

Investigation of Tehran green Space changes and its role in air pollution Using LANDSAT images from 1980-2010



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Abstract

Because of geographical position of Tehran and existence of mountains in the northern part of it, transmit of the northwest prevailing wind to discharge pollution caused by urban activities seems to be complicated and also, construction of industrial factories in the city space and high amount of urban transportation, crisis the air in Tehran. So, study of the amount of green space and their change and role to reducing air pollution in Tehran - caused by urban activity- has highly importance. The purpose of this study is green space developments per capita during the past three decades and its role in the evolution of present air pollution in Tehran. The study areas have been conducted in the Great Tehran about 730 Square kilometers. To implement of this study, LANDSAT imagery of 4 and 5 TM and ETM sensors in the past thirty years have been used. At first radiometric and geometric correction and coordinates unification of all images. The images of study area in Tehran have been selected and then using maximum likelihood classification algorithms for image classification and extracting of plant cover layer and green space done. In this section by using the region borders green space was calculated per capital and thematic map was presented. By using long time Tehran pollution zoning maps, all 22 regions of Tehran in term of pollution have been ranked. And at last correlation between the amount of air pollution and green space was observed. The results show that, at first, the amount of green space per capita was undesirable than the global Standard and at the second, the role of green space to reduce pollution in different areas of Tehran has been impressive.

Key words: per capital green space, satellite images, air pollution, and correlation.

1. Introduction:

Air pollution is the fourth cause of death. International Statistics shows that air pollution caused rank fourth of death. According to the UN reports, every year 3 million people in the worldwide die because of air pollution or its cussed illness.

Particles of metal contaminants such as cadmium, nickel, arsenic, sulfate, nitrate ions and hydrocarbons PAHs what emission in the air has various adverse effects such as reduced IQ, stupidity, liver lesions, asthma and emphysema creates.

Researches conducted by the Air Quality Control Company and the Ministry of Health and Medical Education of the Islamic Republic of Iran have also indicated, the amount of these Pollutants in the air of Tehran is 2.8 times over than the world standard.

Tehran citizens mortality risk have been increased by increasing particles. Results of a regional study in Tehran showed that in one 140 day period, 160 patients in five hospitals were treated by respiratory and cardiovascular illnesses which air pollution induced.

Air pollution which made by fossil fuel vehicles in Iran, especially in large cities and especially in Tehran, entirely critical and dangerous situation to take over. Air pollutant in the large scale was cussed sometimes exclaiming the dangerous air pollution situation by environmental authorities and health authorities of the country and alarmed peoples don't left their homes.

Hence the process of review and study of air pollution in Tehran and awareness of some actions that should be made in this regard is very important.

1.1 Tehran features

Tehran locate between mountain and desert valley in the southern slopes of Alborz mountains. From the south it is spreaded from the Bibishahrbanou mountains and Ray heights to the Shahriar and Varamin plain. In the north, because of the Alborz Mountains, it has been Surrendered. The height of city is 1700 meters above sea level In the north, 1200 m in the center, and finally it is reaches 1100 m in the south.

Geographically, the city has been located from 51 degrees and 8 minutes to 51 degrees and 37 minutes east longitude and between 35 degrees and 34 minutes and 35 degrees and 50 minutes north latitude. lands steep in the city is from north to south. In the Shemiranat mountains, range 10% to 15%, in Tajrish due to abasabad hills 3% to 5% and from abasabad to Enghelab Street 2%. The slope from city sides to the city center is 1%.

Tehran Climate, other than the North Highlands which are a little wet and temperate, is warm and generally dry. Maximum temperature of 39.4 degrees recorded in Tehran and at least the - 7.4 Celsius. the average monthly maximum and minimum are 29 and 1.

Average rainfall in Tehran was low and throughout the year is 316 ml. 36 number of frost days per year has been recorded in Tehran.

1.2. Sources of air pollutants:

Due to expanding cities and increasing sources of air pollutants, most large and industrial cities are pollutant and have risks of infection for people's health that live in contaminated areas. So understanding and knowledge of various aspects of this issue is very important and only by knowledge and understanding of the issue we can prevent or reduce possible risks.

Several types of pollutants were extended by human's natural and artificial activities on land, coming into the atmosphere, so the general air pollution means the presence of a foreign substance in the air that it can be classified based on natural and artificial pollution sources.

Natural Resources: Air pollution such as dust storms, forest fire, volcanoes, pollen and natural gas leaks and pollution from them is a permanent phenomenon that was due to natural processes, its value more or less is fixed in the entire world. Amount of natural pollutants in compared with artificial ones are much more significant. But in nature, there are several mechanisms to faltering them to improve and make creatures life appropriate and sustainable.

Artificial sources: Includes substances such as domestic pollution, industrial pollution, traffic or transport and etc. The role of humans and human activities are clearly marked.

In the Other way to categories EPA¹, air pollution has been classified as follows:

A: transportation: ships, aircraft, trains and automobiles

B: constant fuel from combustion sources such as power plants, etc.

C: industrial processes such as: steel plants, textile and paper

D: solid waste disposal, such as: open waste incineration, open burning and burial of waste, sanitary landfill system and others.

E: Other processes, such as household activities,, Using of insecticide and pesticide cleaning.

1.3. Factors that affecting on air pollution:

For this article several methods can be provided by different categories, but in the natural environment and human factors which increased air pollution can be grouped as following:

1.3.1. Meteorological characteristics:

Atmospheric parameters such as size and wind direction, atmospheric loss rates, relative humidity, etc affect air pollution. Horizontal movement of the air, carry and move pollutants. Pollution carried by wind speed downward. Pollutant concentrations at ground level substantially depend on the size and wind direction and rate of decline. Change in air temperature with increasing altitude result pollutants move relatively faster.

1.3.2. Topographic shape:

Ground shapes and obstacles such as mountains and so will be affected in pollutants emissions. Depending on local conditions and the location, topography, may be beneficial or harmful.

1.3.3. Pollutant properties:

Air pollution importance depends on contaminant type and size and what they are, the solid or liquid or gas. Also depends on the sound or heat or energy or radioactivity, and are combinations of these factors. Reaction between the pollutants in the atmosphere - depending on the pollutant characteristics - may increase or reduce the amount of pollutants in the atmosphere.

1.3.4. Pollutant release method:

How pollutants release and also how quickly releasing pollutants into the atmosphere has the effect of air pollution. Pollutants may periodically or continuously or periodically emit, or be released from a source or several sources or point sources and non point sources. The dispersion of pollutant depends on their release method in atmosphere.

1.4. The role and importance of green areas to reduce air pollution:

Improving public awareness about green Area and meet plant values are necessary and barrier of cities environment disaster destroying by pollution. Therefore sometimes make the importance and role of green area on human life and create more interest in the tree in people's minds are very important and cost-effective solution with high efficiency in reducing pollution and increasing urban life value

The main effects of plants and green Area into the urban life and humans is as follows:

1.4.1. Absorbed radiation:

There are two significant effects of solar radiation on the human body and other organisms. One of them is infrared and the other is UV. Today, cellular effects of ultraviolet light on

¹ Environmental Protection Agency

plants and animals and also its disinfect on them and the role of trees in supporting human and other organisms in the scorching sun is clearly well known.

1.4.2. Dust absorption:

Trees because of their distribute foliage in over all angles and levels, act as a duster. If we observe carefully the tree, we thought trunk can instead handle and foliage instead of filters on a regular duster that can be used at home,

1.4.3. Oxygen production:

Humans need about 15 kg air per day. While their need to the water is 5 / 1 kg and food is 5 / 2 kg. This amount of healthy air that enters the body are 78 percent nitrogen and 21 percent of the oxygen. Other gases such as carbon dioxide, helium, neon and nitrogen and sulfur oxides are very small amount of air weight. For example, 3% carbon dioxide leads to quick human's death. It is important to know that a large amount of oxygen released through the air produced by the green area.

1.4.4. Climate mitigation:

Transpiration of trees play important role in reducing microclimate temperature and increasing relative humidity of air. Temperature of one hectare green area at the July, is 5 / 4 degrees lower than the adjacent space which is empty of trees. And so the relative humidity within the green space to 11% over the outside is measured. With adjusting two parameters mentioned above, green area creates well microclimate that improved nice physical comfort for humans.

1.4.5. Effect in reducing noise pollution:

Noise such as, cars and ... has a important role in the human conformance. Cities space infect by noise pollution. The green Areas reduce the air sound pollution like a acoustic panel.

2. Used data

Data used in this study:

A - 7-band Land Sat images on 19/09/1988 and 19/07/2009

B-Tehran population statistics from 1365 to 1385

C – Map of Tehran regions “22 region in Tehran”

D – Statistics of dispersion of population in the Tehran

E - Pollution statistical information in Tehran

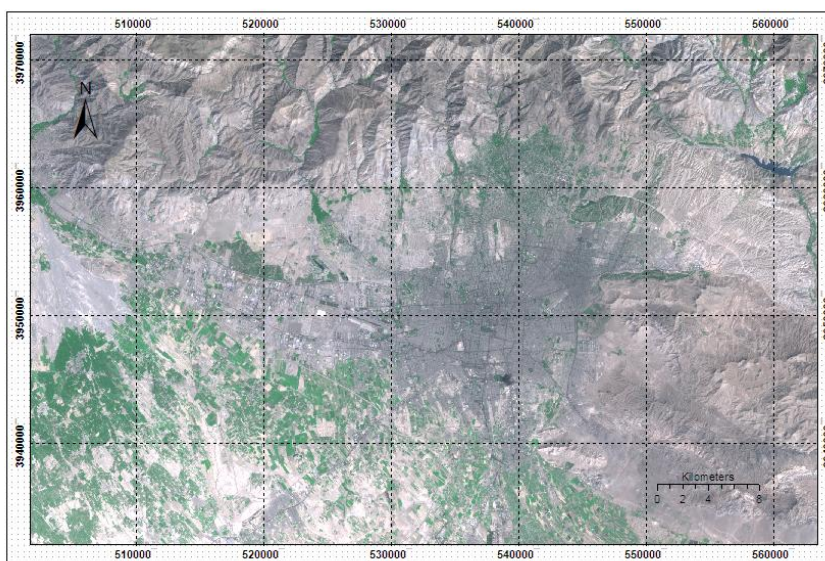


Figure 1: True Color Land sat Image on 1988

Population data zones in Tehran in 1385 by people:

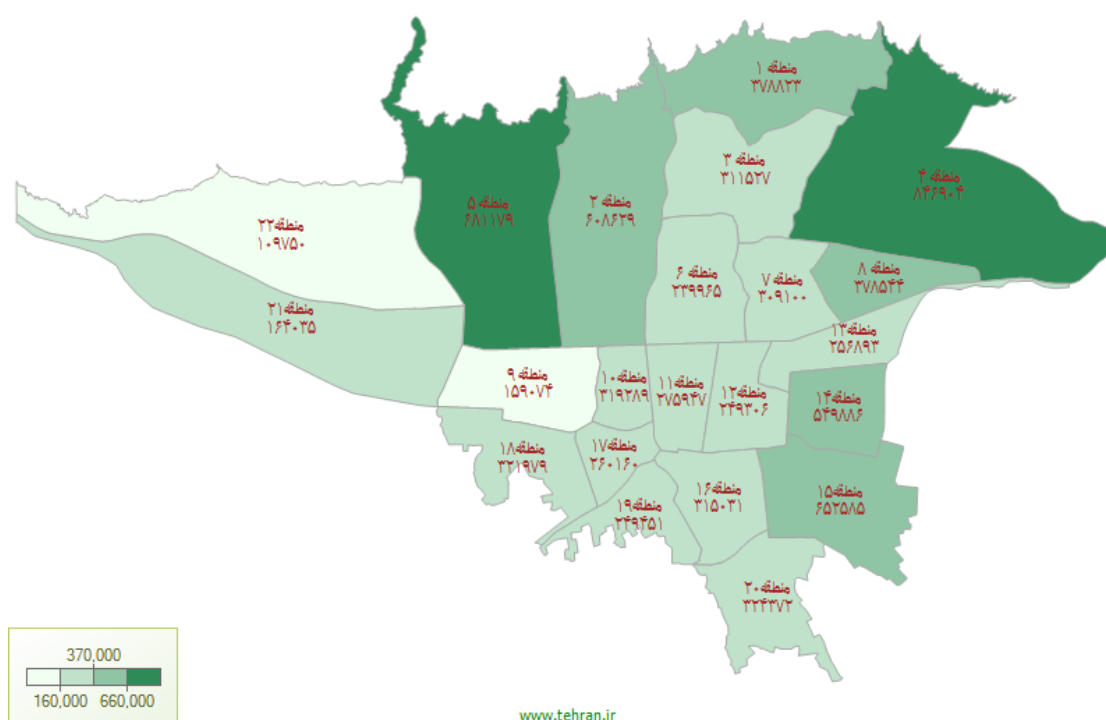


Figure 2: Population distribution map of Tehran in urban areas based on census statistics of 2007 (Tehran Municipality's website)

2.1. Spearman correlation coefficient

In some studies, obtain data interval is not possible or if have no required properties. In such cases we can be ranked raw numbers, although the data rank information to our raw data does not as valuable as raw data.

If the data collected as a rank or rating may be converted, it could be used Spearman correlation or Spearman ρ . To measure the correlation different coefficients are used to. One of which is the correlation coefficient is nonparametric methods.

Null hypothesis, this test assumes that there is no correlation. Ordinal correlation coefficient show with r_s . Correlation coefficient method for calculating paired data (x_i, y_i) for $i = 1, 2, \dots, k$ are this: first all the x terms give the rank values and the same work we do for y. then the difference between the scores of each pair calculated –shows with d_i -. Then calculate the square for all d_i , finally, using this formula to calculate the ordinal correlation coefficient.

$$r_s = 1 - \frac{6 \sum_{i=1}^k d_i^2}{n(n^2 - 1)}$$

To Test Null hypothesis, the hypothetical claim that the x and y variables are with no correlation and are random pairs are matched, no need to assume certain about is sampled population. For large amounts of samples ($10 < n$) distribution can be approximated with bellow formula.

$$Z = r_s \sqrt{n-1}$$

2.2. Pollution Standards Index (PSI)

PSI is a quantity standard for reporting daily air quality and usually contain of five pollutants: carbon monoxide, ozone, nitrogen oxide, sulfur dioxide and suspended particles or particulate matter are used.

According to the pollutant concentration and health standards in U.S. Environmental Protection Agency EPA, concentrations of pollutants to a numerical scale in PSI is converted from zero to five hundred.

Because of unique scale measurement by PSI, it is preferable:

PM-10 ($\mu\text{g}/\text{m}^3$) 24hr	SO ₂ (ppm) 24hr	NO ₂ (ppm) 1hr	O ₃ (ppb) 1hr	CO (ppm) 8hr	PSI
00.0	00.0	0.00	0.00	0.00	0
75.00	00.30	150.00	60.00	4.50	50
150.00	140.00	300.00	120.00	9.00	100
375.00	300.00	600.00	200.00	15.00	200
625.00	600.00	1200.00	400.00	30.00	300
875.00	800.00	160.00	500.00	40.00	400
1000.00	1000.00	2000.00	600.00	50.00	500

Table 1: PSI pollutants Concentration table

According to the index rate and the following table, air quality can be realized in the last 24 hours.

Descriptor	Good	Moderate	Unhealthy	Very Unhealthy	Hazardous
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PSI	0-50	50-100	100-200	200-300	> 300
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Table 2: Air Quality According to PSI

Regarding the air quality index for each pollutant can be reported. But the overall condition of the weather index is maximum, meaning that usually belongs to the highest PSI pollutant is generally CO or PM-10 is used.

3. Research method

Determine the green area per capita largely depends on the City bioclimatic characteristics.

On this basis, circumstances of green area per capita in a desert town or a big city such as Tehran should be different with a seaside town.

Suggested methods for determining the green area per capita, mainly determined the specific green area for leisure, i.e. urban and public green spaces and other fields such as landscaping, roads network, and others. Green area function which assumed must be evaluated.

For example, although the roads green space may belong to the ecological and environmental effects, but its original function is about traffic network and traffic follow, so other effects are less important. Therefore, like other elements of the Urban Green entities can be considered an independent role.

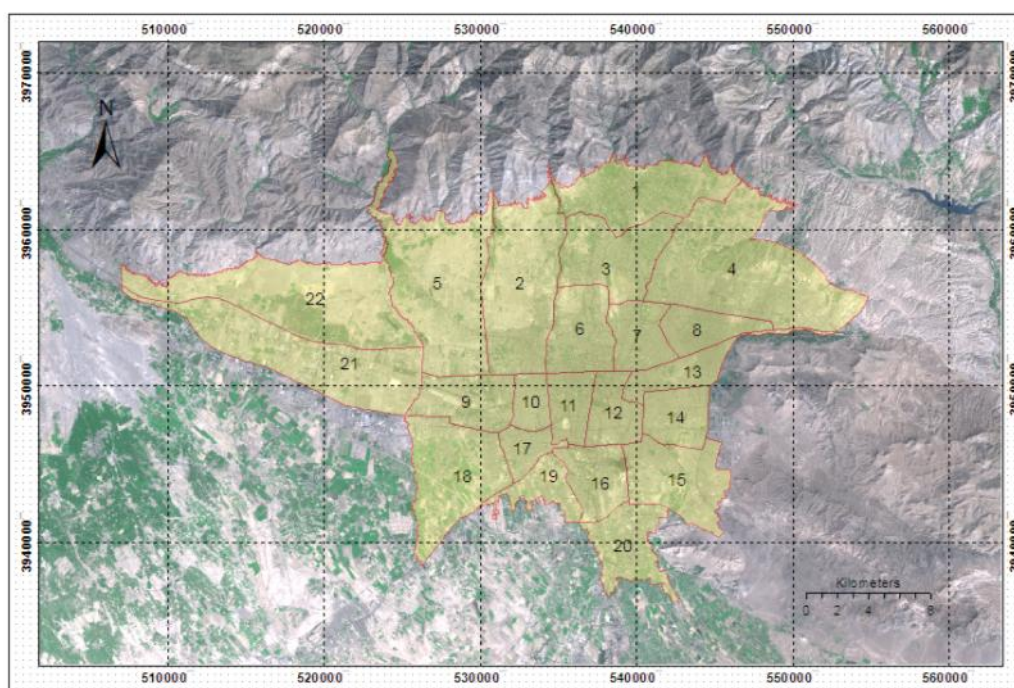


Figure 3: areas of current Regions in Tehran on 1988 Landsat Image

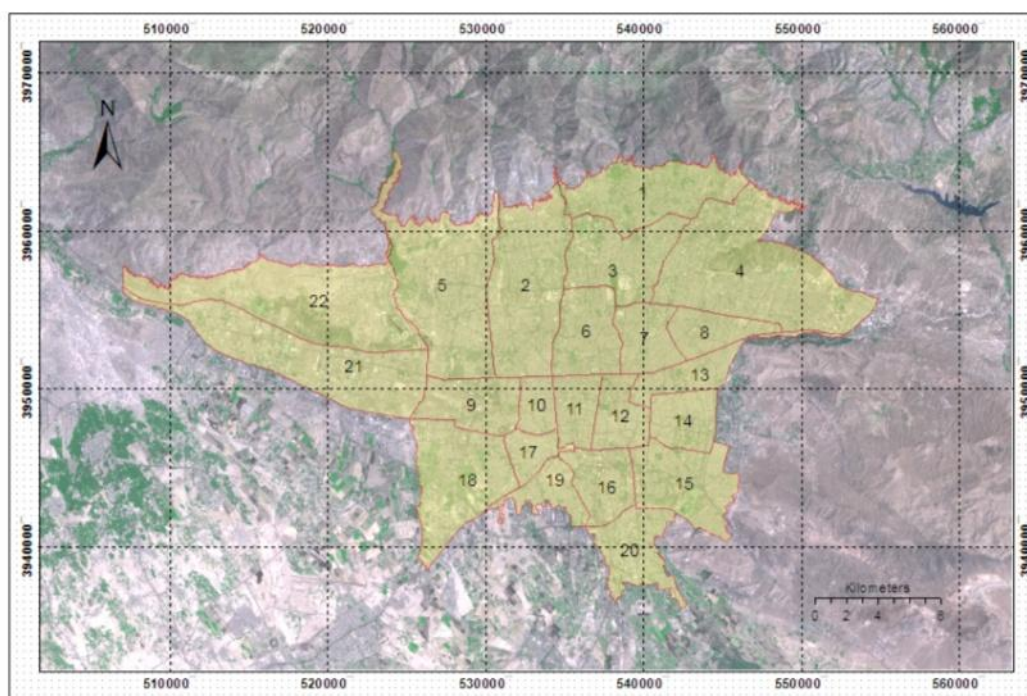


Figure 4: Areas of current Regions in Tehran on 2009 Landsat Image

Note here that the subject of this research is in connection with clearance role of green area and its relationship with pollution, therefore, this article was trying to independently recalculate the amount of Tehran green space per capita with help of remote sensing data, so in this method all green area roles such as beautification of urban furniture or Green area in streets are also having been considered. So all the flora on the campus of Tehran refinery pollution in the city has been studied and involved - apart from what they considered for the role has been.

To calculate the green area per capita in the first, by using satellite images and classification them in several spectrum band, attempts to isolate and calculate the total amount of these green area in Tehran regions. In this regard, first, false-color images by using bands 2, 3, 4 has been made and then by using remote sensing applications², satellite images classified in eighth classes by using maximum like hood method.

This class is as follows:

Agricultural areas, green space, water, mountains, forests, hills mound, industrial buildings and urban areas. Three classes, agriculture, forests and green spaces in calculation have been determined as green areas.

²Erdas

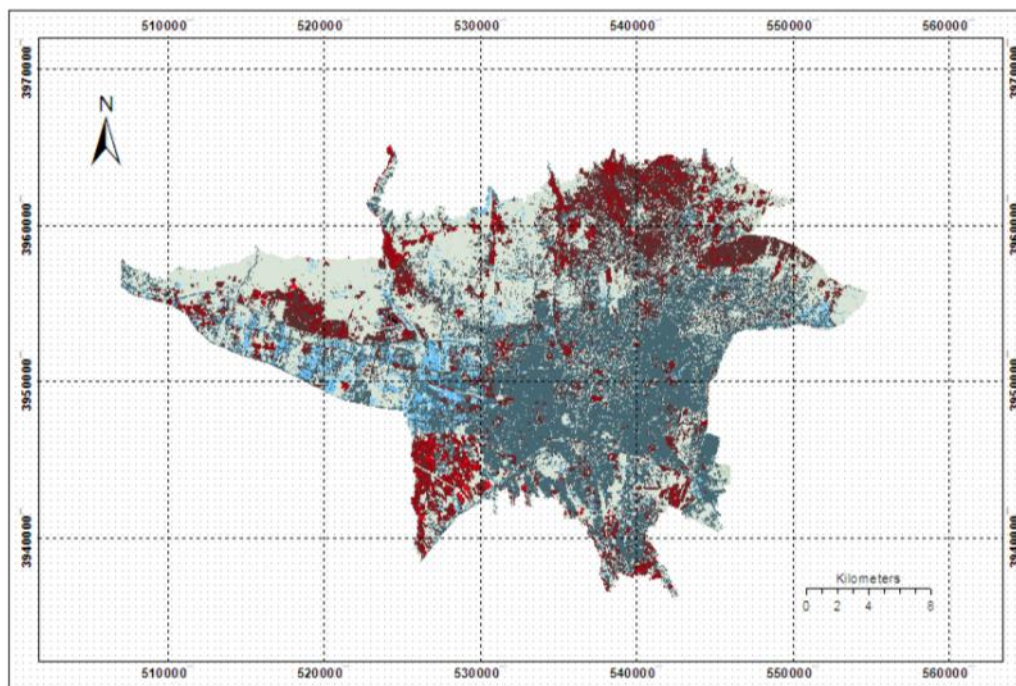


Figure 5: View of the classified image, red presents green area

Following shows classification results of green area in 1988 and 2009 of Landsat image in urban areas of Tehran:

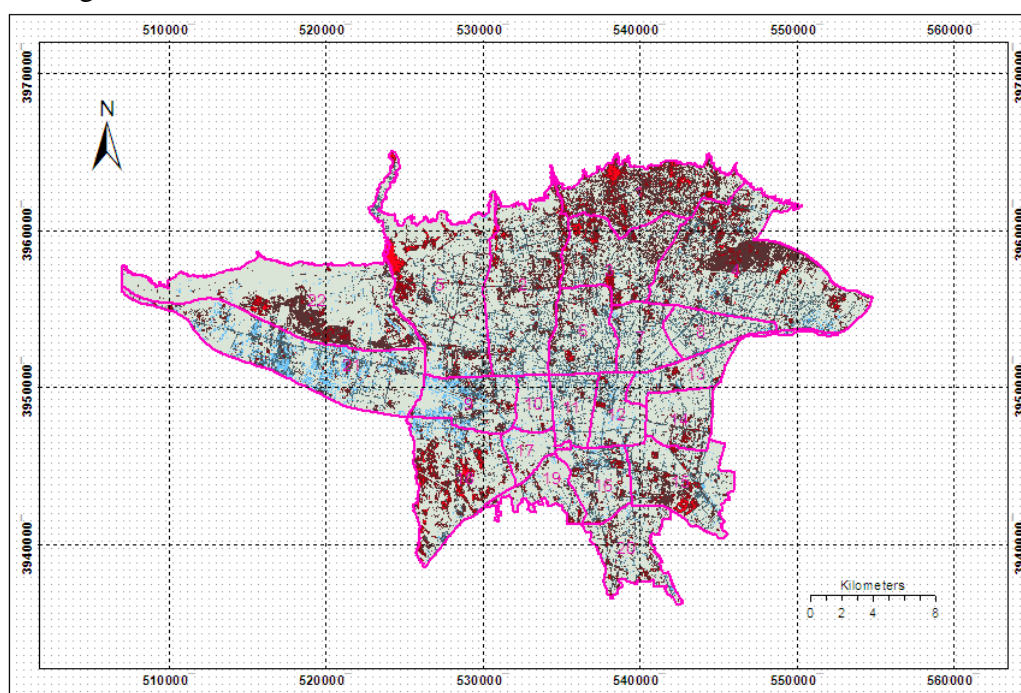


Figure 6: Tehran Study area of green areas in in 2009

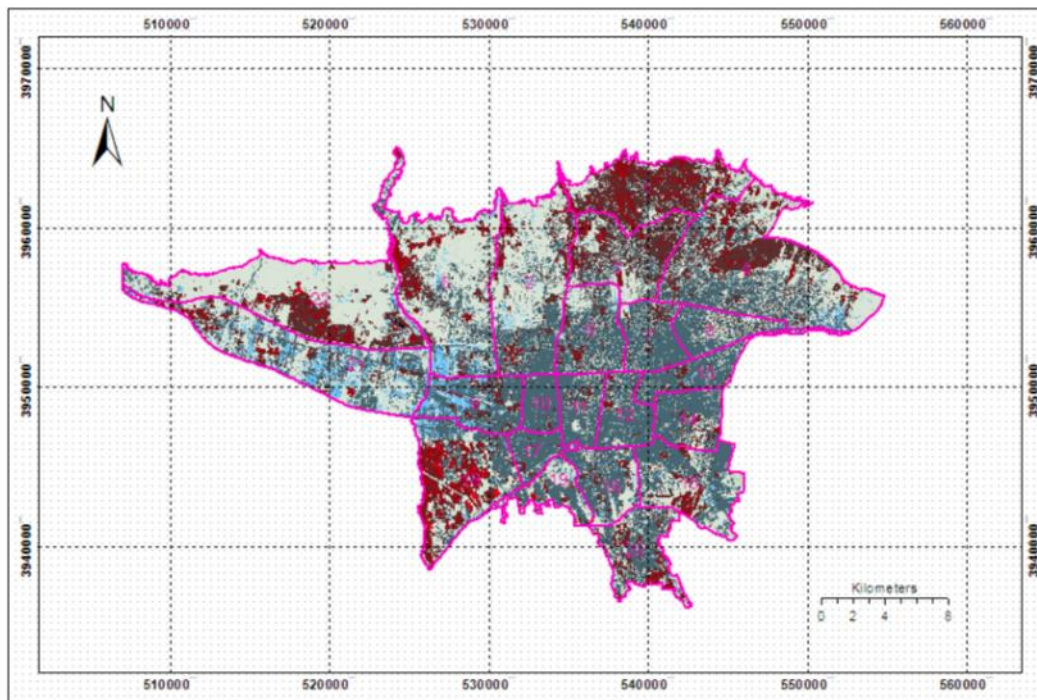


Figure 7: Tehran Study area of green areas in in 1988

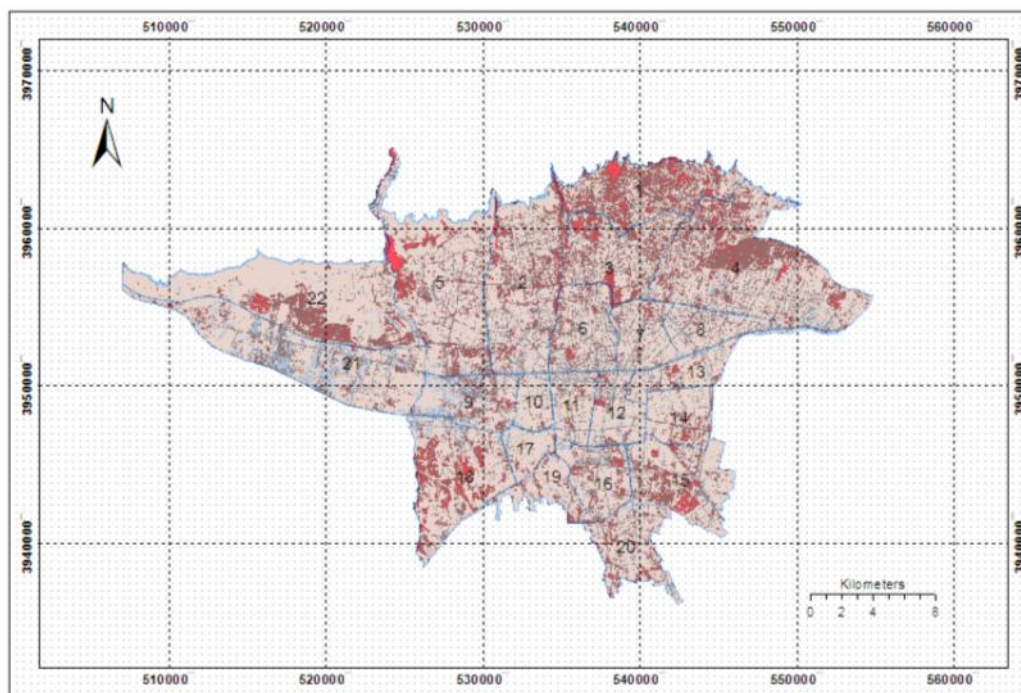


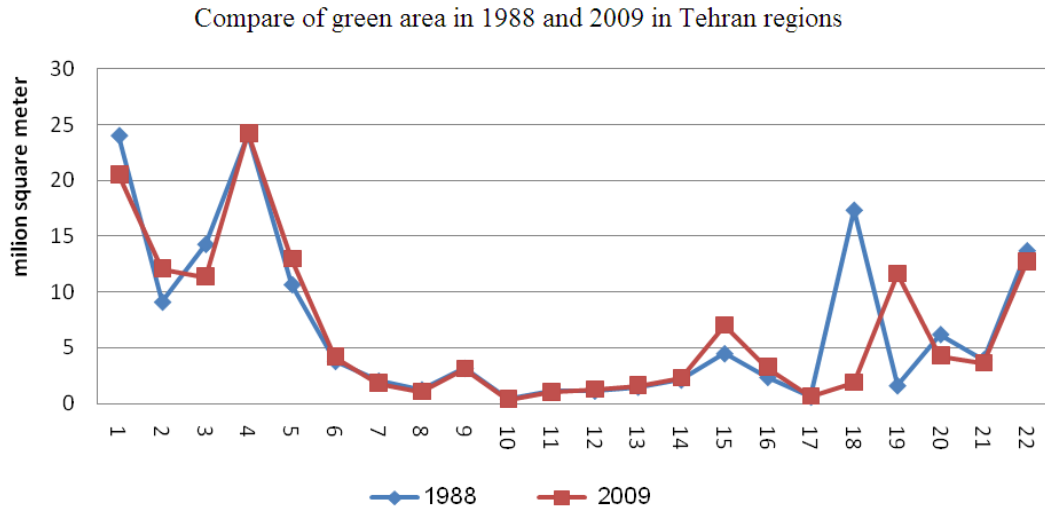
Figure 8: Overlay of Tehran regions and the city green area map, computed based on 2009 image

Now according to population data for Tehran, we will attempting to determine the green area per capita in Tehran based on square meters per person.

Year	Population(Person)	Total green area (Ha)	Green area per capital (Square meter per person)
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1988	6042584	13041.630	21.58
2009	7962429	14162.850	17.78

Table 3: Per capita green area in the study period



Now, by using pollution data of Tehran, attempting to determine the number of days more than the limit air pollutants in different regions of Tehran. To that reason stations data of Environmental Protection Agency was used.

At first, data about coordinates and the amount of over standard pollutant days for each station identified and then by using the IDW method, the center of each region has been valued as regions value.

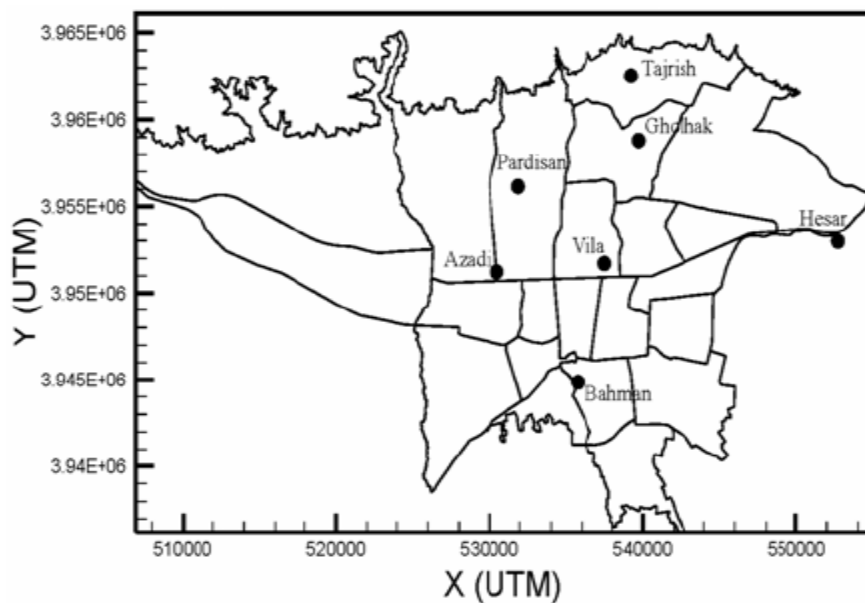


Figure 9: Dispersal of air pollution control stations of the Environmental Protection Agency in Tehran

Station name	CO (max 8hr : 9 ppm)	O3 (max 1hr : 0.08 ppm)	PM ³ (max 24hr :150 ppm)	SO2 (24hr : 0.14 ppm)
Azadi	70	58	90	25
Tajrish	40	0	28	0
Gholhak	40	43	91	0
Bahman	0	0	37	0
villa	98	84	100	14
Pardisan	4	3	5	0
Sorkhe hesar	0	67	15	0

Table 4: Number of days over the limit air pollution in Tehran Environment stations in 2009

Results of calculations that made for different regions in the following table are available. The important point here is that due to the existence, other fixed pollution measuring stations and other mobile stations and also used existing models to determine pollution in regions can be a more accurate estimate of the pollution. But in this study data from the Environmental Protection Agency has been sufficient.

Regions	CO (max 8hr : 9 ppm)	O3 (max 1hr : 0.08 ppm)	PM (max 24hr :150 ppm)	SO2 (24hr : 0.14 ppm)
1	40	0	28	0
2	4	3	5	0
3	40	43	91	0
4	21	53	25	0
5	34	26	47	12
6	98	84	100	14
7	71	53	93	7
8	39	66	68	5
9	55	40	68	18
10	53	34	67	17
11	60	41	75	18
12	63	43	78	18
13	36	29	62	11
14	21	18	50	4
15	8	9	41	3
16	0	0	37	0
17	19	14	23	9
18	3	2	12	1
19	0	0	30	0
20	0	0	12	0
21	13	9	17	5
22	22	17	29	8

Table 5: Number of days pollutants are over the limit in Tehran region as per IDW method

Continue in the zoning maps in different regions of Tehran, pollution based on carbon monoxide, ozone, particulate matter, sulfur dioxide and number of days of pollution by PSI index is shown. you see the result of the above data and Computation with a GIS software.

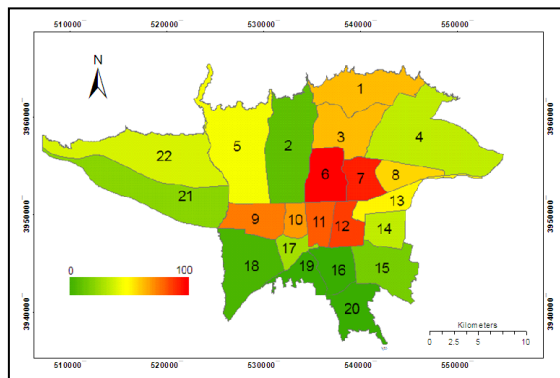


Figure 10: Pollution of regions based on the number of CO pollutant days

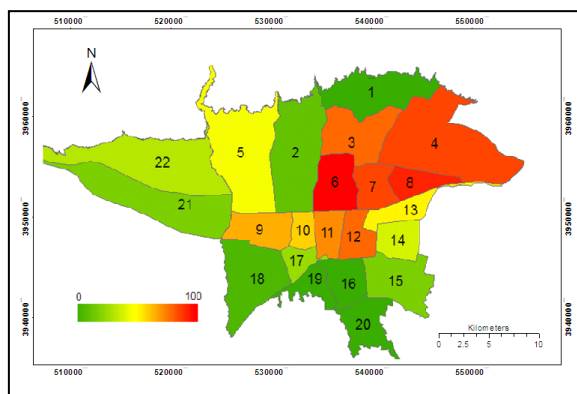


Figure 11: Pollution of regions based on the number of O3 pollutant days

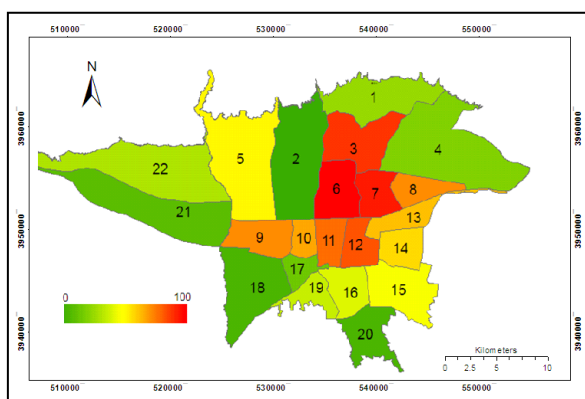


Figure 12: Pollution of regions based on the number of PM pollutant days

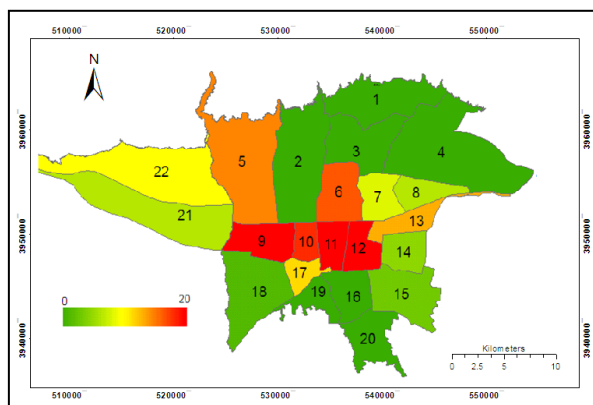


Figure 13: Pollution of regions based on the number of SO₂ pollutant days

Now, after creating pollution zoning map and classification of data, attempting to determine the per capita green space based on the data, then, compares it with existing data on the website of Tehran Municipality. Obviously, according to the description on the site council, per capita calculated by this institution was based on public green areas, including parks, green spaces within and along streets and parks and other green areas such as private gardens and green spaces within the homes are not considered.

Regions	Population (Person)	Green area- RS (Ha)	Green area per capital- RS meter-) (Person)	Green area- website (Ha)	Green area per capital- Website meter-) (Person)
1	378823	2055	54	573	15
2	608629	1208	20	1137	19
3	311527	1137	36	3171	102
4	846904	2426	29	788	9
5	681179	1296	19	749	11
6	239965	415	17	250	10
7	309100	182	6	116	4
8	378544	103	3	152	4
9	159074	309	19	81	5
10	319289	35	1	49	2
11	275947	101	4	157	6
12	249306	123	5	129	5
13	256893	159	6	158	6
14	549886	228	4	232	4
15	652585	702	11	879	13
16	315031	326	10	335	11
17	260160	60	2	89	3
18	321979	188	6	346	11
19	249451	1165	47	500	20

20	324372	429	13	487	15
21	164035	362	22	259	16
22	109750	1273	116	197	18

Table 6: Tehran Green area per capita in 2009 according to data calculated by remote sensing and Tehran Municipality website

Now, by using data calculated, attempt to determine the correlation between the green area per capita and over limits pollution in Tehran different regions.

The following table shows correlations between air pollution regions of Tehran and data obtained from the green area per capita of the city regions that the calculation consists of both municipal website statistics and remote sensing data.

Pollutant type	CO (max 8hr : 9 ppm)	O3 (max 1hr : 0.08 ppm)	PM (max 24hr :150 ppm)	SO2 (24hr : 0.14 ppm)
RS Data	-0.15	-0.20	-0.24	-0.23
Website Data	-0.15	-0.02	-0.07	-0.45

Table 7: Correlation between the Tehran green are per capita and its urban air pollution in 2009

4. Results:

According to the calculations, it is clear that amount of urban green area during the studied years not noticeably changed in Tehran and according to increasing population in Tehran over the years 1988-2009, we face with loss of per capita green area in these years. Amount of green area per capital from 22 meters in 1988 reduced to 18 meters in 2009. That clearly shows, it is less than global green area per capital – at least 25 m per person- and its distance is significant.

in addition, the history of about 15 years air pollution in Tehran shows that the pollution levels in different parts of Tehran with green areas per capita is very little correlation - in accordance to Table 7 - and even we can say that although increases green area may result a little improve in Tehran air quality but the impact of green areas on the air was petty and not closely related. So possibility of other factors such as the almost certain existence of cars, industrial areas and other pollution sources of pollution have more impact than green area and mostly should reviews each of these factors in separate research projects to finding appropriate solutions to resolve air pollution problems of this metropolis others in the world.

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