The Effects of Urban Environment on Climate Changes, Case study: Tehran, Iran

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Abstract

Natural climatic conditions in urban areas can be changed by human physical environment. Climate as a natural system and city as a human system have close mutual connections. Urban population growth and consequent increase in urban physical expansion may lead to intensification in human activities and disturbances in the environment. This contributes to alterations in solar radiation, balance of energy in urban atmosphere and eventually undesirable changes in the urban climate. In this study, average of Diurnal Temperature Range (DTR) has been applied as an index of climate change. This index indicating the difference between maximum and minimum temperatures has variations with their increasing or decreasing trends. To examine DTR changes in Tehran, we have used minimum and maximum temperatures and cloudiness data of Mehrabad Synoptic Station from 1956 to 2006. The results of the examination have indicated that there are slight changes in urban climate. This is accompanied with changes in urban population growth and consequent urban physical development.

Keywords: Urban Climate, Urban Population Growth, Atmospheric Threshold, DTR Index, Tehran, Iran.

1- Introduction

Climate of a city is an outcome from the mutual relationship between natural and human factors (Khoshakhlagh *et al*., 2011). The humankind always seeks action plans as the fight or adaptation plans to adjust himself to the environment (Ghahroudi *et al*., 2012). However, this trend has been changed during times and we are facing with a high level of human intervention in the natural environment (Schutkowski, 2006, Ghahroudi, *et al*., 2012; Ghahroudi and Nezammahalleh, 2013). Urban environment as evolved from the interrelations of manmade-natural processes is expanding on whole the biosphere of the earth. An expansion in physical extent of cities has increased the pollutants and then these factors have resulted in climate changes and atmospheric threshold change (Lamptey *et*

al, 2005; Tonkaz and Cetin, 2007; Abbaszade *et al*. 2010; Kim and Kim, 2011; Taghavi, 2011).

Climate change is highly taken into account for financial disadvantages and for social and economic consequences of atmospheric threshold boundary occurrences (Mohammadi *et al*., 2005). Urbanization and expansion of cities in addition to rapid population growth and industrial activities with wasteful usage of fossil fuels have increased atmospheric pollution (KhoshAkhlagh *et al*., 2011). Penetration of pollutant substances into the atmosphere influences four climatic elements, i.e. temperature, pressure, humidity and wind, as the main effective factors in human activity and prosperity (Alijani, 1993). An Increase in climatic threshold phenomena such as flood (Ghahroudi and Nezammahalleh, 2013), tropical storm, hurricane, hailstorm and thermal waves in urban environments is the main matter of concern for climatologists and administrative authorities throughout the world (Babaeian, 2009). The climate of the case study has its specific conditions with problems on urban planning (Kakooei 2008; Ghahroudi and Nezammahalleh, 2013). Therefore, identification of climate and its changes in every region can be helpful in appropriate land use planning in urban planning (SheiykhBeiglou, 2008). An assessment of climate change processes helps urban managers adopt properly the most appropriate resolutions. In this study, the average temperature as an important index of climate change (DTR) (Stone and Weaver, 2003; Abbasi, 2009; Lim, 2012) that has been highly affected by urban physical development and human activities is applied to determine the climate change in the urban area. Consequently, this study has applied DTR index for daily temperature changes. Therefore, it has investigated two hypotheses: 1) the process of daily temperature fluctuations is getting changed; 2) these fluctuations are mainly resulted from the changes of maximum temperature quantities due to extra demographic–physical growth of Tehran.

2-Theoretical Review

There are important indices such as data based GCM and RCM models by which climate changes can be examined and also simulated (Ghamdideh, 2010). There are also data based geological methods including evidences from the bottom of the oceans, animal's fossils and dendro climatology, which are geological approaches of climate change (Ahmadi *et al*, 2012; Feyzi, 2009) and also by geomorphological studies (Ghahroudi *et al*. 2013).

Some data such as boundary indices are based on statistics (Abbasi, 2009). We defined extreme threshold event as an infrequent phenomenon that is located in the upper and lower sector of statistical distribution. Selection of boundary indices for climate change and its consequences is one of the most important points that should be taken into account by researchers. In this study, a major project has been done in the meteorological research institute (Rahimzadeh *et al*., 2011). Many of these indices were introduced by European Climate Support Network as the largest project on climatic assessment of Europe in 2000. Boundary indices must be simple, clear and useful for the future (Peterson *et al*., 2001). Implementation of this long term equal data shows the situation of extreme values. This study has examined indicator thresholds

index. The averages are unable to reflect the fluctuations obviously. Hence, some researchers like Stone and Weaver (2003), Gallo *et al*. (1996), Collatz *et al*. (2000), Daoee (1999), Sun *et al*. (2006), Abbasi (2009), Scheitlin and Dixon (2010) and IPCC (2007) have applied the Diurnal Temperature Range to demonstrate climate change in their studies.

3-Geographical location

Tehran is located in the south of Alborz Mountain Range and in the north of Iran central dessert (Fig. 1). Tehran (from 35° 35´ to 35° 55´ N, and from 51° 04´ to 51° 32´ E) is warm and dry in summer, and cold and humid in winter. The north and northeast of Tehran is surrounded by Alborz Mountain Chain (Ghahroudi and Nezammahalleh, 2013). The natural place with a suitable natural environment has attracted a huge population. One of the main environmental problems of Tehran is overcrowded tall buildings. This tendency has probably been resulted from the lack of integrated urban planning system. For instance, unreasonable urban policies and programs in the housing and transportation may be a cause for environmental problems in whole the city (Ghahroudi and Nezammahalleh, 2013).

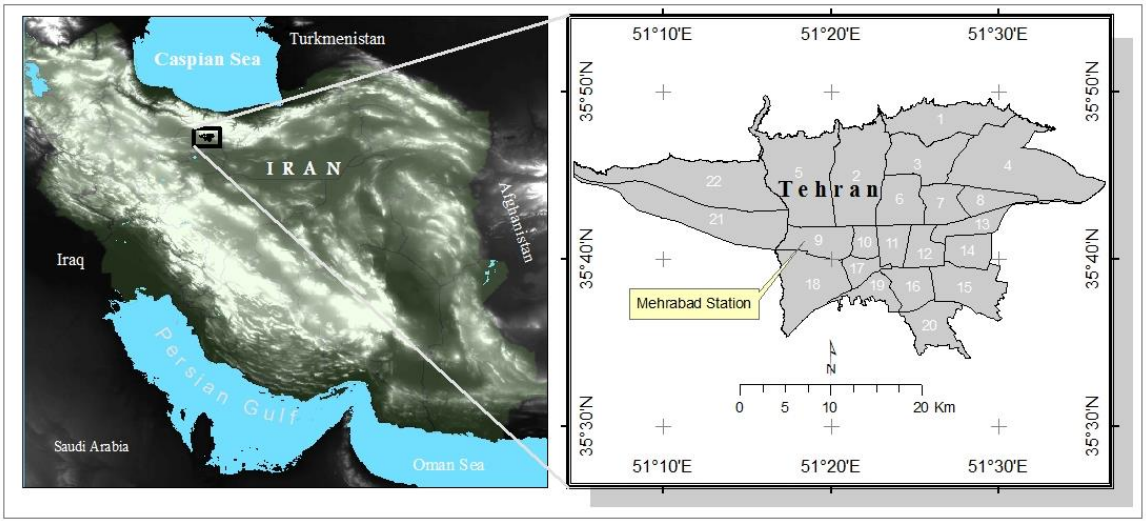

Figure 1) The location of Tehran City

4- Pressure of population growth

Tehran city has experienced a rapid growth in both population and land use during 30 years period of this study as a problem (Gallo *et al*., 1996). The population of Tehran was raised quickly up to 46 percent during recent three decades. Tehran faced a rapid population growth and then an intensive land use (Gallo *et al*., 1996) during recent three decades (Table 1 and 2) and also a consequent physical expansion (Fig. 2). This issue may be intensified by transportation of vehicles and fossil fuel consumption. Therefore, all the issues have caused an increase in the amount of carbon dioxide and atmospheric pollutants. Entering these pollutants into the atmosphere would prevent energy of the earth from escaping at night (Alijani, 1993). This process might increase the minimum temperature and limit the threshold.

Table 1) Tehran population growth

year	1966	1976	1986	1991	1996	2006	2011
Population	2719730	4530223	6058207	6497238	6758845	7711230	11305832
Growth rate (%)	5.1	2.9	1.3	0.78	1.3	n.a	n.a

5-Methodology

In this study, we have used two kinds of raw and processed data. Raw data including temperature (minimum and maximum) and cloudiness from 1956 to 2006 were obtained from Iran Meteorological Organization (Table 3) (Stone and Weaver, 2003). The processed data was acquired from the raw data by using Microsoft Excel and SPSS software. At the first step, we have calculated the range of temperature changes and then we have selected study periods validating access and accuracy of statistics. Therefore, the accuracy of synoptic statistics of the station has been analyzed and clarified. Subsequently, data of each month were divided into separate pages to make the procedure of study fast, easily and more accurately.

Table 2) The portions of used areas on kinds of land uses, Tehran, 2006.

Number	Land use type	Used area (km^2)	Percentage of total
1	Residential	177	28.8
2	Trade- administrative	26	4.2
3	Industrial	27	4.4
4	Transformation and Storage	30	4.9
5	Traffic and Access Net	114	18.6
6	Urban Services	50	8.1
7	Green Spaces	70	11.4
8	Agricultural	35	5.7
9	Military	44	7.2
10	Abandoned	41	6.7
Total		614	100

Source: http://atlas.tehran.ir

Consequently, the data of each month is severed by using SPSS software. Then, the separated data were transferred to Microsoft Excel for examination and drawing the related diagrams.

In this research, Reformed Mann-Kendall Trend Test (RMKTT) Method was applied to analyze data as the following way: in the Mann-Kendall Method T quantities are calculated for time I and U(T) and as mentioned in the Mann-Kendall Test, ends at the I time and U(T) are computed at the time N=I.

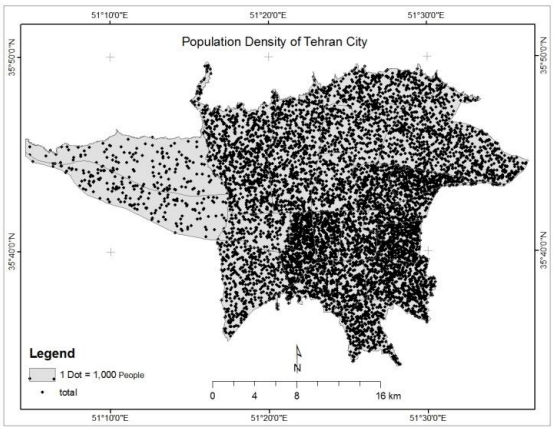

Figure 2) Current population density of Tehran.

We have done our research based on TDR index that contains the following formulas:

$$Ni + Ni' = yi - 1 \qquad \text{(Eq. 1)}$$

$$i' = (n+1) - I \quad , \qquad Ni' = ni$$

The quantities of Ui´ for recurring series are computed using following equation:

$$Ui' = -U\,(Ti) \qquad \text{(Eq. 2)}$$

If Ui and Ui´ sequences are diagrammatically drawn, on condition that trend is significant, Ui and Ui´ sequences will intersect each other at the commencement of the phenomenon, whereas if there is not a significant trend, Ui and Ui´ sequences will be parallel or act with more than one intersections without direction change. Likewise, the trend includes long term changes in time series which is a simple function of time and does not contain incidental changes (Stone and Weaver, 2003). Trend changes may be linear, quadric, polynomial or exponential function, logarithm function, etc.

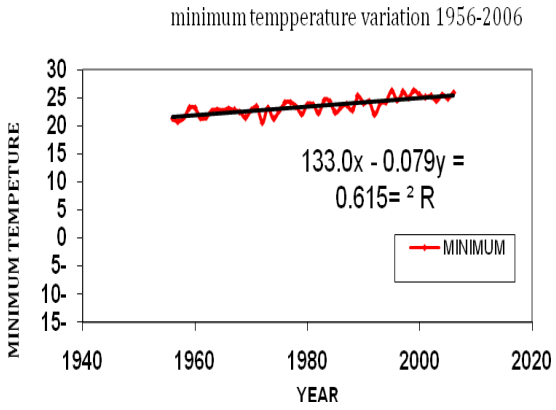

Figure 3) Minimum temperature variation 1956-2006.

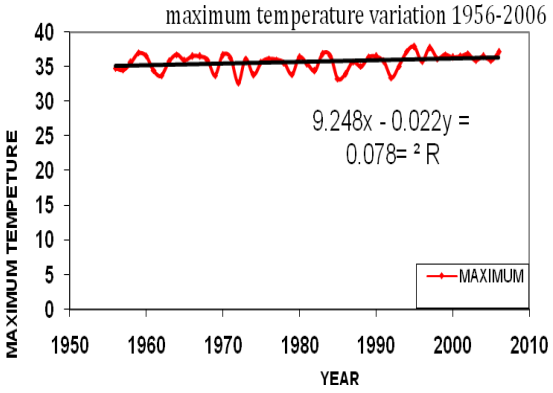

Figure 4) Maximum temperature variation 1956-2006.

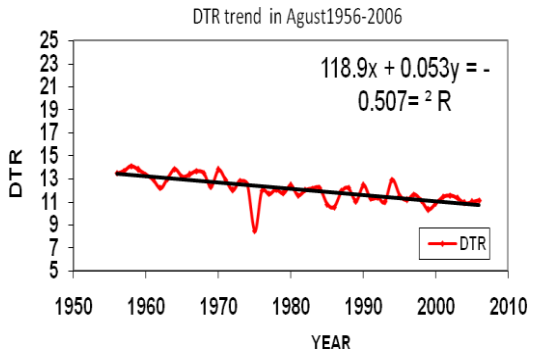

Figure 5) DTR trend in August 1956-2006.

The results have been represented in Figs. 3 and 4 and a result based on TDR trend for August can be seen in Fig. 5.

As it can be seen in Fig. 3, the minimum temperature has considerably experienced an increasing trend so that in the average of

40 years this value ascended from 22º C to 26º C. This increase of just 4ºC, perhaps as a result of a rise in industrial activities and consumption of fossil fuels in the cities in the 40 years period, may cause harmful consequences for urban environment (Stone and Weaver, 2003; Sun *et al*. 2006).

Table 3) minimum and maximum temperature data.

years	Min temperature	Max temperature	years	Min temperature	Max temperature
1956	21.32	34.81	1982	22.36	35.42
1957	20.84	34.55	1983	24.66	34.41
1958	21.48	35.61	1984	24.37	36.82
1959	23.19	37.00	1985	22.43	36.59
1960	23.23	36.58	1986	23.37	33.24
1961	21.45	34.42	1987	23.75	33.94
1962	21.48	33.71	1988	22.81	35.71
1963	22.74	35.74	1989	25.33	35.03
1964	22.90	36.77	1990	24.04	36.40
1965	22.74	35.94	1991	24.44	36.50
1966	23.13	36.52	1992	22.06	35.75
1967	22.81	36.52	1993	24.06	33.45
1968	22.52	36.03	1994	24.30	35.07
1969	21.45	33.77	1995	26.32	37.21
1970	22.84	36.65	1996	24.56	37.88
1971	23.39	36.32	1997	26.09	35.74
1972	20.61	32.65	1998	25.04	37.73
1973	23.32	36.16	1999	26.42	36.19
1974	21.26	33.81	2000	25.50	36.74
1975	22.74	35.65	2001	25.10	36.37
1976	24.19	36.16	2002	25.30	36.55
1977	24.26	35.97	2003	24.54	36.86
1978	23.48	35.55	2004	25.59	35.90
1979	22.06	33.84	2005	24.93	36.51
1980	23.90	36.35	2006	25.98	35.92
1981	23.87	n.a	n.a	n.a	37.11

6- Research findings

There was a regular raise in the trend of maximum temperature in the years of study (Fig. 4). The increase of maximum temperature reached 37.8º C in 1970 and it might be a result of increasing population growth, decline of vegetation cover (Collatz *et al*., 2000) and enormous physical constructions in urban surfaces (Stone and Weaver, 2003).

It can be understood from DTR Diagram (Stone and Weaver, 2003) that in addition to a pulse in the trend of the index there is a decrease from 1970 to 1980. The decrease might be happened through Elnino (Pahlavan, 2009). There is obviously a decline in DTR Index during the years of study due to the raise in the minimum temperature that can be representative of a warming in the climate of the region. An increase in population growth, human activities, industrialization and consequent atmospheric pollutants may be some the causes for the relative raise. The decline of DTR Index augments the occurrences of natural disasters including flooding, intensive rainfalls of short duration and dust storms (Fig. 5). Lamptey *et al* (2005) had been concluded that the urbanization decreases DTR in northern American cities and this is in accordance with the results of this research. Tonkaz and Cetin (2007) have studied the impacts of urbanization on the temperature of a semi-arid region and concluded that the urbanization gives rise to an increase in minimum temperature. In a study by Kim and Kim (2011) it was demonstrated that about 56% of raise in total temperature in Korean peninsula is controlled by warming due to urbanization as it is stated in the results of this study. As it was suggested by Sang (2012) the minimum, maximum, and DTR have a positive trend in 20 years period of his study, in this study we found such a positive trend for Tehran city. Against the results of Sang (2012) in his study on river delta, we concluded that on urban areas the daily temperature and DTR would be increased by urbanization; on this delta the maximum temperature experienced more increase than it was experienced by minimum, but against the results in Tehran urban area the raise of minimum temperature is slightly more than those of maximum.

6-Conclusions

The growth of urban population and then urban physical development especially unsustainable physical expansion of buildings have probably caused disturbance of natural system of the environment and destruction. Climate changes in a large area usually have an enormous impact on human and natural ecosystems (Sun *et al*., 2006), and mutually are influenced by urban population growth and urban constructions. In the case of Tehran, this trend might have led to changes in solar radiation, energy balance in urban atmosphere and eventually disturbance and adverse changes in climate of the city (Scheitlin and Dixon, 2010; Sun *et al*., 2006). There can be seen negligible trends variability in the parameters. However, the increasing trend of maximum temperature in Tehran is slighter than minimum temperature. This issue might be caused by an increase of aerosols derived from traffic and high urban pollution and as a consequence of a growth in cloudiness (Scheitlin and Dixon, 2010). On the other side immoderate construction and destruction of vegetation can be effective factors in the boundary threshold change in Tehran (Callotz *et al*., 2000). Because the extra construction causes an increase in solar energy reception and warming of the structure during days, but due to their lower specific heat, this structures release the energy faster in nights and this process can lead to a change in boundary threshold in urban environment (Alijani, 1993). Therefore, urban planners and managers must consider these changes as serious hazards for city and human activities (Lim

et al., 2012). Finally, some suggestions can be stated. To rehabilitate the atmospheric conditions of Tehran into a normal situation, we need to: (1) Formulate and implement a comprehensive urban environmental action plan; (2) Provide appropriate planning in order to manage the traffic jam, implement traffic limitations and improve utilization of clean energy sources; (3) Reform the laws and implement the climate compatible construction's regulations; (4) And to apply strict rules for reduction of atmospheric pollutions in municipalities.

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