# Environmental crises in the Metropolises of Iran

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## Abstract

The explosive growth of the population in Iran within the last four decades on the one hand and the problems in rural areas on the other hand have resulted in the mass migration of villagers to cities. Thus the number of city-dwellers, which constituted 47 percent of the total population of the country in 1960s, increased to 55 and 66 percent in the two decades that followed and to 70 percent in the year 2002. The greater part of the migrating population have settled in the metropolitan cities of Tehran, Mashhad, Esfahan, Shiraz and Tabriz. This sudden influx of population within a short period of 40 years has impeded comprehensive urban planning and the rapid and inharmonious growth of the physical texture of the metropolitan cities has given rise to numerous difficulties, making life in urban areas hazardous and costly.

In this article, using aerial photos and satellite images taken in previous decades, the growth processes of the Metropolitan cities are demonstrated and the present and future environmental problems of these cities are explored. The results of this study show that the growth of the physical texture of Metropolises has had an effect, directly and indirectly, on the possibility of the occurrence of floods and earthquakes, the creation of heat islands, changes in the climate, shortage of water, pollution, and destruction of the natural environment, etc.

## 1 Introduction

A country of southwest Asia, Iran has an extensive area of 1648000 sq km and a population of 65 million. It is located in the desert belt of the northern hemisphere. Iran has 700 urban centers with 5 metropolises of more than 1 million population. The capital, Tehran, has over 1 million population, followed by Mashhad (2.3 million), Isfahan (1.8 million), Tabriz (1.4 million)

The Sustainable City III, N. Marchettini, C. A. Brebbia, E. Tiezzi & L. C. Wadhwa (Editors)

and Shiraz (1.1 million). All the metropolises of Iran are located in crucial tectonic and climatic situations and have therefore a high geographical hazard factor.

The metropolises of Tehran and Isfahan have developed on the margin of desert depressions supported by central Alborz and the Zagroz mountains; Mashhad has developed on a plain between Kappeh Dagh and the Eastern Alborz mountains; Tabriz has developed at the foot of the Sahand Volcano and Shiraz inside the folded systems of the Zagross. Tectonically, these areas are located within the unstable belt of Alps-Iran-Himalayas, which is characterized by highly destructive earthquakes.

The topographic situation of the metropolises, which have developed on the alluvial fans, pediments and low slope plains, creates a special situation with respect to floods and water blockage, so that these cities suffer great costs every year as a result of the floods from the mountains. The unfavorable climatic conditions include abrupt and intense fluctuations of temperature in various seasons of the year, consistent stability of air and shortage of rainfall. These conditions not only form the phenomenon of heat islands, but also play an important role in the scarcity of water and the concentration of pollution in the metropolises.

## 2 Urbanization growth in Iran and the emergence of environmental crises

From 1950 to 2000, Iran experienced an unrestrained urbanization development. The great cities of Iran have now in unstable environmental conditions and are faced with very serious crises. Since such cities developed earlier than was expected, urban planning in Iran has faced a great challenge. In fact, the major problems the metropolises are now faced with are as follows: the master plans do not meet the needs of the ever-increasing population, the master plans for urban development have their own shortcomings and the urban areas face natural environmental limitations.

From 1900 to 1955, the population increase was rather slow, but after that, especially in recent decades, the increase has been dramatic. Based on the available statistics, the rate of urbanization increased from 31.4% in 1950s to 47% in 1970s, and to 60% in 1990s. It is now in the vicinity of 70% (Haeri and Zanjani, 1988; Hatami Nezhad, 1997; [12].

In Tehran, Mashhad, Isfahan, Tabriz and Shiraz, the population explosions are basically the result of mass migration of villagers to cities, especially after the implementation of the Land Reform plan during the Pahlavi rule. As a result, the cities developed in every direction with no attention to the master plans. On the other hand, patterns of gradual development anticipated in the comprehensive plans were not compatible with the ownership of the lands in the vicinity of cities and the land needed for the expansion of the city is usually provided by changing the farm land owned by private owners to residential areas. For this reason, the responsible organizations do not have a check on the plans [8].

The Sustainable City III, N. Marchettini, C. A. Brebbia, E. Tiezzi & L. C. Wadhwa (Editors)

The unrestrained growth of the metropolises by constantly encroaching upon the countryside results in unsuitable urban architecture, narrow streets and passages, inappropriate land use, substandard capitation and substandard buildings and structures. The villages that have become part of a metropolis have kept their own traditional structure, which is quite incompatible with the architecture of the surrounding area. The vulnerable and fragile environment of Iran can no longer tolerate the pressure of the metropolises. The metropolises have not only changed the natural shape of the earth, but also exploited the resources needed for urban development, the water needed by the ever-increasing population and the space needed for more development. On the other hand, the high consumption of fossil fuels, the dumping of construction debris and the sewage has resulted in vast pollution of the environment, so much so that in each metropolis the environment is polluted within a radius of tens of kilometers.

## 3 The development of the Metropolises and the change in the climatic conditions and air pollution

The role of cities in the greenhouse warming of the Earth and the formation of heat islands throughout the World has been proved [4]. The greenhouse effect started when cities began to occupy expansive natural space. The study of the temperature changes in the metropolises of Iran from 1950 to 2000 indicates an increase in temperature of one to two degrees Celsius. Interestingly, since 1970s, as the cities have begun to develop more rapidly, there has been a sudden increase in temperature [6].

The most important reasons for such changes in the metropolises are firstly the change of the usage of lands, secondly the unrestrained use of fuels, and thirdly the vertical growth of the metropolises and their topographic situations. The study of aerial and satellite images in various periods shows that the cities have developed mostly in areas that used to be agricultural lands and orchards. For example, from 1955 to 2000, approximately 240 sq km of the most productive agricultural lands and orchards of Mashhad were destroyed as the city expanded on all directions (Table 1).

Table 1: Trend of growth in Mashhad and conversion of land use.

| Grassland Converted | Rural areas now part of the city | Conversion of Agricultural Land | Area (sq km) | Year |
|---|---|---|---|---|
| --- | --- | --- | 16 | 1955 |
| --- | 0.5 | 16.5 | 33 | 1965 |
| 16.8 | 1.2 | 43 | 78 | 1975 |
| 18.3 | 4.7 | 119 | 220 | 1985 |
| 53.5 | 1.5 | 45 | 320 | 1995 |
| 19.75 | 0.25 | 15 | 355 | 2000 |

The Sustainable City III, N. Marchettini, C. A. Brebbia, E. Tiezzi & L. C. Wadhwa (Editors)

If we add the agricultural land destroyed by the villagers whose villages were connected to the cities and by the people who migrated to cities and lived in the outskirts during the years 1995 to 2000, the land use of more than 300 sq km of has been converted.

The change in the conversion of land use in the climatic conditions of Iran has increased the amount of energy absorption by 40% and the terrestrial radiation combined with the exhaustion of fossil fuels has created a heat island. The vertical expansion of the metropolises has dramatically affected the local and regional wind patterns, so that mountain and plain wind, which outside the metropolises in the Alborz and Zagros mountains is a prevailing phenomenon, is almost nonexistent inside the metropolises and happens only by chance.

The increase in the atmospheric temperature in the metropolises has an effect on the amount and type of the precipitation. For example, the amount of annual rainfall in Mashhad has increased 60 mm within a period of 44 years from 1951 to 1994 [6]. The change in the heat exchange shows itself as heat islands, topographic situations, a lack of local wind and untimely rainfall, and all of these have had an effect on the pollution in the metropolises. These factors, which result in the repetition of the phenomenon of heat inversion, bring about the concentration of pollutants. The number of days in which the inversion phenomenon happens in the metropolises is 250 days on average: Tehran: 300 days [3]; Mashhad: 270 days (Arefzadeh, 1999); Isfahan: 260 days (Varesi, 1997).

The inversion phenomenon happens more or less similarly in all the months of the year. The frequency of occurrence varies between 25 to 30 days a month. The thickness of the inversion layer changes from 350 meters in winter to 700 meters in summer.

The most important air pollutants in the metropolises include $SO_2$, $NO_2$, CO and particles suspending in the air, and on all days when inversion happens, the amount is greater than the permissible limit. For example, the amount of particles suspending in the air in Mashhad was reported to be more than the permissible limit in 280 days of the year (ranging from 260 mg/m$^3$ to 2000 mg/m$^3$ [5].

In the metropolises, automobiles are responsible for 75 to 80% of the air pollution, and factories and fuels burned in homes are responsible for the rest. Respiratory and cardiovascular diseases have shown a 1.5% increase and the spread of winter diseases in the metropolises is due to air pollution (Bigdeli, 1999). Also, the constant fall of acid rain in the metropolises and the vicinities, which is due to air pollution, has done irreparable damage to water and soil resources, agricultural products and buildings [2].

## 4 Expansion of the Metropolises and the increase of the possibility of flooding

The metropolises of Iran are now seriously facing the problem of flooding and water blockage. In summer 1985 in Tehran, and in spring 1991 in Mashhad, the floods left considerable human and material loss. Every year, the metropolises

The Sustainable City III, N. Marchettini, C. A. Brebbia, E. Tiezzi & L. C. Wadhwa (Editors)

witness heavy rainfalls as a result of the formation of the phenomenon of heat islands, resulting in floods and water blockage in hundreds of places. Considering the morphological situation of Tehran and Mashhad, which are located on the alluvial fans and low lands, various independent catchments find their way into the cities. These catchments are characterized by low area (most of them less than 1000 acres), a considerable difference in the upstream and downstream, steep slopes and poor plant cover. All of these are instrumental in the formation of destructive floods.

Unfortunately, in the development process, no plan has been anticipated for controlling floods and sediments from the catchments and for the classification of the areas susceptible to floods within the realm of alluvial fans; rather, an increase in the amount of gravel and sand taken from the riverbanks, the dumping of considerable amounts of construction debris inside the catchments, designing the drainage system with low efficiency and, in general, the fight with nature instead of living with it in peace, have resulted in an increase in the possibility of the floods. A comparison of aerial photos (1956, with a scale of 1:55000) and satellite images (Landsat TM, 1987 and 2002) taken from 1950s to 2000 shows that the natural sewage pattern in Mashhad has been destroyed as a result of the expansion of the city, and that 23 main channels derived from the mountains on the alluvial fans are now led through 8 narrow canals. To supply the stone of little value used in the foundation of the buildings, 70 mines, small and large, have been established within an area of 4.5 sq km of the catchments; tens of kilometers of road has disturbed the slope hills; 12000 cubic meters of construction waster and debris have been dumped along the main stream courses and tens of thousand cubic meters of sand and gravel has been removed from the river banks. Also, local cattle breeding farms with over 5000 cattle in the limited space of the catchments have destroyed the plant cover and many plant species.

Apart from the aerial photos and satellite images and field studies in Mashhad, geomorphologic studies indicate that in the past, stream flows, after they separated from the mountains, were led with no restraint through various main stream channels from the apex to the base of the alluvial fans, and since the city only occupied a small area, the flows did hardly any damage to residential areas and urban installations (Hosseinzadeh, 1999). Under such conditions, the water flow, from the apex to the base of the alluvial fans, faced the phenomena of penetration, branching and distribution, losing power as they moved forward. Today, the city has expanded as far as the mountains, encroaching upon the catchments. Thus, there is no longer a large enough area for the floods to lose power after they are formed, hence the raging floods. Today the floods have high load of sediment from the remains of the stone taken from the mountains and construction waste and debris. If, after the recent ten-year draught period in which Mashhad has witnessed no raging torrent, a wetter period begins, the destructive force of the floods will increase dramatically. The increase in the volume of the sediment not only increases the destructive power of the floods, but also fills the existing canals inside the city. Due to poor planning and inappropriate land use, the expansion of the metropolises has increased the impenetrable surfaces by 50%. This not only strengthens the power of the floods,

The Sustainable City III, N. Marchettini, C. A. Brebbia, E. Tiezzi & L. C. Wadhwa (Editors)

but also pollutes the runoff. Considering the topography of the metropolises, the polluted runoff has polluted large areas of the city. Also, the polluted runoff cannot be reused for the irrigation of the agricultural lands below the metropolises, where water is rare and valuable.

## 5 Water crisis in the metropolises

At present the metropolises of Iran face an average of 30% shortage of water, which will reach 50% by the year 2020. In recent years, especially during summer, water has been rationed in the metropolises and the green areas have suffered greatly from the lack of water. During the years 1950 to 2000, Tehran used the Karaj and Latyan rivers to supply the water needed. This affected the agricultural activities in the vast plains of Karaj, Shahriar and Varamin. In the last ten years, Tehran, needing still more water, had to resort to ground water, which is not of good quality. By the year 2020, it is estimated that Tehran will need 1.2 billion cubic meters of water a year. To meet this need, part of the water from the river Taleghan will need to be used (Ahmadian, 2001).

Tabriz, Isfahan and Shiraz, which also depend so much on the water from rivers, have faced a serious crisis in the recent dry years, and are considering using the water from rivers as far as 100 kilometers from the cities. Mashhad, the second largest religious metropolis in the world, needs 700000 cubic meters of water every day, while, due to its resource limitations, can only supply 480000 cubic meters a day [14]. About 90% of this water is taken from the ground water resources and the rest is supplied by two small rivers around the city. Since the amount of water taken from the ground water resources is much more than the amount supplied, the level of the water table decreases by 13.3 meters a year. The authorities are now considering transferring water from the river Harirood on the border of Afghanistan. The sewage in the metropolises is dumped into the absorption wells, not only polluting the ground water in the lower areas of the cities, but also making these areas uninhabitable by raising the level of the ground water.

## 6 Expansion of the metropolises and the increase of the possibility of earthquakes

All the metropolises of Iran are located in areas with a high risk of earthquakes (Ministry of Housing and Urban Development, 1997). The metropolises have been expanded on every side without considering faults and lands with liquefaction capability. Great parts of Tehran, Mashhad, Tabriz and Shiraz are located on earthquake faults and lands with fine texture sediments. The dumping of sewage and the rising of water table have increased the possibility of earthquakes. The structural and architectural characteristics of the metropolises of Iran not only increase the possibility of earthquakes, but also cause the mortality and financial loss to increase considerably in the event of earthquakes stronger than 6 on the Richter scale. In such cases, the country will face a national catastrophe as there is no crises management, the streets and

The Sustainable City III, N. Marchettini, C. A. Brebbia, E. Tiezzi & L. C. Wadhwa (Editors)

passageways are too narrow, there are not ample green and open spaces, the buildings are so dense, the public do not have enough information and are not prepared for a catastrophe of this magnitude, and finally, the buildings are of low quality and collapse easily.

## 7 The metropolises and transformation of the surrounding areas

The rapid concentration of population in the metropolises and the inability of the government to control their growth has not only created a crisis inside the metropolises, but has affected the surrounding areas within a radius of several hundred kilometers. The dumping of tens of thousand tons of garbage and several million litres of sewage every day has resulted in severe environmental pollution in the vicinity of the cities. Also, the destruction of the environment by removing the plant life, constant removal of stone, sand and gravel from the riverbanks and the pollution of water and soil is on the increase. As far as Tehran is concerned, this trend has affected all the mountainous areas, the forests in the north and even the Caspian Sea.

## 8 Future outlook and suggestions

The trend of migration from villages to cities is almost uncontrollable. In spite of the fact that in the last twenty years the villages have been offered considerable services, they are not able to keep their population since the economic policies of the government are not clear and the privileges of the cities and the villages are not comparable. Life in the villages depends first and foremost on farming, and farming does not meet the financial needs of the villagers since the government does not support farming, the agricultural machinery is too expensive and the prices are not stable. On the other hand, the younger generation are lured to the attractions of city life, the ease of access to health, educational and treatment facilities and easier ways of earning a living. The problem of migration from smaller cities to the metropolises is now being worsened. Measures should be taken to prevent villages befalling to small cities. Rather than trying to meet the housing needs of city-dwellers, priority must be given to the wise plans for urban development. We must waste no time in replacing unsustainable cities with sustainable cities and, most importantly, developing the cities with environmental considerations. To achieve these objectives, it is essential that the following are undertaken.

1. Management methods should be corrected, both at national and local levels.
2. Defined economic policies should be pursued, and adapted to the economic potential in every area and region.
3. The rules concerning the preservation of natural resources and the prevention of pollution and the destruction of the environment should be revised.

The Sustainable City III, N. Marchettini, C. A. Brebbia, E. Tiezzi & L. C. Wadhwa (Editors)

4. Urban planning should be assigned to the experts and governmental and non-governmental economic organizations should be not authorized to have a share in urban planning.
5. The principle of Social Justice should be observed in the distribution of services and facilities.
6. The policies of urban development, which up to now have been pursued on a trial and error basis, should be abandoned and positive experience should be used.
7. The main decisions made for the comprehensive plans of the cities should be strictly followed; the change in such decisions has so far been the most important factor responsible for the present status of the metropolises.
8. The land development project, which should have been carried out years ago, should be implemented right away.
9. Rather than selling the vertical space of the city and the land in the vicinity of cities as a means to supply the costs of the cities, ample budget should be granted to the related urban organizations.
10. Last but not least, special attention should be paid to universities as the only authorities that are able to provide solutions, and special emphasis should be placed on urban studies and urban planning projects.

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