

# Evaluating Human Consolation in Sadra Town Regarding Bioclimatic Indexes

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**ABSTRACT:** As it is one of the most important vital tenets to choose a suitable place to live, it is better to evaluate the relation between the human healthiness, and natural and climatic features as temperature, humidity, sun light, and daylight hours which are the important parameters in human life for finding the best place considering consolation and convenience. In this part of the research, it is tried to check the convenience or the inconvenience of life in Sadra from the point of view of climate using some climatic indexes such as day convenience factor, night convenience factor, Beaker bioclimatic index and thermo-hygrometric index. The research results show that there is not any bioclimatic pressure and the climate is pleasant in Sadra throughout the year. It is possible to help Sadra for accomplishing the best city programming to make it progress by giving the city features to civil programmers and with the help of evaluating the indexes and the models according to human convenience or inconveniency in different times of the year.

**Keywords:** Bioclimatic Consolation, Sadra Town, Terjang Index, Beaker Index, Thermo-Hygrometric Index

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## INTRODUCTION

One of the affective factors on human life, health and comfort is atmospheric and climatic situation. Directly and indirectly, human is affected by these factors since the birth. Today, the climatic situation on human life, health, comfort, and behaviour is studied under the title of Human Bioclimatology (Bicker and Higgins, 2000).

Some of the scientists believe in climate effects on human activities in a way that relate the rise and fall of the first human civilizations to climate. Favourability or unaffordability of the climate is more effective than any other factors in choosing a place and development of cities. Accordingly, emptiness of population in many different parts of the world and population density in particular geographical part of the world is due to the climate of these areas. Different climates, and their yearly and seasonal changes, make human to have his dwelling area in accordance with environmental climate. Windows width and length, walls width, buildings form, roof style, building materials, building height, and every other thing are in accordance with climate (Rahnamaee, 1990).

Harmonizing house and climate is caused that human organism can save its temperature in a preferable condition. According to climatic view four factors which are temperature, humidity, wind, and sun radiation have an important role in making the human comfort. Among these factors, temperature and humidity have more effect on human health and cosiness; hence, most of the indexes and evaluating models of human comfort are based on these two factors (Jahanbakhsh, 1998). Human relation and the environment does not show the complete domination of environment; but human always build new

environments with good relationship, and always try to save them from floods, quakes, heavy rains and snows to obtain his environment comfort (Shekooi, 2006). Human bioclimatic comfort depends on the balance between human body and the environment. A range of temperature degrees in which temperature transmittance happen in a good way is called human comfort area. No region can be favorable considering physical activity and human comfort. That is, there is no standard region, and human. Thus comfort cannot be fixed completely, and it relatively changes for different people with different ages, health conditions, physical activities, and outfits; and in accordance with different seasons, and people's accustoming with the environment (Mohamadi, 2007).

In this research, Sadra town comfort or discomfort is studied by evaluating its bio climate. In this way it gets possible to help to this new city progress to have a preferable city with the best human and urban comfort programs.

## MATERIAL AND METHODS

### The region for studying

The new town of Sadra is one of Fars towns which is located near Shiraz, and founded recently. Geopolitically, it is apart from Shiraz. The new town of Sadra is located 14 kilometres North West of Shiraz; a place between Shiraz metropolis, Marvdasht, and Zargan.

Sadra limits to X=634597 to X=654923 and Y=3289076 to Y=3303842 using UTM Zone 39N picture and Cartesian system.

Hierologically, the lands used for building Sadra belong to Tashk Lake, Bakhtegan Lake, and Maharloo Lake catchment area. It locates in Fars north district and

on eastern slope of southern part of Zagros. This lake is a place for emptying the surface waters too. The mentioned region is divided to five sub regions which are about 31000 square kilometres altogether.

There are some planes with different spaces in each of these regions; all of them contain cities, villages, and agricultural fields. The new Sadra town field of study that is 25 kilometers northwest of Shiraz is one of these planes which is 360 square kilometer; and surrounded by Malousjan mounts in the north and Ghalat mounts in the south and the west.

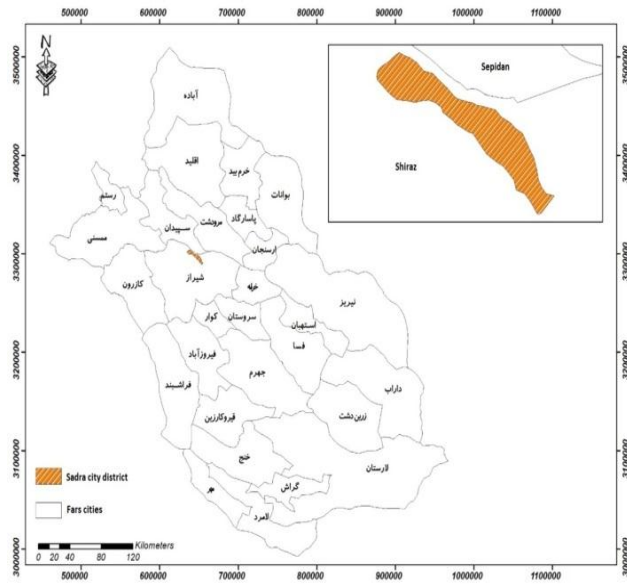


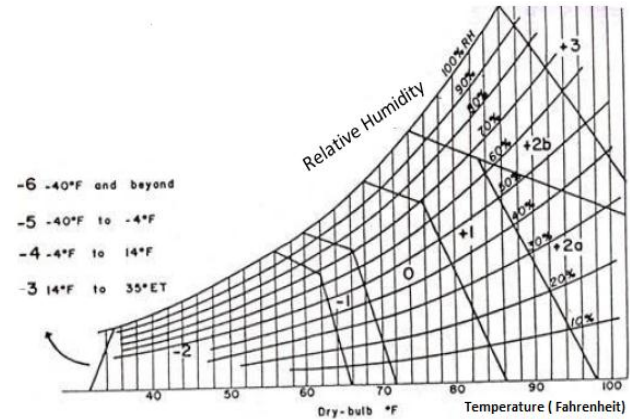
Figure 1. The Political position of Sadra in Fars

As Sadra does not have weather station and nearby stations records are used for this town, so the Ghalat synoptic station records which are the nearest to Sadra according to research are used in this study.

The method which is used here is analytic-practical and is based on documentary, statistical, and library studies; and Terjung, Beaker, nervous pressure, and wind indexes are used in order to obtain stable development and indicating preferable human comfort. And in the end, some suggestions are given to design and build a proper city with human comfort, using the results and based on the bioclimatic building table for Sadra climate.

### Terjung index

This index is one of the most important bioclimatic indexes for assessing human comfort (Mohamadi, 2007). One of the most important advantages of this index compared with other indexes is simultaneous using of the highest number of climatic indexes which control the human body temperature. Using this index one can indicate the most preferable region for staying and living of people who suffer from climatic illnesses (kaviani, 1993). Terjung is based on comfort coefficient and wind cooling coefficient. Figure 2 is used to indicate the comfort coefficient. This graph actually shows the comfort human obtain in situation of different mixtures of temperature, humidity, and in normal situation that is in normal clothing and without physical activity (Mohamadi, 1999).



Graph1. Comfort limit coefficient based on Terjung

In this graph the horizontal axis shows temperature based on Fahrenheit, and the curves indicate the humidity in percentage. Where these two climatic factors encounter happened in different places which are shown by different numbers and symbols Table 1. Base on Figure 2 and Table 1 human comfort coefficient at the region in which we do research on is written in Table 2.

Table 1. Terjung concepts, symbols, and signs

Dominant feeling	Beyond coldness	extra cold	Very cold	cold	Very cool	cool	pleasant	warm	hot	Very hot	Extra hot
group	Uc	Ec	Vc	Cd	K	C	M	W	H	S	Eh
symbole	-6	-5	-4	-3	-2	-1	0	+	A-2	B+2	+3

Table 2. Sadra temperature average, relative humidity, and comfort coefficient base on Terjung (2002- 2012)

	farvardin	ordibehesht	khordad	Tir	Mordad	Shahrivar	Mehr	Aban	Azar	Deiy	Bahman	Esfand
Temperature (c)	13.6	20	25.7	28.7	28.2	25.4	20.8	13.8	6.7	4.4	5.4	10
Temperature(F)	65.5	67.9	78.2	83.3	82.7	77.8	69.5	56.9	45.7	40	41.7	50
Relative Humidity (%)	51.7	38.5	27.6	27.3	28.8	30.3	32.5	32.5	55.9	65.9	65	53.3
Comfort coefficient	Very cool	cool	pleasant	pleasant	pleasant	pleasant	pleasant	Very cool	Very cool	Very cool	Very cool	Very cool

Source: Ghalat weather station

Ghalat weather station 10-year statistics is used to calculate the Terjung comfort coefficient in Sadra district. Calculations show that comfort coefficient is pleasant or very cool in most seasons (table2). Another point is that the physiologic changes in fall is almost sudden in a way that between two months of Mehr and Aban the situation change from pleasant to very cool. However physiologic slow transition in spring make the living situation pleasant in Sadra in a way that comfort coefficient changes from very cool in Farvardin to cool in Ordibehesht and pleasant in Khordad; this can increase the potential of Sadra progress.

### Indicating comfort coefficient during day

Day comfort coefficient from relative maximum daily temperature average in Fahrenheit and relative minimum daily humidity in percent is used to indicate day comfort coefficient in different months of year base on Terjung. Accordingly Table 3 shows the day comfort coefficient for Sadra.

**Table 3.** average of maximum temperature, average of minimum relative humidity, and day comfort coefficient of Sadra base on Terjung

	farvardin	ordibehesht	khordad	Tir	Mordad	Shahrivar	Mehr	Aban	Azar	Dey	Bahman	Esfand
Maximum average temperature (C)	19.4	25.7	31.4	35	34.7	32.4	27.2	27.2	13.5	9.8	10.6	15.5
Maximum average temperature (F)	66.9	78.2	88.5	95.1	94.5	90.3	80.9	80.9	56.3	49.7	51.1	59.9
Minimum relative humidity average (%)	40.8	29.2	20.3	20.4	21.1	22.3	24.9	34.7	43.9	55.3	54.7	44.6
Day comfort coefficient	pleasant	pleasant	warm	warm	warm	warm	pleasant	Pleasant	Very cool	Very cool	Very cool	Very cool

Source: Ghalat weather station

### Indicating day comfort at night

Night comfort coefficient during the year base on Terjung is calculated from average of daily minimum temperature in Fahrenheit and average of daily maximum relative humidity in percent. Table 4 shows Sadra comfort coefficient of night. Physiologic situation of Sadra is calculated and indicated again base on Terjung and resulted in these consequences. Title (must be in brief and properly identified), Name of Author(s), Affiliation and Address, and Corresponding Author (including institutional address and e-mail address) should be given.

**Table 4.** average of minimum temperature, average of maximum relative humidity, and Sadra night comfort coefficient base on Terjung

	farvardin	ordibehesht	khordad	Tir	Mordad	Shahrivar	Mehr	Aban	Azar	Dey	Bahman	Esfand
Minimum average temperature (C)	4.7	13	18	21.1	20.7	18.1	14	14	2.4	-0.7	0	4.1
Maximum average temperature (F)	45.4	55.5	64.3	70.1	69.3	46.6	57.2	57.2	36.2	36.2	32	39.5
Minimum relative humidity average (%)	60.5	47.6	36.3	35.9	37.7	39.1	40.6	54	64.1	64.1	73.6	61.5
Night comfort coefficient	Very cool	Very cool	Very cool	pleasant	pleasant	Very cool	Very cool	Very cool	Very cool	Very cool	Very cool	Very cold

Source: Ghalat weather station

### Beaker bioclimatic index

From all climatic factors related to human bio climate temperature, and wind are used in this index which is more preferable and more inclusive. Wind cooling power is calculated from the following formula in this index (Ghanbari et al. 1998).

$$1) cp = (0.26 + v^{0.632})(36.5 - t)$$

In this formula  $cp$  is based on milicalorie per square centimeter per second (mcal/cm<sup>2</sup>/sec), and  $v$  is average

wind speed base on meter per hour, and  $t$  is the average of daily temperature base on Celsius.  $CP$  is actually the wind cooling power of the environment according to the difference between body temperature and the environment temperature. Cooling power degrees of the environment and human bio climate stimulation thresholds are summarized in Table 5.

**Table 5.** environment cooling power degrees and bioclimatic threshold base on Beaker study

Human Bioclimatic situation	Environmental situation	CP amount		
Bioclimatic pressure	Hot, warm, humid, unpleasant	0-5	A	
Bioclimatic comfort limit	Tolerable warm	5-10	B <sub>1</sub>	B
Bioclimatic comfort limit	slight pleasant	10-20	B <sub>2</sub>	
Slight stimulation	cool	20-30	C	
Medium to hard stimulation	Cold and a little vigorous	30-40	D <sub>1</sub>	D
Irritating medium stimulation	Very cold	40-50	D <sub>2</sub>	
Extremely irritating	Extremely cold	50-60	D <sub>3</sub>	

Bioclimatic pressure happens when  $CP$  is less than 5 or more than 20 bases on Beaker index. Unpleasant situation created in the first case because of the high heat and in the second case in which  $CP$  is more than 20, there is discomfort situation because of the environment coldness. Generally, Beaker index result for evaluating the environmental situation can be described as follow:

The  $CP$  less than 10 shows the unpleasant (warm) bioclimatic situation, and the region is located in group A. If  $CP$  is between 10 and 20, it shows the environmental pleasant bioclimatic situation (group B) and the  $CP$  between 20 and 30 shows the unpleasant environmental situation (cold); and at last, if  $CP$  gets more than 30 unpleasant bioclimatic situation (very cold) happen in the region and in gets into group D. the assessment of Beaker index of Sadra is done base on Ghalat weather station for 10 years and is shown in table 6. There is no bioclimatic pressure, and there is pleasant climate in Sadra as it is shown in this table.

**Table 6:** cooling power of environment (CP degree) base on Beaker (base on micro calorie per square centimeter per second)

	farvardin	ordibehesht	khordad	Tir	Mordad	Shahrivar	Mehr	Aban	Azar	Dey	Bahman	Esfand	
Minimum average temperature (C)	4.7	13	18	1.21	7.20	1.18	14	14	4.2	-7.0	0	1.4	
Maximum average temperature (C)	4.19	7.25	4.31	35	7.34	4.32	2.27	2.27	5.13	8.9	6.10	5.15	
average temperature (C)	6.13	20	7.25	7.28	2.28	4.25	8.20	8.13	6.7	4.4	4.5	10	
Average wind speed (not)	6	5.5	6.6	1.5	5.4	1.4	8.3	5.3	3.2	1.3	6.3	4.4	
Average wind speed (m. sec)	1.3	8.2	4.3	6.2	3.2	1.2	9.1	8.1	2.1	6.1	7.1	3.2	
CP index	At night	8.27	4.21	5.18	5.13	2.13	8.14	3.17	17	9.21	7.26	26	8.26
	group	C	C	B2	B2	B2	B2	B2	B2	C	C	C	C
	in Day	4.16	9.9	1.5	3.1	5.1	3.3	2.7	7	7.14	1.19	5.18	4.17
	group	B2	B1	B1	A	A	A	B1	B1	B2	B2	B2	B2
	overall	9.21	1.15	8.10	9.6	7	9.8	1.12	1.17	5.18	23	2.22	22
group	C	B2	B2	B1	B1	B1	B2	B2	B2	C	C	C	

Source: Ghalat weather station

### Thermo hygrometric index

Dry bulb temperature and dew point temperature are used in this index. This index is used more in warm areas and does not work with windflow. Thermo hygrometric index is calculated by the following formula:

$$2)DI = 0.99 \times Td + 0.36Tdp + 41.5$$

In this relation *DI* is the thermo hygrometric index, *Td* is dry bulb temperature base on centigrade, and *Tdp* is dew point temperature base on centigrade. In this index, if the *DI* is between 60 and 75, the human bioclimatic situation is equal with comfort feeling (A), and if it is less than 60 coldness feeling (B) and more than 75, about 50% of people get irritated of heat (C), and if this coefficient passes 80, all of people suffer from the heat.

For indicating the thermo hygrometric index of Sadra, monthly statistics of Ghalat weather station in a 10 year period from 2002 to 2012 are used in this study. Table 7 shows the Sadra thermo hygrometric. As it is seen, in Aban, Azar, Dei, Bahman, Esfand, and Farvardin bioclimatic situation indicate coldness feeling (B), in Ordibehesht, Khordad, Shahrivar, and Mehr bioclimatic situation indicate comfort feeling (A) and in Tir and Mordad the bioclimatic situation is in a way people feel warm (C).

**Table 7.** comfort thermo hygrometric parameters of Sadra

	farvardin	ordibehesht	khordad	Tir	Mordad	Shahrivar	Mehr	Aban	Azar	Deiy	Bahman	Esfand
Dew point temperature average (C)	6.13	20	7.25	7.28	2.28	4.25	8.20	8.13	6.7	4.4	4.5	10
Dry bulb average (C)	4.8	8.11	2.14	2.16	2.16	5.14	6.11	9.7	8.3	8.1	7.2	6.5
Thermo hygrometric index	58	5.65	72	8.75	2.75	9.71	3.66	58	4.50	6.46	8.47	4.53
Thermo hygrometric symbol	B	A	A	C	C	A	A	B	B	B	B	B

Source: Ghalat weather station

## RESULTS AND DISCUSSION

According to the studies base on Terjung and according to the results in table 2 in this research, Farvardin and last 2 month of fall (Aban, Azar) and all of winter are in the district of -2 which indicates physiologic situation with very cool comfort coefficient. The last month of spring (khordad) and all of summer and the first month of fall (Mehr) are in the district of zero which indicates the physiologic situation with pleasant comfort coefficient.

These studies show that the feeling of most of residences changes from pleasant to very cool.

Existing Sadra in comfort limit of -2 in Farvardin, Aban, Azar, and all winter indicates that it has physiologic condition with very cool coefficient in six months of the year that is half of the year.

By thinking a little on table 2 one can say that the region physiologic changes are not sudden, in a way that from Tir till Mehr it has a pleasant situation and from Aban to Esfand it is very cold like Farvardin. Ordibehesht

is also cool. All this changes are sequential and there is no sudden change between them base on Terjung.

According to tables 3 and 4 which have day and night comfort coefficient, comfort coefficient is as follows: in the first 2 months of spring (Farvardin and Ordibehesht) and in the first 2 months of fall (Mehr and Aban) the region situation is pleasant. The last month of fall (Azar) and all of winter have very cool situation. Night comfort coefficient is as follows: in all of spring, in the last month of summer (Shahrivar), and in all of fall and winter the weather condition is very cold; only the first 2 months of summer (Tir, Mordad) have pleasant condition at night. Generally, 1/3 of days of year months have pleasant situation, 1/3 of days of year months have warm situation, and 1/3 of days of year months have very cold situation. According to Terjung the only situation which does not exist in day in this region is very cool.

Nights situations in the region are as follows: more  $\frac{3}{4}$  than of year seasons have very cool situation at night, and the first 2 months of summer have pleasant situation. Again, according to Terjung the only situation which is not dominant at night is the cool situation.

Cooling power degrees base on Beaker index based on Beaker studies in three situation of night, day, and overall which are shown in table 6, indicate that night situation in the region is that half of the year is in C district, the other half is in B<sub>2</sub> district. Farvardin, Ordibehesht, Azar, dei, and Bahman are in C district with cool environmental situation, and Khordad, Tir, Mordad, Shahrivar, Mehr, and Aban are in comfort bioclimatic district of B<sub>2</sub>, with the pleasant environmental situation.

Day situation is as follow, all of summer is in bioclimatic situation of A, and hot, war, humid, and unpleasant environmental situation; and Ordibehesht, khordad, and Aban are in comfort bio climate of B<sub>2</sub> with mild and pleasant environmental situation. Beside, all of winter and Farvardin are in C district of mild stimulation with cool environmental situation.

According to region thermo hygrometric study base on table 7, one can realize that *DI* amount is between 60 and 75 in four months of the year that is Ordibehesht, Khordad, Shahrivar, Mehr; this shows that environmental situation of the region is of comfort and relaxation. Half of the year in Farvardin, Aban, Azar, Dei, Bahman, and Esfand *DI* amount is more than 75 that shows 50 percent of people are annoyed by heat.

## CONCLUSION

Recognizing bioclimatic potential in different geographic regions can help the civil, eco-tourism progressive, migratory, and other related comfort parameters plans. Here, using the climatic indexes is considered one of the best ways to assess the effect of climate on human comfort, and consequently on determining the progress potential and urban progression. Studying of Sadra climate base on human comfort using different bioclimatic index show that Sadra is so suitable and convenient considering climatic comfort, and there is no climatic limitation on this city progress. The outcome results using three studying methods of human comfort coefficient in Sadra which are Terjung bioclimatic index,

Beaker bioclimatic index, and thermo hygrometric index can be revealed in this table.

**Table 8.** outcome result of comfort coefficient using different methods

Index	farvardin	Ordibehesht	Khordad	Tir	Mordad	Shahrivar	Mehr	Aban	Azar	Dei	Bahman	Esfand
Terjung	Very cool	cool	Pleasant					Very cool				
Beaker	cool	Mild pleasant		Tolerable warmth			mild pleasant		Cool			
Thermo hygrometric	coldness	Comfort feeling		50% feel annoyed of heat		Comfort feeling		coldness				
Result	Very cool	Mild pleasant	pleasant	Tolerable warmth	pleasant		Very cool					

Sadra climate study shows there is no limit for Sadra progress and it has high progress potential. Finally, Sadra has a cool and pleasant climate. In fact, these studies are used as a factor to indicate pleasant situation, however for regional programming other methods with higher attention should be used.

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