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**THE STUDY OF BIOCLIMATIC INDICES AFFECTING HUMAN COMFORT
(TABRIZ CASE STUDY)**

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ABSTRACT

Determining bioclimatic situation of each month of the year regarding the studied area, we can use various programming such as architecture, houses, hospitals, parks, recreations, etc., in which the human bioclimatic type has a role and has been investigated.

Recognizing the comfort of each area, we can program in tourism industry, as well as the human comfort. In the study we tried to investigate human's comfort or lack of -comfort using the bioclimatic indices of stress, temperature effective, and Mahani using Tabriz weather station during 1951-2011. The results showed that the case is located in cold and very cool ranges in terms of stress index during Winter and Autumn. According to this index, Tabriz Town is located in cold range about 41% of the year time, in very cool range 16% of the year time, and in cool range 8% of the year time. Because Tabriz is a mountainous city, most of the digits are in the range of -1000 and 790. The Temperature effective index was investigated daily, nightly, and monthly, and the results showed that, according to table 13, about 50% of the year time, Tabriz is located in very cool range, 25% in cold range, and 25% in cool range. In nightly view, the city has the comfort condition on May and October. The most of comfort in nightly condition

is related to very cool range. In monthly view, generally the summer season has the comfort range and low ranges of comfort and very cool are equal in terms of percentage that is 33% of the year times. Finally the condition of architecture climate of the area was investigated using Mahani index. In these indices, the required guidance in terms of human comfort and lack of - comfort at various times of the year in accordance with Tabriz feature and characteristic are provided which can be effective in most of the city planning.

Keywords: Comfort, Tabriz City, stress index, affective temperature, Mahani.

INTRODUCTION

Climate is one of the major affecting factors of human life and means the prevailing climate of a region in long term (1). Air flow rate has a direct impact on thermal exchange in the form of displacement and evaporation. The higher the air flow rate, the more the ratio of thermal equilibrium to the form of displacement and evaporation. The average temperature encompassing the environment will affect thermal exchanges of the body with environment in the form of radiation (2).

In climate view, 4 elements have the main role in the formation of human comfort condition. The elements consist of temperature, humidity, radiation and wind. Among these climate elements temperature and relative humidity have the more effect on human comfort and health, and this is why most of models for evaluating the human comfort have been concentrated on these two elements(3).The weather temperature has the main role in thermal exchange in the

form of displacement. The weather relative humidity effects on thermal exchange in the form of evaporation. The more humid the weather, the less the ratio of thermal equilibrium in the form of evaporation would be. In the saturated air (relative humidity of 100%), no thermal exchange in the form of evaporation would be done (1).

Air flow rate has a direct impact on thermal exchange in the form of displacement and evaporation. The faster air flow, the more ratio of thermal equilibrium to evaporation and displacement form would be increased. The average temperature of surfaces encompassing the environment will effect on thermal exchanges of body with environment in the form of radiation (2).The results of the study showed that the effect of irradiative temperature of the surfaces encompassing the thermal comfort is low times of air temperature. If the body is juxtaposed to cold surfaces, submits a significant amount of its heat to its surfaces. The result of this

body heat dissipation is cold feeling (world meteorological organization, 1991).

The meaning of human comfort condition is a set of conditions which is appropriate at least for 80% of the people thermally. In other word human feels neither cooling nor heat in that condition .Some researches regard so called thermal neutrality as a more accurate phrase; because man doesn't feel cold, heat and local discomfort resulted from climate issues (4).The issue can be derived using statistical relations and mathematical formulas.

The studied area

Tabriz city with an area of 2167 square kilometers (4.8 % of the province area) is the center of East Azerbaijan province, Tabriz plain is located in the West of this province and in the extreme east and south East, at 46 degrees 17 minutes of east longitude and 38 degrees and 5 minutes of north latitude from the Greenwich meridian.45% of the province population live in Tabriz county, and more than 40% live in Tabriz city only.

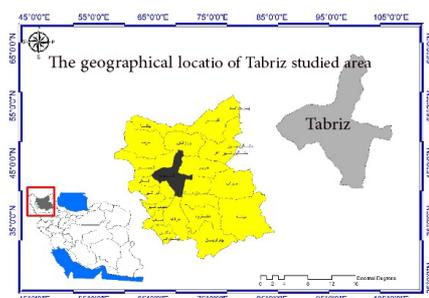


Figure 1: The studied area

The main body of the article

In this research we have used different models and methods in order to comprehensive assessment of bioclimatic condition in relation with human comfort concept. In this regard we used the data of Tabriz synoptic station during 1951 to 2011. Firstly, the accuracy and homogeneity of data have been assessed and missed data have been restored through conventional methods. Then, a large volume of data has been classified and analyzed using the soft wares of Excell and Spss. Experimental models and defined parameters as stress index, Temperature effective and Mahan have been used to check the bioclimatic status of Tabriz city.

1-Review and introduction of bioclimatic indices

1-1- Stress index

The index is used for open space and outdoor, the air flow is also concerned (Gholami Birghadar, 1998.12). Understanding the impact of climate elements on the thermal exchange between man and the environment resulted from extensive methods which can be analyzed as climate in terms of human health and comfort. This kind of analysis is done in the form of what is called stress. The indices specify the type of imposed physiological

stress to make peace between heat absorption and dissipation. The rate of heat absorption or disposal depends on specified activity to some extent, also depends on temperature and moisture gradients between the body and its environment to some extent. Therefore, the stress index is based on these considerations in physiological climatology and have been planned in order to assess the gradients which depend on radiation and atmospheric conditions. Climatic stress indices can be considered in two categories:

- 1- Those which emphasize on feeling such as cold and heat.
- 2- Those which concentrate on biological activities such as disposal of evaporative heat from the lungs and effects on the environment condition on heartbeat.

Moreover, no single index can be used for all of climatic conditions. For example all of four main environmental elements that are radiation, temperature, humidity and speed play role. In contrast, the humidity has been less concentrated in lower temperatures, but the role of wind speed is very important. The most important point of the method is that the calculation results of tow cold and warm climates are such that the stress index in cold climates is calculated for month with

monthly average temperatures Less than 20 degrees Celsius. Also the stress index in warm climates is calculated for month with monthly average temperatures more than 20 degrees Celsius (Mohammadi .2007:188).

Stress index for temperature more than 20 degrees Celsius is:

$$CI = I - dI \quad (1)$$

Where, CI is comfort numerical index, I is Temperature effective index and humidity given the calm climate condition, and DI is another index adding the additional cooling effect of air movement. I and DI respectively are:

$$I = (0.5 + u^2 * 10^{-4})(T - 80 + 0.11u) \quad (2)$$

$$dI = -0.35v^{0.5}(20 + 0.5u - 0.2T) - 35V^{0.5} \quad (3)$$

Where T is temperature, u is the percent of relative humidity; v is Wind speed (miles per hour).

In usual formulas used in cool and cold climates, the combination of wind and temperature conditions has been considered without regarding the humidity factor. Moreover, the cooling power of surrounding environment climate condition has been emphasized. The cooling power is expressed through different methods, the most common of which is calculated through the following relation:

The stress index for temperatures less than 20 degrees Celsius is calculated through the following relations:

$$H = 0.57V^{0.42} * (36.5 - T) * 36 \quad (2)$$

$$H = (10.9V^{0.5} + 9 - V)(33 - T) \quad (3)$$

Where H is cooling power and Temperature effective index and wind speed for months

less than 20 degree centigrade (kilocalories per hour per square meter), T is temperature (centigrade), and v is wind speed (meters per second). Classification of comfort coefficient of stress index is summarized in table 1.

Table 1: classification of comfort coefficient of stress index

Comfort coefficient of temperature more than 20 degree		Comfort coefficient of temperature more than 20 degree	
CI comfort coefficient	Heating air	H comfort coefficient	Cooling air
Less than -5	Cool with lack of comfort condition	395-540	Cool
-1 to -5	Cool with lack of comfort condition	540-790	Very cool
0	comfort	790-1000	Cold
1 to 5	Warm with comfort condition	1000-1200	Very cold
5 to 10	Warm with comfort condition	1200-1440	Biting cold
10 to 15	Very lack of comfort condition	+1440	The skin surface freezes quickly
More than 15	Fully lack of comfort condition	-	-

Reference: Mohammadi .2007, 2009

1-2- Temperature effective index

This method is based on using air temperature and humidity, and the assessment of climate comfort situation would be possible using these two parameters. The temperature effective is calculated using the following formula:

$$ET = T - 0.4(T - 10)(1 - \frac{RH}{100}) \quad (1)$$

Where T is air temperature (degree centigrade), RH is relative humidity (percent), ET is temperature effective.

Table 2: Human comfort (temperature effective index)

ET	Temperature Coefficient
>30	very very hot
27.5-30	Sultry
25.6-27.5	very hot
22.2-25.6	Hot
17.8-22.2	Comfort

15.5-17.8	Cool
1.67-15.5	Very cool
(-10)-1.67	Cold
(-20)-(-10)	very cold
<-20	Very very cold

1-3- Mahani Index

The table was presented by Carl Mahani for the first time in 1971.

Mahani tables are guidance for climate - related planning through available data easily and have presented some guidance of building according to climate condition. In his table, the factors effective on comfort such as temperature, wind, humidity and radiation are investigated, and the comfort situation of weather station is specified in terms of standard ranging of temperature and relative humidity acquired through

experimental studies. One of the advantages of this method is that it classifies the thermal comfort of day and night in 6 categories. This feature help present the guidance proportionate with uncomfortable condition in architectural plans.

Mahani table of the area determine the comfort of day and night of every month, according to the annual average temperature of the area and average relative humidity of the same month. First the humidity group determines the station of every month, and then the comfort range of that month day and night is determined using humidity group of every month in comparison with climate data. In next step, maximum and minimum temperature of each month are compared with upper and lower level of comfort range. If this temperature is higher than threshold, the situation is hot, and if it is less than threshold, the situation is cold, and if it is between these two ranges, the situation is suitable.

Results

The stress index of Tabriz County:

The average of daily temperature indicates the day and night temperature. The highest average of temperature of Tabriz city is 25.74 and the lowest one is -2.2.

Relative humidity is the ratio of water vapor in the air to the amount of water vapor that can exist at the same temperature.

The situation of relative temperature of Tabriz city shows that the lowest relative temperature is related to July and August months, and the highest one is related to January.

Wind is a vector parameter having direction and speed and created because of pressure difference (Razjuyan, 2000). The lowest recorded wind speed is 4.32 m/s and related to December, and the highest one is 10.19 m/s related to August (meteorological Organization).

Because the studied area is mountainous, the month's temperature more than 20 degree is disregarded, and stress index of Tabriz City used for temperature less than 20 degree centigrade which have more various situation in relation to the temperatures more than 20 degree centigrade. Therefore, according to 4-1 table, Tabriz is situated in cold range in view of stress and comfort coefficient in January, February, March, November, and December, very cool in April and October, and cool in May. So we can understand from the results that Tabriz area has cold winters. So using the heating appliances is necessary in these months.

Table 3- The stress index for temperature less than 20°C in Tabriz City.

Thermal condition	$H=0.5W^{0.42}*(365-T)^{36}$	$H=(10.9V^{0.5}+9-V)(33-T)$	Month
Cold	1520.5	982.9	January
Cold	1515.4	951.3	February
Cold	1425.6	848.1	March
Very cool	1213.5	648.9	April
Cold	944.9	511.8	May
	741.1	357.3	June
	602.3	247.5	July
	601.5	253.9	August
	742.4	376.1	September
Very cool	943.4	551.8	October
Cold	1166	737.3	November
Cold	1364.3	877.3	December

Temperature effective index of Tabriz city:

According to 4-6 tables indicate the Temperature effective index of Tabriz City the comfort situation has shown daily, nightly, and monthly. According to calculated et, Tabriz is located in cool bioclimatic situation in January, February, and December, very cool in March, April, October and November, and comfort situation in June, July, August, and

September. Considering the daily bioclimatic situation January, February, and December, are in cold situation, and March-June, October, and November in very cool ranges; July-September in cool ranges. The nightly bioclimatic condition is slightly different with daily one so that the comfort situation can be found in May and October only. June is very hot, and July and August is hot and sultry.

Table4: Calculated Monthly temperature effective of Tabriz city.

Monthly bioclimatic condition	Monthly ET condition	Month
Cold	-0.8	January
Cold	1.3	February
Very cool	5.9	March
Very cool	10.9	April
cool	15.2	May
Comfort	19.1	June
Comfort	21.7	July
Comfort	21.5	August
Comfort	18.3	September
Very cool	13.1	October
Very cool	6.8	November
cold	1.6	December

Table 5: Calculated Nightly temperature effective of Tabriz city

Monthly bioclimatic condition	Monthly ET condition	Month
Cold	2.8	January
Very cool	5.2	February
Very cool	10.5	March

cool	16.3	April
Comfort	21.3	May
Very hot	25.8	June
Sultry	28.5	July
Sultry	28.4	August
Hot	25.2	September
Comfort	19.3	October
Very cool	11.8	November
Cold	5.5	December

Table 6: Calculated Daily temperature effective of Tabriz city

Monthly bioclimatic condition	Monthly ET condition	Month
Cold	-3	January
Cold	-1.2	February
Very cool	0.7	March
Very cool	7	April
Very cool	10.4	May
Very cool	13.7	June
Cold	16.4	July
Cold	16.2	August
Cold	13	September
Very cool	8.7	October
Very cool	3.7	November
Cold	-0.5	December

Mahani index of Tabriz city

The effect of bioclimatic condition on building formation and some of the architecture detailed are investigated using table 4 in Mahani method. Following, we evaluate the index related to Tabriz station. According to table 9, in daily condition Tabriz is located below comfort range during 8 months of January, February, March, April, May, October, November, and December, and above the comfort range during two months of July, and August, and in comfort range during two months of September and June. But in nightly condition, Tabriz is located in below comfort condition like daily condition during 8 months, and in comfort condition during only 4 months of June, July,

August, and September (the tables (7-12) related to this index are enclosed).

After determining the thermal situation of Tabriz station, Human comfort and lack of comfort situation, the condition of being dry or humid determined and the results showed in table 10. According to this table, it was determined that the index of humid thermal situation has not been selected in no month, but the indices of dry situation has been selected in most of months. The index of 1a exist during two months of June and September indicating the situation in which the temperature variation more than 20 degree centigrade, and low relative humidity cause lack of comfort, also the index of 3a exist during 8 months of January-May, and October-December. In

Mahani Method after determining undesirable climate condition. General guidance along with some preliminaries have been presented in order to contrast the condition. We can obtain the building outline with transferring the number of obtained indices.

Generally according to Mahani 4 tables in climatic condition of Tabriz city it is better that the city has compact design, and the building orientation should be East-West in order to be exposed of sun light as far as possible. The windows dimension should have the area of 20-40% times of the area of building view, the walls should be light, and the delay time should be short.

The average opening size should be 25 to 40 percent of the wall area. The man body faces the wind and located in height in northern and southern walls. The ceilings should be light, with reflective surface and double wall. The following results obtained using table 12:

The average size of openings, skylight and windows area is 25 to 40% of wall area. The man body facing the wind and should be in height in opening places of south and north walls. The walls and floor thermal capacity should be light and low. The ceilings should be light, with reflective surface and double walls.

DISCUSSION AND CONCLUSION

Finally, the climate is one of the most important factors affecting various aspects of human life, especially in health and human comfort. The main objective of this study is to provide guidelines for the establishment of peace through building design appropriate and consistent with the climate of Tabriz County and consequently reducing energy consumption and its optimization in the city. To do so, we used the methods of stress, temperature affective, and Mahani indices. Statistical analysis and data of Tabriz Weather stations, it became clear that the climate characteristics of the city are mountainous and cold. From stress index view, Tabriz is located in cold and very cool range and generally about 41% of the year times located in cold range, 16% of the times located in very cool range, and 8% of the time is located in cool range according to this index. The need of using Heating Appliances is very higher in these seasons and it is felt that most of the numbers are in the range of 790-1000 due to its mountainous characteristic. Temperature affective index was evaluated daily, nightly, and monthly, and it the results showed that most of the areas are located in cool, cold and very cool range in daily condition.

Which about 50% of the year times is located in very cool range, 25% is in cold range and 25% in very cool range respectively according to table 13. In nightly view, it is in comfort condition in May and October and in very hot and sultry condition in June, July, and August. The most comfort ranges in nightly

condition is related to very cool range. In monthly view, generally the summer season has the comfort condition. Two ranges of very cool and comfort have the same percentage which equal to 33% of the year times.

Table 7: the percentage of temperature affective index ranges

Bioclimatic ranges	cold	Very cool	cool	Comfort	Hot	Very hot	Sultry
The frequency percentage of daily bioclimatic condition	25	50	25				
The frequency percentage of nightly bioclimatic condition	16.6	25	8.3	16.6	8.3	8.3	16.6
The frequency percentage of monthly bioclimatic condition	25	33.3	8.3	33.3			

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Enclosed tables-Number 8-13:

Table 8: Mahani assessment

AMT	Highest		Monthly temperature variation	The average of The average minimum temperature	The average of The average maximum temperature	Month
13.54	32.8		8	-5.7	2.3	January
			8.8	-3.8	4.9	February
			10	0.5	10.6	March
			10.9	6	16.9	April
			12.1	10.6	22.8	May
AMR	Lowest		13.4	15.3	28.8	June
			13.4	19.3	32.8	July
			13.5	19.1	32.6	August
38.52	5.72		13.8	14.4	28.2	September
			12.3	8.3	20.6	October
			9.9	2	11.9	November
			8.1	-2.8	5.2	December

Table 9: Mahani assessment

Wind	Monthly raining(mm)	Humidity group	The average relative humidity of each month	Average monthly minimum relative humidity	Average monthly maximum relative humidity	Month
The highest frequency of the first dominant wind						
SW	21.7	4	72.3	57	84	January
SE	24.1	3	68.6	52	83	February
SW	40	3	61.3	42	80	March
N	52.1	3	55.8	36	77	April
SW	41.2	3	50.2	30	72	May
SW	16.1	2	40.4	23	60	June
N	5.7	2	36.2	21	53	July
E	3.3	2	36.2	21	53	August
SE	8	2	39.1	22	58	September
W	22.3	3	50.2	32	69	October

SE	27	3	46.6	45	81	November
SW	21.8	4	71.4	54	84	December
		283.7	Total Annual Raining			

Table 10: The situation of Thermal indices

Night	Day	Thermal stress	Night comfort		Monthly average minimum	Day comfort		Monthly average minimum	Temperature (AMT)	Humidity group	Month	
			Minimum	Maximum		Minimum	Maximum					
C	C							2.3	13.5	4	January	
C	C			18	12	-5.7	24	18	4.9	13.5	3	February
C	C			19	12	-3.8	26	19	10.6	13.5	3	March
C	C			19	12	0.5	26	19	16.9	13.5	3	April
C	C			19	12	6	28	21	22.8	13.5	3	May
.	.			19	12	10.6	29	23	28.8	13.5	2	June
.	H			22	14	15.3	31	25	32.8	13.5	2	July
.	H			22	14	19.3	31	25	32.6	13.5	2	August
.	.			22	14	19.1	31	25	28.2	13.5	2	September
C	C			20	12	14.4	31	25	20.6	13.5	3	October
C	C		19	12	8.3	29	23	11.9	13.5	3	November	
C	C		19	12	2	26	19	5.2	13.5	4	December	

Table 11: The situation of total dryness or humidity of thermal indices

Total	December	November	October	September	August	July	June	May	April	March	February	January	Month	
													Humidity	
0													Air movement (required)	H1
0													Air movement (desired)	H2
0													Protection against raining	H3
				has			has						dryness	
2													Heat accumulation	A1
													Sleep out	A2
8	has	has	has					has	has	has	has	has	Cold seasons problems	A3

Table 12: Mahani Preliminary Recommendation

Recommendation	Total indices of table 4					
	Dry			Humid		
	A3	A2	A1	H3	H2	H1
	8	0	2	0	0	0
Locating						
1-The building orient should be east-west so that they are not exposed to sun light as far as possible			0-10			
2- Compact design around a central courtyard	5-12		11 or 12			

	0-4					
Spacing						
3-Open space to penetrate the wind						11 or 12
4-the same as 3, but prevent from cold/hot wind						2-10
5-compact design						0 or 1
Air movement						
6-Rooms with single wall Permanent conditions for air displacement			0-5			3-12
7-Rooms with double wall Temporary conditions for air displacement			6-12			1 or 2
8-No air displacement					0 or 1	0
Openings						
9-Large openings-40-80% of north and south walls	0		0-1			
10-Very small openings.10-20%	0 or 1		11 or 12			
11-Medium Openings.20-40%	Any other condition					
Walls						
12-Light walls, short delay time			0-2			
13-Weight interior and exterior walls			3-12			
Ceiling						
14-Light insulated ceilings			0-5			
15-Weight ceiling, delay time more than 8 hours			6-12			
Sleep out						
16-A space for sleeping out is required		2-12				
Protection against raining						
17-Protection against weight rain is required						

Table 13: Recommendation of Mahani Detailed architecture

The name of station: Tabriz	The indices of thermal situation					
	A3	A2	A1	H3	H2	H1
	8	0	2	0	0	0
Opening size, skylight, window						
Wide: 40 to 80% of the northern and southern walls	0		0-1			
Medium: 25 to 40 percent of the wall area	1-12		2-5			
Small :15 to 25 percent of the wall area			0-10			
Very small: 10 to 20% of the wall area	0-3		11-12			
Medium: 25 to 45 percent of the wall area	4-12		11-12			
Opening place						
In the northern and southern walls. the human body faces wind and in the height			0-5			3-12
The same as above- It is also embedded in the inner walls			6-12		3-12	1-2
Opening protection						
Be protected from direct rays of the sun	0-2					
Be protected against rain				2-12		
Walls and floors						
Low and light thermal capacity			0-2			
Wight- delay time more than 8 hours			3-12			
Ceilings						

Light, with reflective surface, double wall			0-2			10-12
Light-isolated ,a good dam			3-12 0-5			0-9
Weight, delay time more than 8 hours			6-12			0-9
Outer space						
Space for sleeping outdoors		1-12				
Adequate supplies to refuse raining water				1-12		