations, the best simulated results belong to temperature, then relative humidity, and finally wind. What is important here is that, no model is without error, but error threshold is reduced as much as possible, so that actual conditions can be modeled in a better way, so as to provide more acceptable results.

Table2. Statistical validation of modeled data with actual data

Wind(Speed)									Humidity									Temperature								
2003			**2006**			**2010**			**2003**			**2006**			**2010**			**2003**			**2006**			**2010**		
R	RMES	IOA	R	RMES	IOA	R	RMES	IOA	R	RMES	IOA	R	RMES	IOA	R	RMES	IOA	R	RMES	IOA	R	RMES	IOA	R	RMES	IOA
0.68	0.77	0.75	0.71	1.77	0.77	0.67	1.1	0.77	0.91	2.1	0.88	0.89	1.75	0.93	0.83	1.12	0.87	0.97	0.25	0.98	0.98	0.20	0.96	0.94	0.93	**0.97**

In this section, first based on two proposed scenarios, the changes of monthly values of components, such as temperature, relative humidity, and wind speed were evaluated and the results are presented below. To summarize the results and present it in a compact manner, this section is evaluated and analyzed in the form of mean difference between dry lake scenario and its actual condition for two components of minimum and maximum temperature and relative humidity. It should be noted that the values of maximum (minimum) temperature are assigned to the day (night), and the values of maximum (minimum) relative humidity are related to the average of long nightly (daily) hours. Therefore, negative (positive) values reflect a decrease (increase) in temperature or relative humidity in dry lake scenario, as compared to the real condition (lake full of water). As can be seen in Figure (1), the minimum temperature components in the dry lake scenario were compared to the lake being full of water scenario, and nightly temperature reduced in all months. But the maximum temperature decrease was for winter, spring, summer, and autumn which belonged to January with −2.20 °C, April with −0.75 °C, September with −0.59 °C, and finally December with −1.90 °C, respectively. Thus, according to the seasonal averages, winter with a decrease of −1.70 °C had experienced the maximum nightly temperature decrease, while summer with −0.50 °C had witnessed the minimum nightly temperature decrease. In the following, the modeled outputs for the maximum component temperature showed that in the dry lake scenario compared to the lake full of water scenario, monthly average of daily temperature will increase in all months without any exceptions. The maximum average daily temperature increase was 2.60 °C, which was modeled for summer, and then spring and autumn were in the second and third place with 1.81 and 1.18 °C, respectively, while winter experienced an increase of 0.62 °C in the fourth place. The findings of this section showed that August and February experienced the maximum and minimum daily temperature increase with 2.9 and 0.41 °C between different months of the year, and other months of the year fluctuated between these two months. Finally, considering the dry lake scenario compared to the lake full of water scenario, it can be seen that the maximum temperature decrease was for cold months of the year, whereas the maximum temperature increase happened in warm months of the year, as shown in Figure 1. In this section, based on the two scenarios of dry lake and lake full of water (actual condition), the minimum and maximum values of relative humidity of Shiraz city were simulated and compared. With respect to the modeled outputs, it became clear that in the dry lake scenario compared to the lake full of water scenario, reduction of relative humidity will occur for both the minimum and maximum relative humidity indices. Therefore, the annual mean maximum of relative humidity reduces 5.80%, but this value for minimum relative humidity is about −7.37%. Therefore, the annual decline of relative humidity, which often occurs in hot hours of the day, is something more than cool hours to cold nightly hours. In this regard, the average maximum relative humidity decrease for winter is −4.40%, spring −5.77, summer −8.97, and this value for autumn is −4.07%.

However, the average reduction in the minimum relative humidity for winter and spring has been −6.63 and −7.53%, respectively, and this value for summer was −10.17 and for autumn it reached −5.13%. Thus, the maximum and minimum relative humidity decrease is related to summer and winter. It is also important to note that in the scenario of dry lake, August has experienced the maximum of relative humidity decrease for both factors of maximum and minimum of relative humidity with values of −9.9% and −11%, respectively. The minimum relative humidity decrease for both factors of maximum and minimum of relative humidity was assigned to December with values of −3 and −3.9% (Figure 1). What is important when comparing dry lake scenario outputs with the scenario of lake full of water is the simulation of more decrease in relative humidity for warm months and also daily hours, which is equivalent to relative humidity factor in comparison with cold months of the year, and nightly hours, which is equivalent to maximum relative humidity factor.

These outputs clearly reveal that assuming drying of Lake Maharlu, all months of the year will be accompanied by a decrease in relative humidity, as in contrast to the increase in daily temperature and decrease in nightly temperature; these changes can affect thermal comfort situations of Shiraz city.

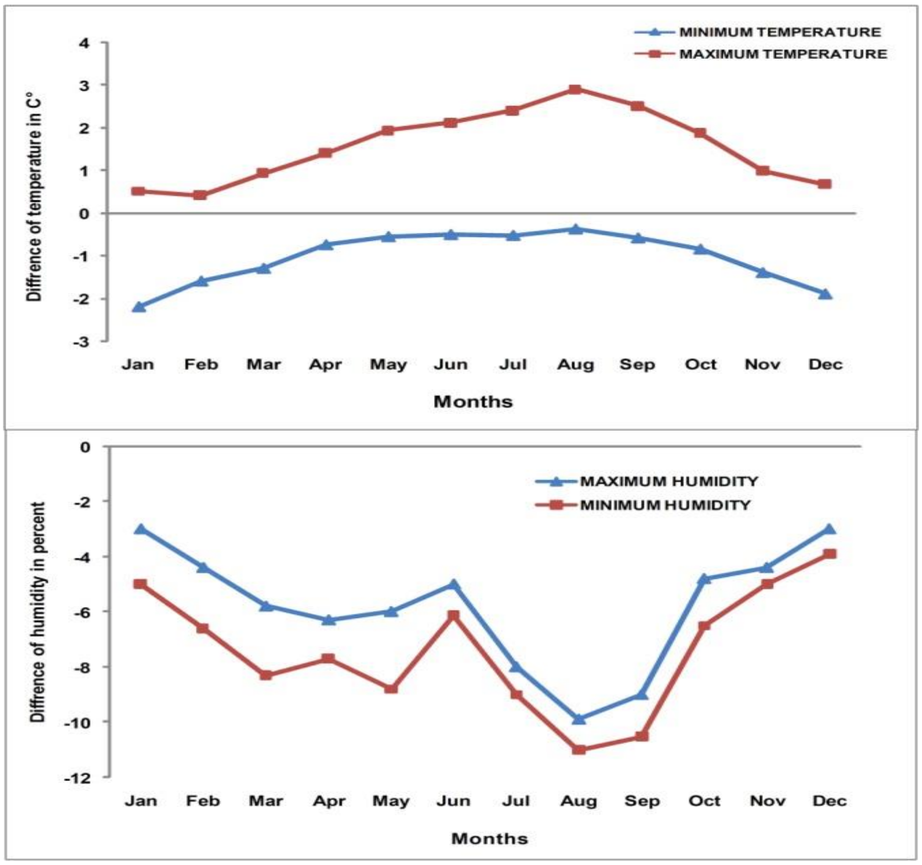

Figure 1. The difference between modeled temperature values (minimum and maximum) and relative humidity (minimum and maximum) based on dry lake scenario in comparison with the scenario of lake full of water (actual condition) for different months of the year.

With regard to the comparison of outputs of dry lake scenario with lake full of water, it can be seen that for average wind speed at night, a dominant pattern was not observed during months of a year. Therefore, for months of one season, increasing and decreasing values of wind speed can be seen. However, for daily hours considering lake being dry, it can be seen that wind speed reduces in most months of a year and, the amount of changes equals zero only in two months of July and September. In general, as is shown in Figure 2, the average annual wind speed according to lake being full of water is 1.89 m/s which decreases slightly in the dry lake scenario and is reduced to 1.72 m/s.

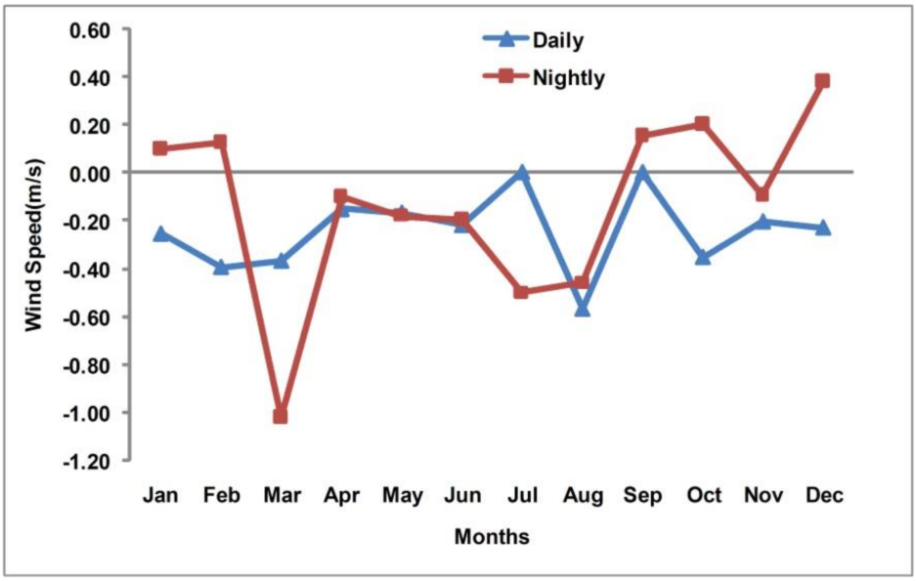

Figure 2. The difference between modeled wind speed based on dry lake scenario in comparison with the scenario of lake being full of water (actual condition) for daily and nightly average of different months.

Based on the statistical period of 1960 to 2010, long-term and monthly average for two bioclimatic indices, namely, THI and CPI was calculated for Shiraz city, and the following results were obtained. According to Figure 3, the minimum amount of THI was for cold months of the year focusing on winter. Therefore, the coldest month of the year with THI = −0.23 belonged to January, and this month was in the very cold qualitative zone. But two other months of this season were located in cold qualitative zone. In spring, values of THI index was changing between qualitative ranges of cold to comfort, and June with a THI of 17.98 was located in comfort qualitative zone. In summer, first two months were in the warm zone, and September with THI = 17.34 was in the comfort zone. Finally, bioclimatic zone of autumn was changing between cool to cold, and December with THI = 2.90, as the coldest month of the year, was located in the cold bioclimatic zone. However, the results of CPI index are similar to THI output with slight differences. According to the CPI index, the coldest month of the year was February with CPI = 28.41, and all winter months were located in cool bioclimatic zone. But spring bioclimatic zone was fluctuating from cool for April to pleasant for May and June. Summer bioclimatic zone was also changing from tolerable warm for July and August to mild and pleasant for September with a CPI value of 13.74. Finally, for autumn, October with long-term average of CPI equal to 18.18 was located in the mild zone, and two months of November and December were found to be located in cool zone. It should be noted that according to the annual long-term average, Shiraz with a THI of 11.98 was documented to be located in the cold qualitative zone, while an average for CPI = 20 belonged to cool bioclimatic zone. Therefore, what was common in these two indices was that both of them had considered June and September as the months with bioclimatic climate comfort. Also, both indices considered July as a month with minimum comfort among warm months of the year, but there were, similarly, slight differences between two indices in determining the minimum of comfort for cold months of the year, because THI considered January as the month with minimum comfort, while CPI considered February as a month with minimum of comfort among the cold months of the year (Figure 3). However, expecting the same results for two bioclimatic indices that could be composed of different components and also have bioclimatic zones with different qualitative and quantitative thresholds was a little far from reality. On the other hand, as it can be seen from the figure, the results of both indices were often identical, and the observed differences could be related to the differences between defined thresholds for these indicators.

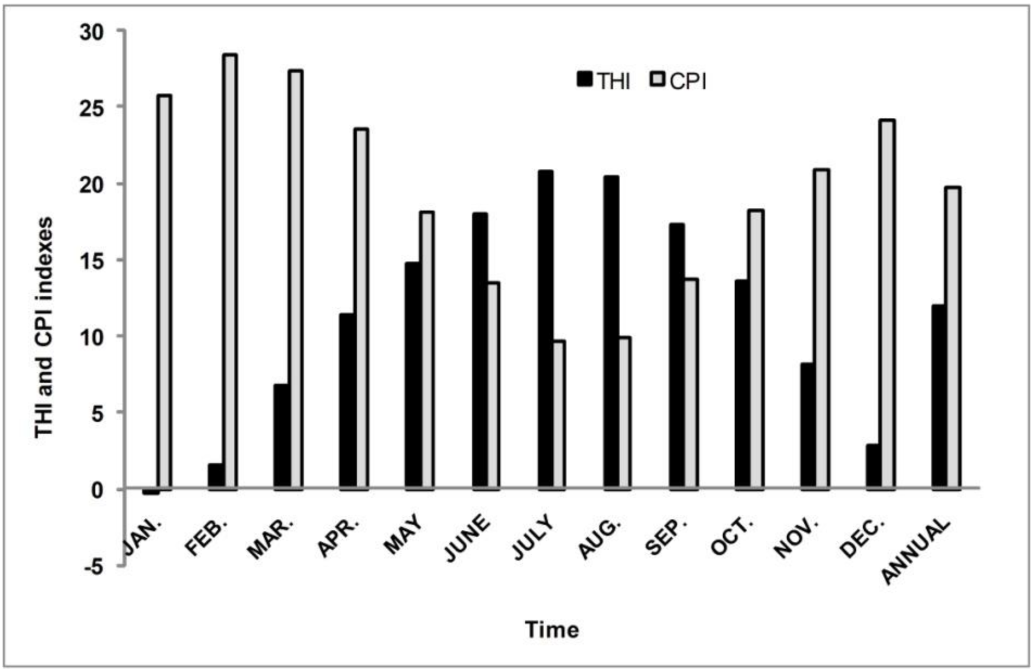

Figure 3. Monthly and annual long-term average of bioclimatic indices of THI and CPI for Shiraz city.

In this part, monthly and yearly trends of bioclimatic indices and fluctuations are investigated along with their decade changes. Prior to stating the results related to changing trend, it should be noted that THI index trend was increasing (decreasing), that is, it tended towards warmer (colder) bioclimatic conditions and thresholds that was different with what existed for CPI index. Since for CPI index, when trends were increasing (decreasing), it meant that climate comfort of that area was tending towards colder (hotter) bioclimatic thresholds. But as the following results of THI index shows, in winter, only March had a significant trend of $R = -0.23$.

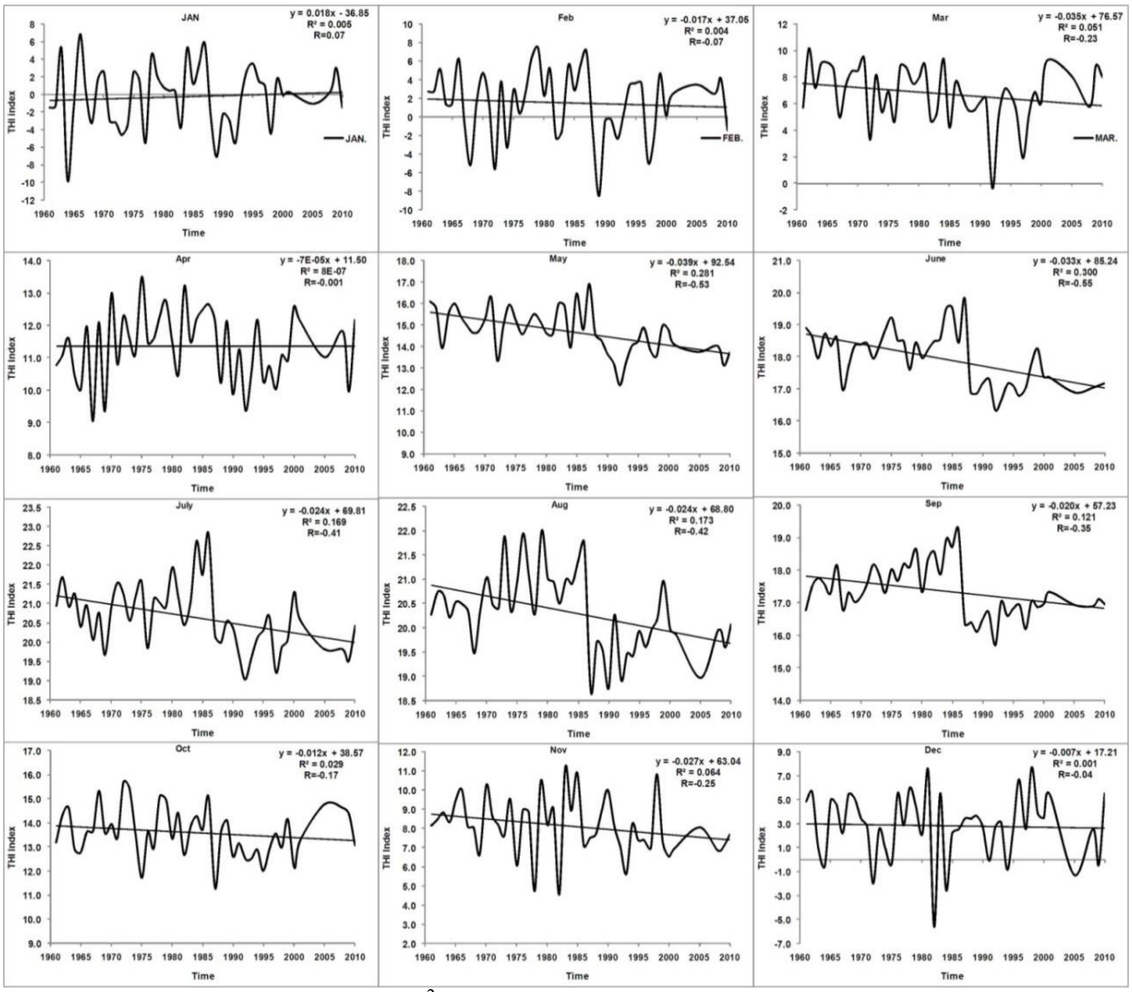

Figure 4. The values of R and R^2 and the monthly THI index changes for the observational period of 1960 to 2010.

This trend indicated that the average of decade changes of THI index with a decrease of −0.07 tended towards cooler climate comfort conditions. In spring, the trends of May (R = −0.53; decade = −0.3), June (R = −0.55; decade = −0.2) had a significant level, which confirms the tendency of climate comfort of these two months towards cooler conditions. But summer was documented to be the only season that the trend for its three months had a significant level; so July (R = −0.41; decade = −0.13), and August (R = −0.42; decade = −0.1), and finally, September (R = −0.35) and decreasing average of decade changes of −0.09 confirmed the tendency of theses three months towards cooler conditions. In the fall, like winter, only one month, that is, November (R = −0.25; decade = −0.3) had a significant trend.

Based on the CPI index, for each season, only one of its months had a significant trend; for winter, it was observed to be January with R = 0.26 and increasing average of decade changes of 1.17, while for spring, it was May with R = 0.24 and increasing average of decade changes of 1.03. The documented values for summer were different, and July experienced a significant trend (R = 0.34; decade = 0.65), and finally, for fall it was November (R = 0.26; decade = 1.22).

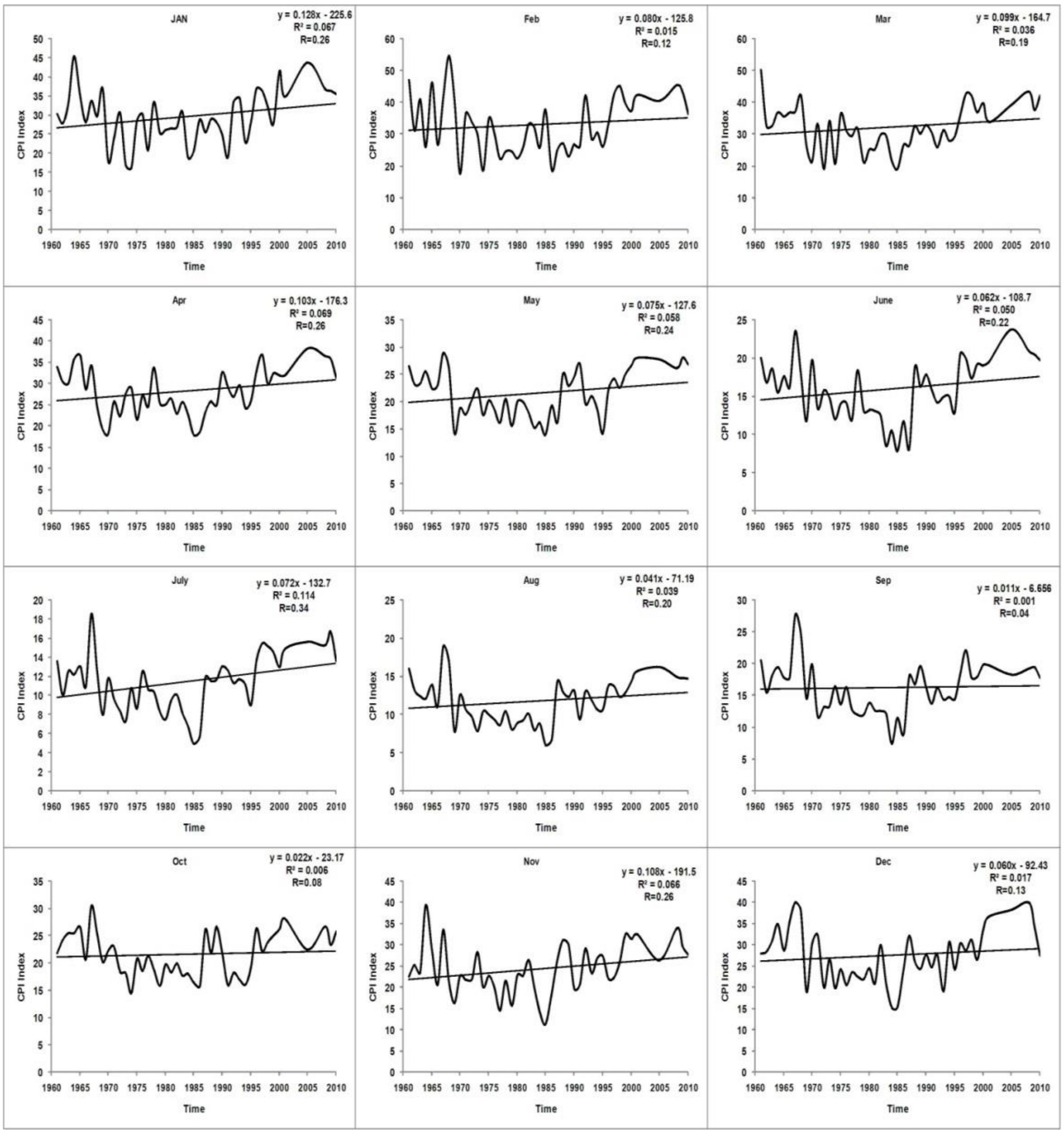

Figure 5. The values of R and R2 and the monthly CPI index changes for the observational period of 1960 to 2010.

The interpretation of these trends is that climate comfort of these months tended towards cooler and colder thresholds and zones, which was not a result conflicting with THI outputs. Although the annual changing trend with R = −0.29 and R = 0.20 showed that Shiraz's annual bioclimatic trend tended towards cooler and colder thresholds, but these changes for THI index had an acceptable significant level, as illustrated in Figures 4 and 6. Therefore, a similar result for both indicators in this section is determining a significant trend for the three months of July, May, and November together. According to both indices, the changing trend of these three months suggested moving of Shiraz's thermal comfort thresholds towards cooler to colder climatic conditions, although other significant trends for other months also suggested moving of climate comfort changes of Shiraz towards cooler to colder climate (Figures 5 and 6).

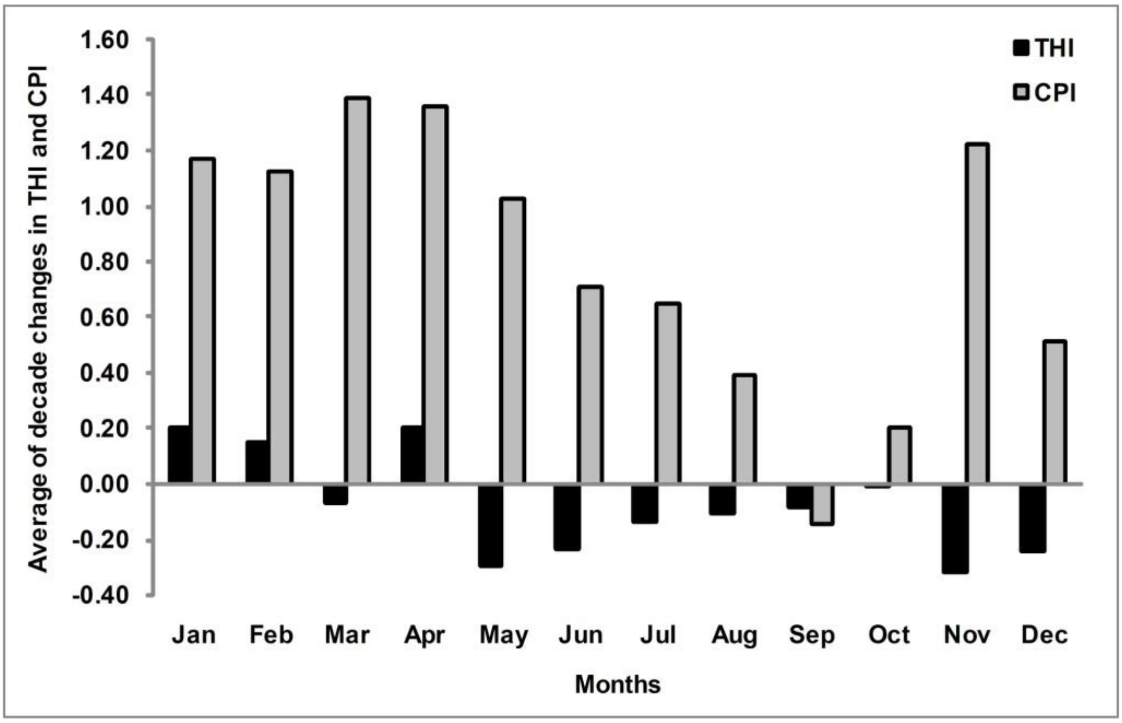

Figure 6. Average of decade changes of CPI and THI indexes for time series of 1960 to 2010

The most significant part of the present study was modeling the effects of Lake Maharlu being dry or full of water on changes of thermal comfort indices, such as THI and CPI. But another innovation of the current study, except for considering scenarios of dry lake or lake full of water, was related to the simulation of daily, nightly, and mean daily thermal comfort conditions, and each of them separately. First, based on the changes of nightly comfort conditions, it can be seen that the maximum value of THI index was assigned to July in both scenarios of dry lake and the lake being full of water. Therefore, THI index for lake full of water was 18.73, while this value was 18.60 for dry lake. It could also be pointed out that in both scenarios, THI was in the comfort zone, but in the scenario of lake full of water, THI tended towards warm zone, which was a little higher than in the scenario of dry lake. Also, based on nightly time period, aside from July, in both scenarios, May, June, August, and September were observed to be in the comfort zones. In addition, based on hourly–monthly average, it was revealed that in both studied scenarios, January had minimum value of THI, while its value for lake full of water and dry lake was 5.27 and 7.05, respectively. In general, the total sum of the difference between the outputs of the scenario of dry lake and the scenario of lake full of water was about 8.86, which was a small figure. But for CPI index, according to monthly average of nightly hours, aside from January to April and November and December, which were seen to be located in the cold zone, other months were located in thermal comfort conditions. But as the results regarding the difference between dry and lake full of water scenarios showed, the value for CPI index was more than THI index. However, Figure 7 reflects the fact that in the conditions of lake full of water, CPI values were documented to be higher than dry lake scenario in all months. In the scenario of lake full of water, thermal comfort thresholds tended towards cooler and colder zones more than outputs of dry lake scenario. But in the second part of this section, the hourly and daily outputs could be put under further attention. This time, according to Figure 7, it was clear that for THI index, the outputs of dry lake scenario showed a higher tendency towards warmer climate comfort zones compared to the scenario of lake being full of water. But for CPI index, the situation was a little different, and various patterns could be seen during the different months of the year. Therefore, during cold months, according to the scenario of the lake full of water, CPI values were something more than the outputs of dry lake scenario, but with the beginning of spring, this situation was reversed. As shown in Figure 7, finally, in summer and winter, the values of both scenarios matched. Thus, according to THI scenario, the maximum values of outputs confirming hot conditions belonged to July, and these values for the scenarios of lake full of water and dry lake were 30.90 and 32.51, respectively. But based on THI index and according to the output of both scenarios, all months of winter and November and December were located in thermal comfort zone. But for CPI, the number of months with comfort had declined and reduced to winter months and November. However, according to the outputs of the CPI, June, July, August, and September were known as the most unfavorable months in terms of thermal comfort in daily hours.

The output of mean daily bioclimatic indices are referred to in the following. Based on THI index, April, May, and October were found to be located in the comfort zone for both scenarios, but for CPI index, aside from aforementioned months, this range was a little wider, therefore, it also included January, March, November, and December. Figure 7 clearly suggests that there was a little difference between the outputs of two scenarios of THI index. This difference in average for each month in the scenario of dry lake was 0.62 units more as compared to the scenario of lake full of water.

But for comfort climate CPI index, the output values of all months showed higher amounts for the scenario of lake full of water as compared to the dry lake scenario. It meant that in the case of existence of a lake full of water, CPI monthly outputs would be closer to the cooler climate comfort conditions. Also, as it is clear from the figure, the difference between the two scenarios in the CPI index showed higher values than THI bioclimatic index. Thus, this difference, as monthly average, for the scenario of lake full of water was 1.47 units more than for the dry lake scenario.

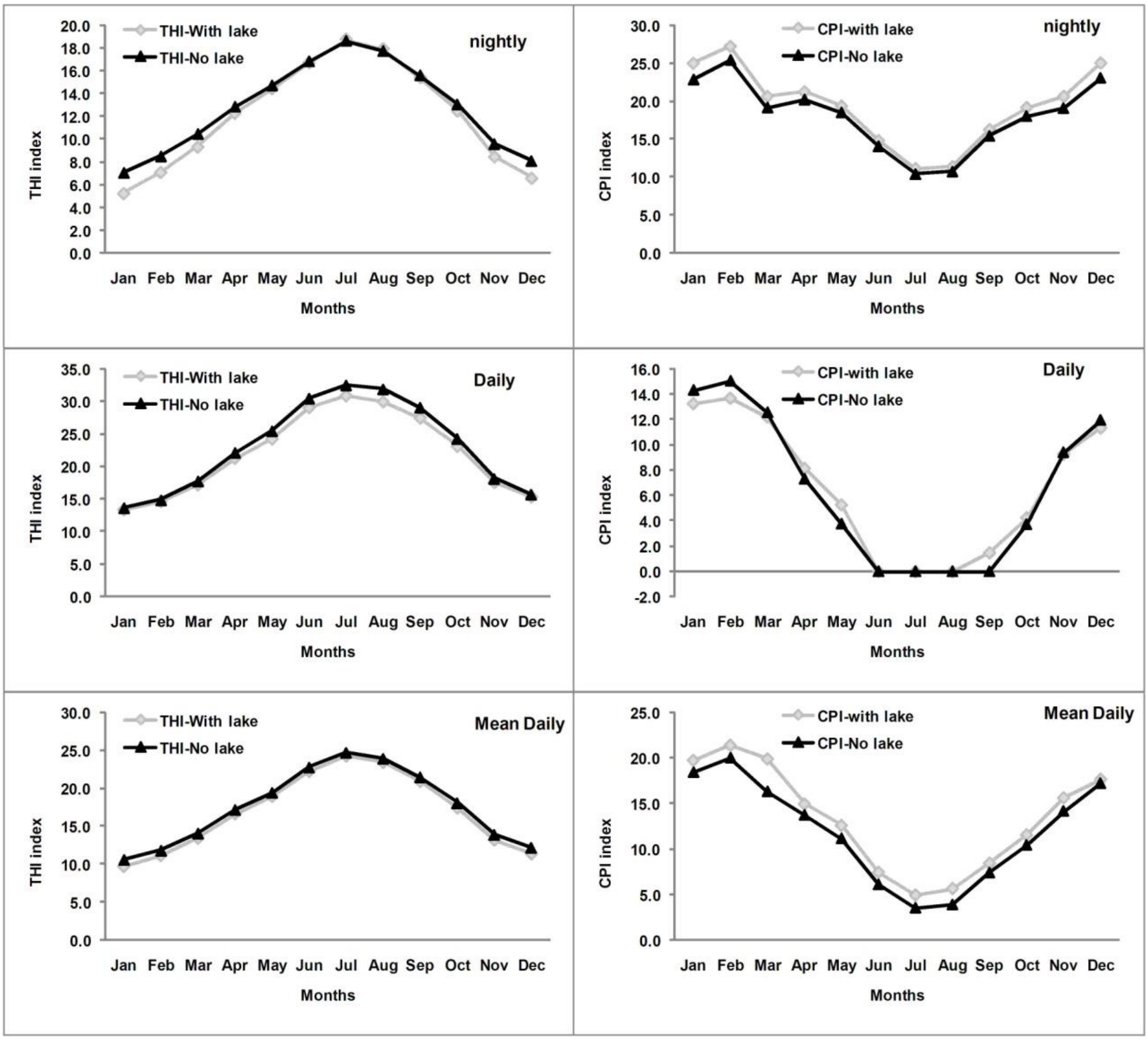

Figure 7. Comparison of daily, nightly, and mean daily of bioclimatic indices in the conditions of dry lake and lake being full of water

In the present study, using TAPM Software Model, two scenarios of dry lake and lake being full of water were conducted for Maharlu Lake in Shiraz. In the dry lake scenario, without exception, in all months, the relative humidity showed some decrease, and its maximum decreases was for warm seasons including summer. The daily wind speed decreased, but no dominant model could be seen for nightly wind speed. There were also found a declining trend for monthly average of THI index, and an increasing monthly trend for CPI index. The THI trend was significant only for November, March, and September. Based on CPI, for each season, only one of its months had a significant trend. For winter, the significant trend was January, while it was May for spring, and for summer and autumn, July and November were, respectively, found to be the significant trends. Unlike CPI index, the difference between outputs of two scenarios of dry lake and lake full of water for THI index showed lower values. In all timing situations, in the condition of dry lake, THI modeled values had simulated greater numbers in comparison with the scenario of lake full of water. In the case of existence of lake full of water, outputs were closer to cooler climate comfort levels. However, considering that as a result of global warming, for semi-arid areas, such as Shiraz, rising temperatures and evaporation is not unexpected, these factors can strengthen dry lake scenario event. At the same time, by increasing the values of THI during most of the year, which could be equivalent to the reduction of CPI, the fact is represented that need and demand for energy in cooling section will increase in order to provide climate comfort and health for the community. The outputs of THI also revealed that long-term average of months with comfort included September and June, but in the scenario of dry lake, these conditions had been transferred to cooler months, such as April, May, and October. Also, about CPI index, in the case of dry lake event, the months with comfort were documented to be tending towards cooler months, such as October to March. The results of the current research can provide helpful information for the future researchers in this field.

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Conflict of interest

The authors declare that they have no competing interests.

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