Asian Journal of Chemistry; Vol. 24, No. 3 (2012), 1381-1392

ASIAN JOURNAL OF CHEMISTRY

www.asianjournalofchemistry.co.in

Air Quality of Konya Province and Sustainable Ecological Urban Design Principles†

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(*Received*: 19 August 2011; *Accepted*: 12 November 2011) AJC-10666

Turkey tends to improve social life comfort by using various imported technology. The rising of urban citizens has been negative pressure on the environmental sources such as air, water and land. Environmental pollution indicators have been affected by local governments' land use decision. A new eco-city planning model has been developed and covers three dimensions plan with the respect of social, economic and politic components. The model is originally based on the application of sustainable ecological urban design principles. The objective of this study is to examine the principles of the eco-city planning for Konya province in order to determine life quality and city health. The data were collected from 4 different areas of Konya in 97.9 hectares and carried GIS platform. The tropospheric SO_2 and PM_{10} levels for 2006 were associated in the pollution maps. Air pollution levels in the area were compared with according to the air quality conservation legislation (HKKY) in Turkey and Directive 1999/30/EC in EU, as well as WHO's air quality guidelines (AQGs). As the study results, some proposes have been recommended for local government where life quality and city health increase.

Key Words: Urban design, Eco-city planning, Air pollution, SO_2, PM_{10}, Konya.

INTRODUCTION

The air pollution is one of the causes of global climate change which the most risky problem of our era and tried to be taken under control by the international contracts today[1]. Therefore, the municipal administrations in Europe are carrying out urgent action plans widely with the aim of reducing the CO_2 emissions by forming a synergy among each other. The air quality urgent action plans require the following priorities[2]: (1) Low energy consumption in housing; (2) Electricity saving in housing, industry and services; (3) Wield spread use of solar energy; (4) Founding renewable polycentric small and medium-scale energy producing centre.

The objectives of air quality urgent action plans are conceptualized with the sustainable ecological urban design principles in the literature of urban planning and these aims are carried out with planning themes such as ecocity, energy active planning, solar city and green city. With taking into account the insulation, it was shown that it is possible to carry out sustainable ecological urban design options from the point of view of building density, building story number and its morphological features in a given site[3,4]. As a central paradigm sustainable ecological design is an ecological approach that takes into consideration not only the nature but also human element as well in locally and globally. As indicators of sustainable development, inherent qualities, capacities and ecological footprints were illustrated in the place of exemplary communities[5]. The strategies of sustainable urban design are organized under five primary variables for achieving sustainability such as human ecology, energy conservation, resource conservation (land, food and fibber), air and water quality. These variables are presented as highly interactive natural cycles where based upon the theory and principles/processes of sustainable development[6].

Impact of rapid growing urban population on the city ecology: Rapid urbanization creates air pollution, soil and water contamination, light and noise pollution[7]. Urban population also affects the functions and services of the local and global ecosystems by creating pressures on the biophysical environment[8,9]. The interaction between cities and urbanization is destroying the natural habitats, reducing the biological variety, causing the extinction of some animal species and breaking the nutrient-energy-water cycle. In this case, the quality and quantity of urban ecological conditions are decreasing in contrast to urban citizen accept a high quality of life which including good public health, an unpolluted environment, good

†The part of sustainable ecological urban design of this study is presented in National Air Quality Symposium. In this article is added into assessment about air pollution values (SO_2 – PM_{10}) associated with the maps.

TABLE-1
URBAN POPULATION OF THE WORLD AND PERCENTAGE OF POPULATION RESIDING IN URBAN AREAS 1950, 1975, 2000, 2010, 2025 AND 2050

Urban population (millions)							
Major area, region, country of area	Note	1950	1975	2000	2010	2025	2050
World		729.317	1,511.414	2,837.431	3,486.326	4,535.925	6,285.881
More developed regions	a	426.930	697.885	869.233	929.851	1,013.700	1,099.730
Less developed regions	b	302.387	813.529	1,968.198	2,556.475	3,522.225	5,186.151
Least developed countries	c	14.684	52.694	167.181	249.442	438.242	914.370
Less developed regions, excluding least developed countries	d	287.703	760.834	1,801.016	2,307.033	3,083.982	4,271.781
Percentage of population residing in Uraban areas							
Major area, region, country of area	Note	1950	1975	2000	2010	2025	2050
World		28.83	37.21	46.40	50.46	56.62	66.70
More developed regions	a	52.58	66.66	72.74	75.16	79.37	86.24
Less developed regions	b	17.61	26.99	40.00	45.08	52.30	65.86
Least developed countries	c	7.32	14.73	24.68	29.17	37.58	54.65
Less developed regions, excluding least developed countries	d	18.97	28.64	42.45	47.90	55.38	68.88

Notes:
(a) More developed regions comprise Europe, Northern America, Australia/New Zealand and Japan.
(b) Less developed regions comprise all regions of Africa, Asia (excluding Japan), Latin America and the Caribbean plus Melanesia, Micronesia and Polynesia.
(c) The least developed countries, as defined by the United Nations General Assembly in 2001, including 49 countries, of which 34 are in Africa, 9 in Asia, 1 in Latin America and the Caribbean and 5 in Oceania.
(d) Other less developed countries comprise the less developed regions excluding the least developed countries.

Source: (Ref. 10), United Nations, Department of Economic and Social Affairs, Population Division, World Urbanization Prospects-The 2009 Revision, Data in digital form (POP/ DB/WUP/Rev. 2009).

food and safe drinking water, as well as possibilities for energy conservation in built environment[11].

The world population has been increasing rapidly in worldwide (Table-1; Fig. 1). Urban population was 224 million in the 1900s that has been reached to 2.5 billion in the last century by growing nearly ten times. The urban population rate was 14 % 1900s, that has been risen to 50 % in 1999. It's estimated that the world population will be 8.1 billion until 2030 and the 60 % of population will be living in cities as pressure of land. In this case, the world urban population will increase *ca.* 1.8 % each year which is nearly twice total world population.

Fig. 1. Earth's combined satellite image (http://img118.imageshack.us/img118/6966/dnya5tr.jpg)

Also in Turkey, population has been growing very fast. About 25 % of populations were living in cities during 1950s where the rate increased to 65 % in 2000 due to ongoing industrialization with impact of rural migration[12].

It is estimated that this rate will increase to 75 % until the year 2015. In the last census the country population was *ca.* 72 million and out of 72 million 46 million population (64 %) was living in urban areas. While 29 % of this rate is living in the five major metropolitans, 20 % is living in big cities.

In biophysical environment cause to presses due to rapidly increasing urban population. Therefore local and global ecosystem's function and serves are directly effected this reality[8,9]. This interactions are caused to fragmentation of natural habitats, reduction of biodiversity, elimination of some species, deterioration of food-energy-water recycles.

Rapidly increasing urbanization rates cause the accumulation of the pollutant parameters particulate matter (PM_{10}) and sulphur oxide (SO_x) in the city atmosphere. These parameters are produced by domestic heating, industrial power generation, emissions caused by motor vehicle and they increase the risk level of urban air quality for all living creatures since they are carcinogenic elements[13,14].

External media concentrations of SO_2 are high especially in the city centre and around the industrial areas. PM grain sizes show great changes according to their darkness, chemical composition and health effects. While the large PM is removed by the natural defence mechanism of the human body, the small PM (< 10 micron) is a carcinogenic pollutant which has an irritant and congestion effect on the lungs[15,16].

Sustainable ecological planning studies: The themes of the biophysical scientific studies which are aimed at reducing the human-centric pressures in urban landscapes focuses can be summed under topics such as urban-rural transitions, the relation between urban and natural patterns that diffuses in different morphological rates of buildings and urban population densities, how urban settlement affects natural cycles, the habitat functions in the city, collecting data about the structure of the habitat and the control of these data[8,9,17]. Conceptual framework of sustainable ecological planning, in a chain of relations based on the circular loop, can be summed in four basic frames which are the routers that shape the urban patterns, urban pattern itself, the use of sources and their reflections on the natural environment (Fig. 2). These concepts shape the built and human environment by directing the urban patterns as feedback with the changes in the rate of the carrying capacity of natural and human environment in the same planning period. At the end of the planning period, the carrying capacity of natural and human environment constitutes a basis for the sustainable planning with the changes in its rate, which occurs in a different systematic relation, but in the same cycle process.

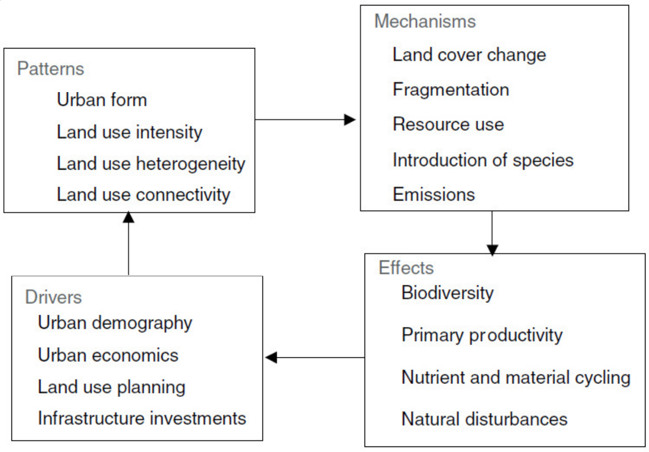

Fig. 2. A conceptual framework of sustainable ecological planning [Ref. 18]

Land use decisions in the traditional planning approaches are based on analytical studies and improved by optimising the socio-economic and environmental structure with the demand for the use of spaces. Different urban patterns that are formed depending on these development scenarios, with the use format in the natural patterns, affect the routers of urban patterns in the local scale as cyclic with effects such as especially the air pollution, bio diversity and human health.

In the metropolitan of Puget Sound (USA, Washington) a study examined the Sustainable Ecological Planning Components on differently chosen urban patterns examples and its parameters relating to the degree of urbanization can be briefed as follows[18]: the percentage of impermeable land use, building density, building story number and its morphological features, mixed-use components in the urban pattern, the percentage of open green spaces, the percentage of forest areas, topographic structure and the proximity to business centres. In the study, urban patterns from different intensity regions were chosen and it was also found that the very fragmented garden-structured single-family housings were more ecological than multi-family residential that consist of the housing groups such as apartment buildings or sites which cause less fragmentation in the natural patterns. The other outcomes of this study[18], mixed functional uses and large-scale trade zones were found less ecological than housing patterns. (Fig. 3). As seen in the Fig. 3, the outcomes of the study are introduced in a hierarchy from the least ecological urban pattern example to the most ecological one.

Fig. 3. Effect to the natural environment of urban patterns in the metropolitan of Puget Sound (ABD-Washington) [Ref. 18]

At the same time, it was found that the transport channels and node points that tie the urban patterns to each other create a high degree of stress on the natural pattern (Fig. 4). In the study, considering the habitat structure in the city and its functions, it is shown that the large volume of traffic networks and their intersection points that are used intensively disrupt the biological integration because of the wide use of vehicles linked to fossil fuel. So main urban roads and intersections are the least ecological urban patterns.

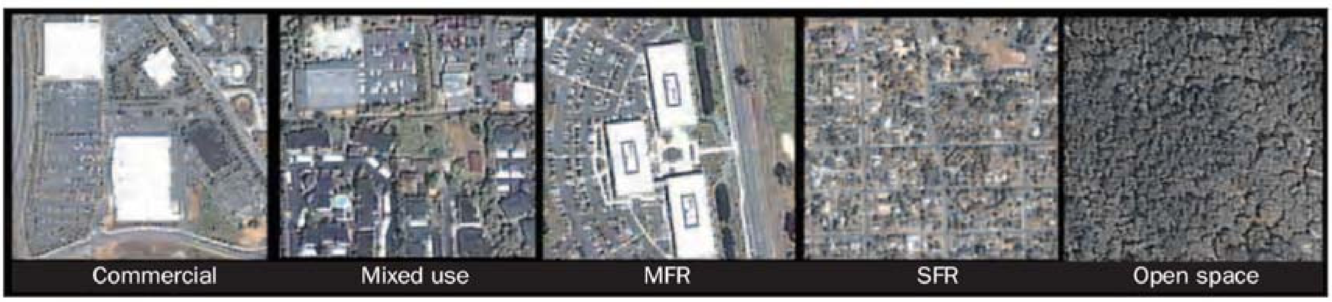

Fig. 4. Effect to the natural environment of urban patterns in the metropolitan of Puget Sound (ABD-Washington), [Ref. 18]

This regulation in the understanding of medieval towns with the human scale has passed to the planning literature as a case which is narrated in the sustainable city debate. On the other hand, the literature related to sustainable ecological planning define the optimum population density limits with different sizes[3] such as 90-120 people/ha and 225-300/ha. Researchers such as Newman accept the gross densities as 100 people/ha in the analysis of the comparison of world cities in terms of urban sustainability[19]. This value which is used as the density of rural character in Turkey is an appropriate ecological size since the use of vineyards and orchards especially in the city periphery has become widespread and the value forms a buffer zone in the transition from the natural environment into the urbanized environment. The density between 225 and 300 represents the appropriate ecological sizes for the city centres as the settlement density in the urbanized character.

The other environmental components of sustainable ecologic planning rather than its urban landscape components can be defined as the maximum-degree benefit from the natural source of solar energy, natural, topographic and the active use of land capability (land capability is a plan data relating to economical and visual quality in addition to the protection of landscape values). The arrangement of houses especially in the optimum sun angle is an environmentalist urban design input which contributes to the country economy by reducing the energy costs except providing natural heating and air condition. Also the active use of biophysical planning components provides important opportunities in the sustainability of sources, in providing the health and comfort of the human and physical environment and in the rational and environmentalist use of country sources.

EXPERIMENTAL

The method of the study is based on using the sustainable ecological urban design principles which are summarized according to literature as a catalyzer that will reflect the air quality-urban pattern relation. The ecological sustainability in the urban design scale will be defined analytically on four different urban- patterns which were chosen with systematic sampling method from the city centre of Konya. The sampling areas consist of housing estates that were chosen from two different regions adjacent to industrial areas, an old housing district in the central business district (CBD) and a less density housing estate placed on the western city periphery. This theoretical framework of sustainability will be evaluated with the air pollution maps of city in an integrated way. Another catalyzer is also the air pollution maps that were formed as to the data of Pollution Measuring Stations in Konya city centre[20] and these maps are placed in five different regions from the centre to the periphery in the urban area of Konya (Mevlana, Anit, Nalçaci, Meram and Özalkent). Aydin *et al.*[20] used the data of particulate matter (PM_{10}) and sulphur dioxide (SO_2) which belonged to the year 2006 and formed pollution maps with the help of GIS. Then, they interpreted these maps with the air quality conservation legislation (HKKY) in Turkey and Directive 1999/30/EC in EU, as well as WHO's air quality guidelines (AQGs). Therefore, this study was aimed to that sustainability of the macro form of the city of Konya in the top scale were evaluated with sustainable urban design principles at lower scale by measuring the parameters of air quality and health of ordering of existing built environment which affects health of other urban natural resources.

Findings on research area: The city, Konya is located at 36.5-39.5° north latitudes and at 31.5-34.5° east longitudes. It is the biggest city in Turkey with its 38.5 square kilometre area. The city's population is *ca.* 1000000 people as regards official records in 2009 and, the metropolitan central municipality sets the city centre with three central district municipalities (Table-2). The research areas are inclusive of fields in these four districts of Konya.

Sustainable Ecologic Urban Design Analysis of Konya City Center: Chosen sample survey regions in the research area which analyses ecological sustainability of different urban patterns aim to show the transition from urban periphery area to city centre and to define the relationship between urban patterns and natural resource which is scattered with different densities in the city. For this reason, sample regions are chosen from four different regions along the routing which passes from industrial areas (1st and 2nd region) through city centre (3rd region) and urban periphery (4th region) (Fig. 5).

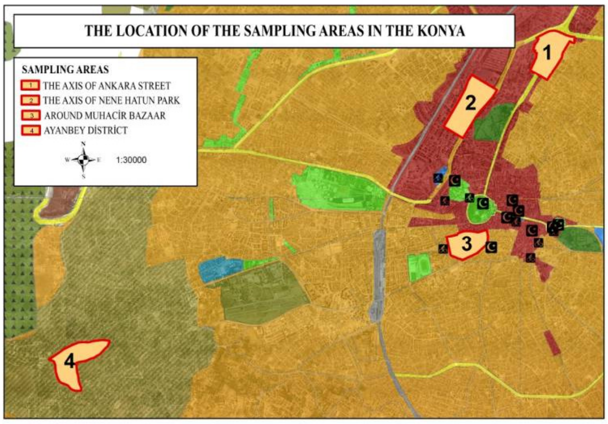

Fig. 5. Dispersion of working areas in the city

After grouping the region as ecological layers, each layer is criticized according to in its own ecological characteristics. The analysis sections are named as stated: The section which examines the exact densities according to buildings blocks is brown stage analysis, the section which criticize the energy use of dwellings according to the number of floors is red stage analysis, the section which examines the use and permeability of green area is green stage analysis and the section which shows the sun and wind orientations of dwellings is yellow stage analysis.

RESULTS AND DISCUSSION

First region: Hava Lojmanlari Residential Region: Ecological Sustainable Design Analysis of the Environment of Ankara Street: There is an industry region belongs to food and building materials sectors with big scale in the north of the survey area (Fig. 6). The research region where 14888 people lives is 24.2 hectares and the average population density of 615 people/ha dwell in the region.

TABLE-2
CHARACTERISTICS RECORDS OF KONYA CITY CENTRE

	Geographical characters	Topography and urban development (Ref. 21), (Ref. 22)	Natural Vegetation (Ref. 23)
Geography	Konya province lies at an elevation of about 3,370 feet (1,027 metres) on the southwest edge of the central Anatolian Plateau and is surrounded by a narrow, fertile plain. It is backed by Bozkır Mountain on the west and enclosed by the interior edges of the central Taurus ranges further south.	Konya city center is low-pitched lowland which has surrounded mountains and hills which are between 2050 and 1250 m in the east, north and north-west directs These elevations are natural threshold limits in growing of the city. Because there is no center of attraction which can cause growing towards the city near regions, growing of the city has been by means of growing inside its own structure. The south-western part of it has been redesigned and a wide avenue leads through the western suburbs to the railway station, but the old city still survives to the east of the acropolis.	Central Anatolia is in the Iran-Turan Region floristically. There are this region's elements both in step vegetation and also defective slope and crests. In only the down region of campus, 222 taxons which belong to 37 families and 155 types are identified. Iran-Turan elements are placed on the top with the average of 60 per cent in terms of dispersion of types to floristic areas. Europa - Siberia elements is 7 %. 15 % of the plants in the region is endemic.

	Developing of urban along the historical era	Monumental buildings
History	Archaeology shows that the Konya region is one of the most ancient settlements of Anatolia. The results of excavations in Catalhöyük, Karahöyük, Cukurkent and Kucukoy show the region was inhabited as far back as the Neolithic Period (Late Stone Age) of BC 7000. Other settlers of the city before Islam were; the Calcolitic Period (Copper Age) civilizations, Bronze Age civilizations, Hittites, Phrygians, Lydian's, Persians, Romans and finally Byzantines.	Ince Minare (Thin Minaret) Medreseh and Karatay Medreseh from 12th century, which were a theological and technological primary school used as tiles museum today, Alaaddin Keykubat Mosque from 12th century. Alaaddin Mosque from 12th century and Ince Minare (Thin Minaret) Mosque are great prayer spaces which are famous of Seljuks Era. Other important mosques at the center of Konya are Iplikci Mosque, Sahip Ata Mosque and Complex, Sadrettin Konevi Mosque and Tomb, Sems-i Tebrizi Mosque and Tomb. St. Paul Church was constructed in 1910 by priests "de l'Assomption" who came here to spiritually assist the families of the French community working in the region.

	Temperature	Precipitation	Wind	Relative humidity
Climate	According the data which is registered since 1929, the highest temperature is 40 ºC (August) and the lowest temperature is -28.2 ºC (January). The temperature difference in the summer nights is 15 ºC. The highest difference is 27.6 ºC (October), (Ref. 21). Annual sunshine duration is 7 h and 20 min on average; average light intensity of sun rays in the city centre is 419, 73 calories per minute a square centimetre	Approximate precipitation is annually 317 mm. The most of rainfall has been in the months of May and December. High and rough topography in the west receive more rain than lowland. The least amount of precipitation in August (0 mm) and the most amount of precipitation is in October (66 mm),	Dominant wind blows from north and the fastest wind blows from the south. Dominant wind's velocity is very low (Average: 2.6 meter/second)	Relative Humidity is least in July and August (Average. 42.6 %), the most in December and January (Average: 76.2 %) in Konya

	Year	1970	1980	1990	2000
Population	Population	200760	329139	513346	742690

	Agricultural sector	Agricultural sector	Service sector
Economy	Especially, the economy of Konya province based on wheat farming agriculture. Turkey's wheat warehouse is considered. 75 % of active population belongs to agriculture, hunting, fishing, hunting and forestry. 40 % of annual gross income is derived from agriculture. At to the land use of Konya province it has got a little more than 90 % of arable land. The main agricultural products are wheat, sugar beets, sunflowers, potatoes and onions. Animal husbandry is a great importance in Konya, too. Sheep, angora goats and cattle are fed. Beekeeping has been developed.	The agriculture-based industries is developed in Konya. Continues to develop. Industrialization has accelerated after 1960. Yet until 1960 except for a few factories in Konya had flour mills. The business number of employees more than 10 people in Konya are 300. Food industry, cement industry, aluminium industry, mining industry, packaging industry, garment industry is so advanced in Konya.	Konya, on account of the population size of our countries is 5th range size, after from Istanbul, Ankara, Izmir and Bursa. The seven companies in Konya, Turkey takes its place among the 500 largest companies. It has got 4 university. Two of them are State University. For example Seljuk University has got 85 000 undergraduate.

The lowest total dwelling area density belonged to Hava Lojmanlari building block with 250 people/ha in the area. The regions in the south west neighbourhood in yellow colour which in the ecological density border line follow the block which is shown with yellow in the brown layer analysis. The blocks which are the darkest brown in legend are the lowest ecological boundary value in terms of density. This region generally concentrates on Ankara street. In the region the most widespread density is 1000-1250 people/ha. This value is over ecological border line and 7 times more than optimum density.

According to the red layer analysis which evaluates the number of storey and the gaps around the dwellings, the most ecological structure group in the 1st region is the three-storey dwellings in the Hava Lojmanlari building block (Fig. 7). The most widespread block height is 10-12 storied in the region and these buildings with their altitude of 36 m affect thermal comfort negatively by changing micro climate (increase in temperature in summer, more wind intensity in winter). And also, because these blocks are stated along Ankara street in the direction of dominant wind and the green area corridor at the amongst building blocks, these buildings cause to produce harsh winter wind by functioning as wind corridor. As there is no buffer green zone between industrial zone in north and these building areas, the particular matter which is produced

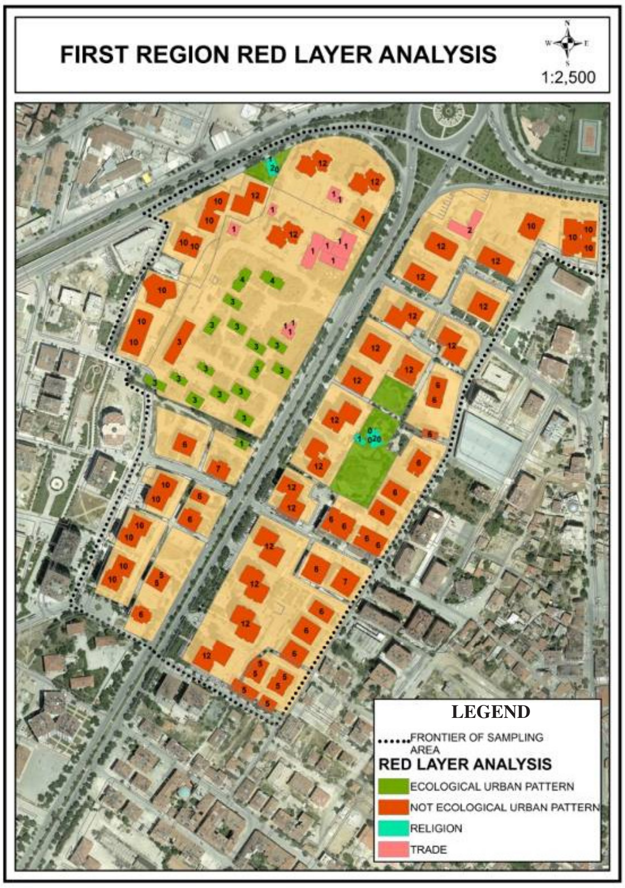

Fig. 6. 1st region red layer analysis with the axis of Ankara street

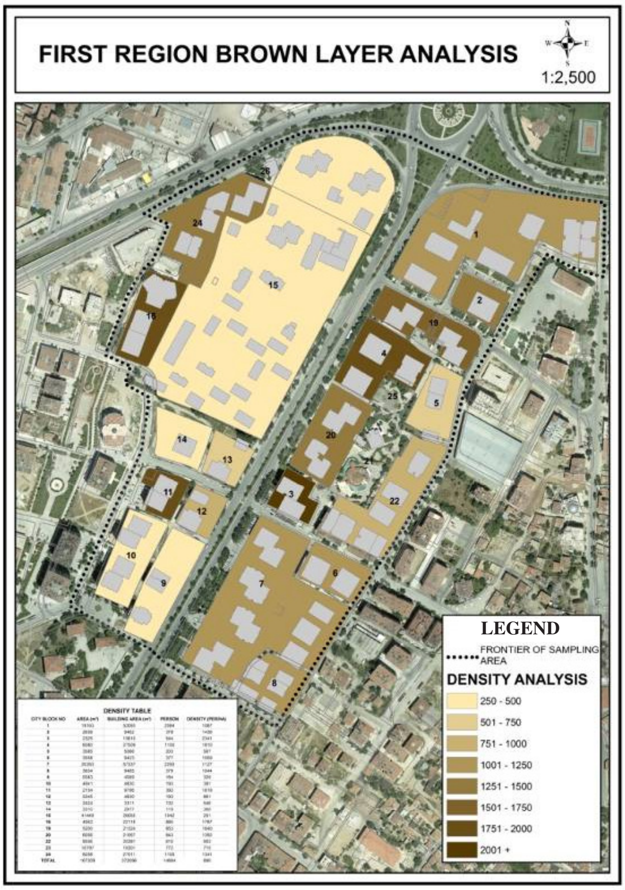

Fig. 7. 1st region brown layer analysis with the axis of Ankara street

in this region contribute air contaminants like CO_2 to reach the city centre.

65 % of the first region survey area is nonpermeable and this area includes buildings, pedestrian and transportation arteries with asphalt laying and car parking areas (Table-3), (Figs. 8 and 9). 35 % of total area is green area; 3 % of this area is public and the rest is personal use of green area (Figs. 10 and 11). 5 m^2 green areas are per person. When the insulation of the blocks is evaluated in the direction of their main axises, the most ecological buildings are yellow and orange ones in terms of storey height and distance amongst them (Fig. 12).

TABLE-3
LAND USING IN FIRST REGION WITH THE AXIS OF ANKARA STREET

Sizes of sampling area		
Land using	Area (m^2)	Percentage (%)
Building	44974.8	18.6
Mixed use	12472.6	5.2
Hard ground	98121.5	40.6
Public green	7222.8	3.0
Private green	75679.8	31.3
Trade	2613.8	1.1
Religion	780.3	0.3
Total	241865.5	100.0

Fig. 8. 1st region green layer analysis with the axis of Ankara street

Fig. 9. A part of 1st region satellite image from ecological Hava Lojmanlari dwells

Fig. 10. A part of view of 1st region photographs: Cigdem Ciftci Personal Archive, 2009

Fig. 11. A part of view of 1st region photographs: Cigdem Ciftci Personal Archive, 2009

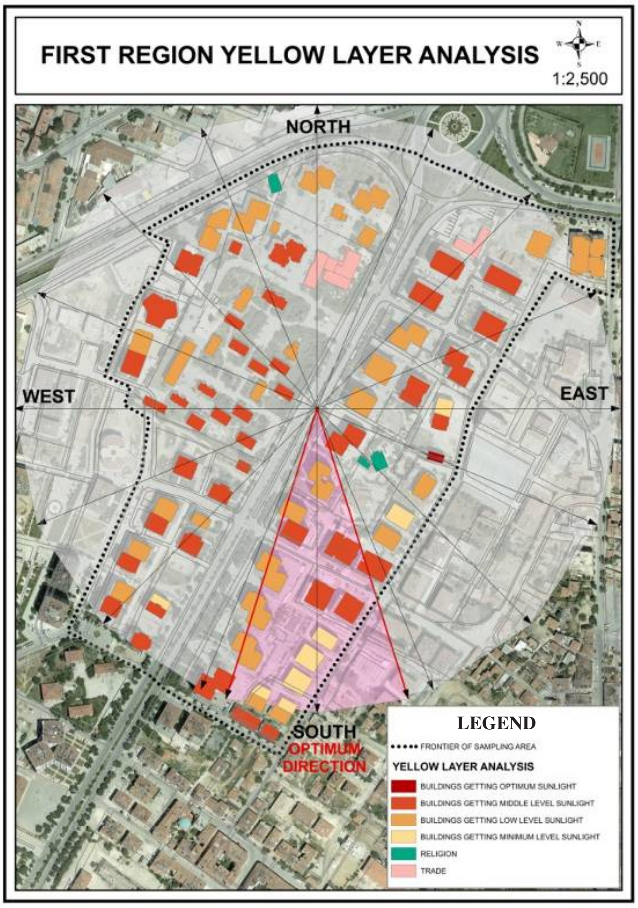

Fig. 12. 1st region yellow layer analysis with the axis of Ankara street

Approximately 15 m area is allocated for side garden between the 12 storied (36 m in height) dwelling blocks. Although the buildings have frontage with the 17. 5 angle from south axis to south west and south east are ecological, they receive light in a low level because they do not provide the minimum garden gap of 54 m.

Second region: Ecological Sustainable Design Analysis of the Environment Nalçaci Street Nene Hatun Park: The second research region where 21382 people lives is 29,3 hectares and the population density of 730 people/ha dwell in the region.

The block which has the least density in the analysis area is building block with the number 10 in the north east with the density of 703 people/ ha and its ecological density border is over 300 person per ha (Fig. 13). Other regions also do not have the quality of ecological sustainability according to the brown layer analysis. When the brown layer analysis is followed, it can be seen that the densest dweller regions is located at intersection of Nalçaci-Sille in the south-east and south-west of survey area and secondly also in the north-east of the study region, adjacent to the south to the 17 storied Tower Business Centre.

According to red layer analysis storey height in the region is averagely 10-storey (Fig. 14). The 11 storeyed dwellings which are parallel to Nalçaci Street contribute to urban wind corridor. As to the number of storey, the most widespread 13 storied blocks affects the thermal comfort negatively by changing the micro climate especially in the summer months.

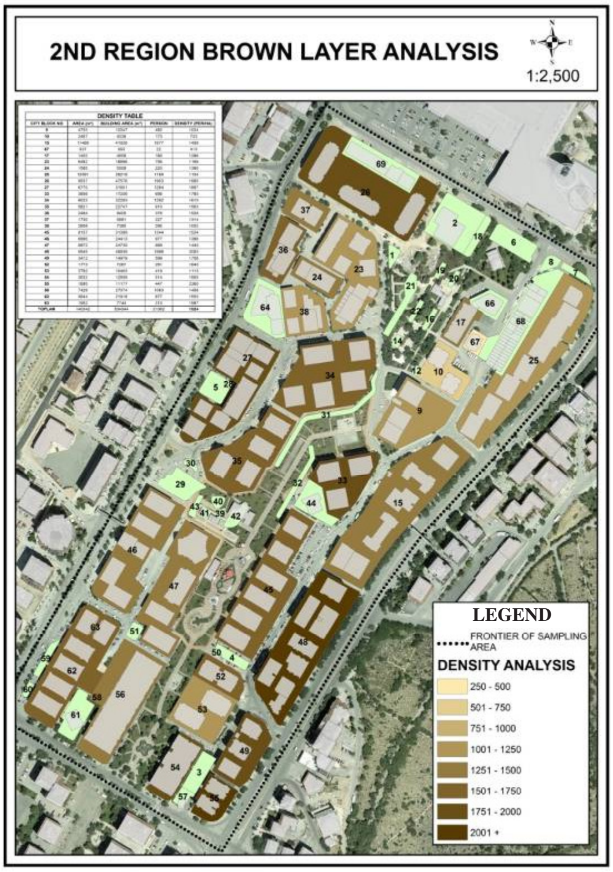

Fig. 13. Brown layer analysis of the first stage with the axis of Nene Hatun Park

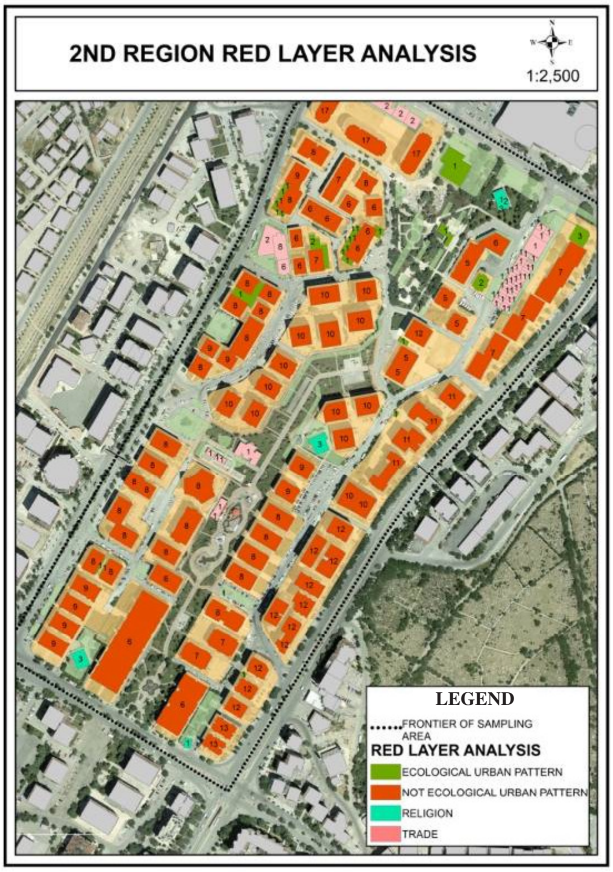

Fig. 14. 2nd region red layer analysis with the axis of Nene Hatun Park

The ratio of open green areas is 41 % in the region; 14 % of them are public green areas (Fig. 15, Table-4). There is 6 m^2 green area per person in the construction housing estate. Because green area use is for the sake of a dense population use, current area cannot provide the standard of 7 m^2 per person at least.

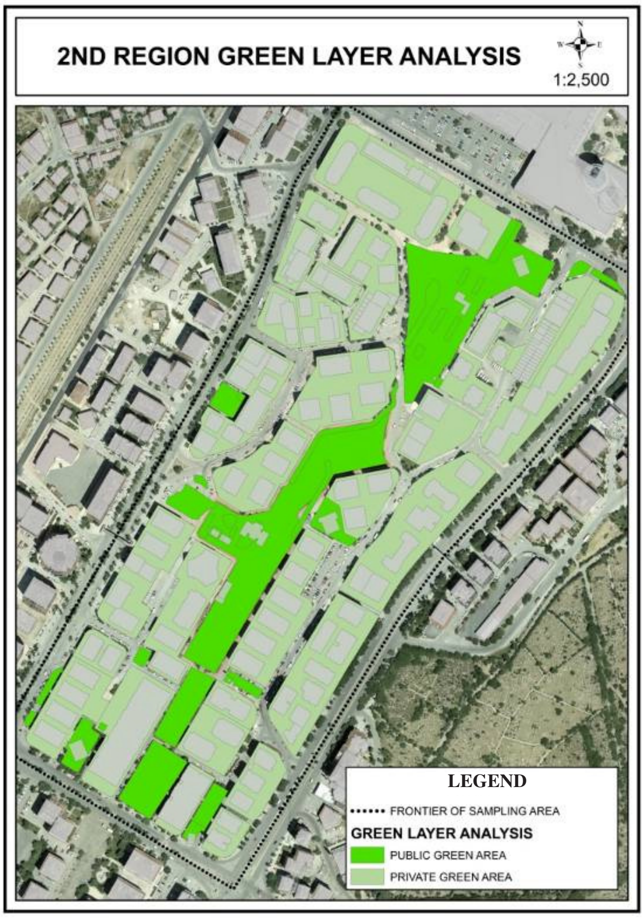

Fig. 15. 2nd region green layer analysis with the axis of Nene Hatun Park

TABLE-4
LAND USING IN 2nd REGION

Sizes of sampling area		
Land using	Area (m^2)	Percentage (%)
Building	13333.7	4.5
Mixed Use	51535.6	17.6
Trade	5907.8	2.0
Hard ground	100914.0	34.4
Public green	40079.4	13.7
Private green	80228.7	27.4
Religion	1149.7	0.4
Total	293149.0	100.0

Nene Hatun Park with approximately its 50 m width provide for good insulation to builds in the middle of building blocks (Fig. 16). But the distances for side gardens in the buildings at the same frontage line as each other are *ca.* 12 m and this is very under the minimum border of 54 m which is a limit value. Although the12-13 storied blocks which have the south east in Nalçaci Caddesi, as they do not have the minimum distance condition, they cannot get enough sun. The 17 storied

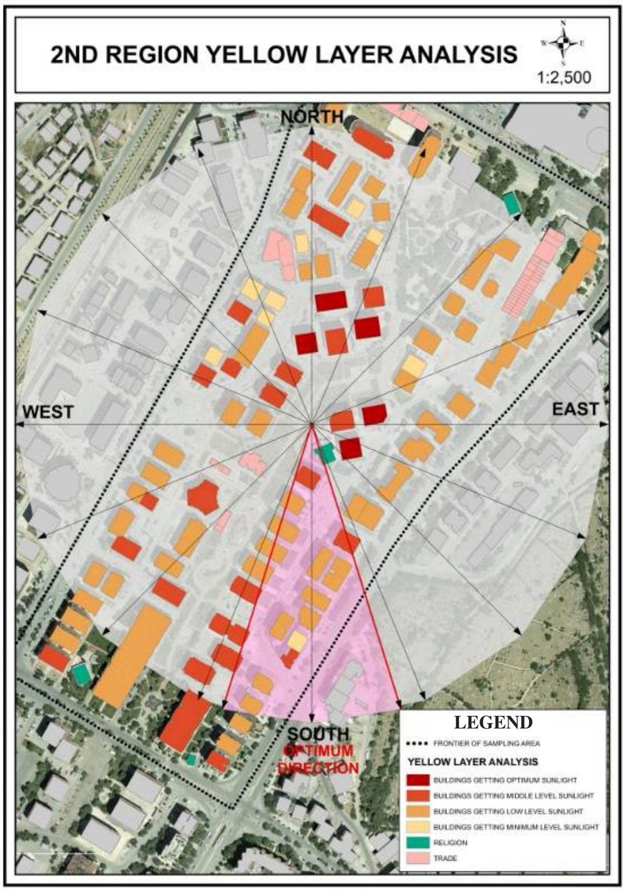

Fig. 16. 2nd region yellow layer analysis

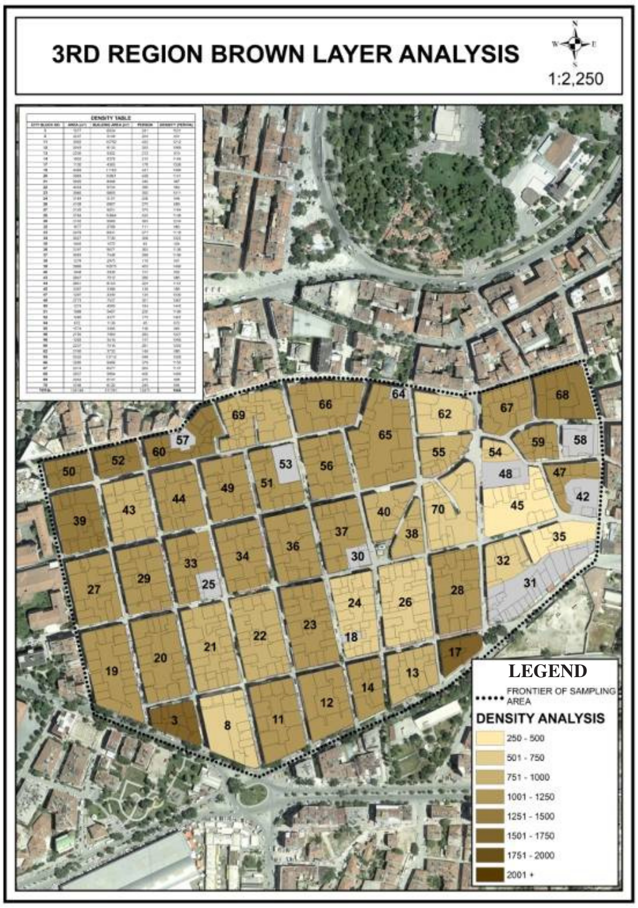

Fig. 17. 3rd region brown layer analysis around Muhacir Bazaar analysis

blocks in the North West cannot receive day light because there is not also enough distance between blocks and blocks cause to shadows with wide-field.

3th Region: Ecological sustainable design analysis around Muhacir Bazaar: The third survey area is located in the south of Alaeddin Hill where is an Archaeological and Natural Sites. This residential area is 17,66 hectares and at the research area accomodates 12471 people with the density of *ca.* 736 people/ha (Table-5), (Figs. 5 and 17). The number of building block are 35 which has the least density with 324 people/ha and has the characteristic of ecological sustainable region. But as a result of the fact that sampling area is very near to the traditional city centre, the ages of buildings are *ca.* 50-60. Other sampling blocks, except for 35th building block, do not have the characteristic of ecological sustainability.

TABLE-5
LAND USING IN 3rd REGION

Sizes of sampling area		
Land using	Area (m^2)	Percentage (%)
Building	81259.9	46.0
Mixed use	11604.3	6.6
Trade	3453.2	2.0
Hard ground	41542.8	23.5
Public green	4113.2	2.3
Private green	33100.8	18.7
Religion	475.1	0.3
Administration	263.5	0.1
Primary school area	811.6	0.5
Total	176624.4	100.0

The average of storey height in the research area is about 3 storey (Fig. 18). Dwellings that are parallel to the streets in direction of dominant wind contribute to the urban wind corridor. 3-5 storied buildings are opening to the streets whose amples are *ca.* 7 m. Despite being few storied, ground floors cannot receive sun because street amples are under 10 m which the due standard.

21 % of the area is allocated as green area and 2.3 % of this is for public use (Fig. 19). In this green area there is 3 m^2 for each person and this is very under the minimum green area standard which is 7 m^2.

Because blocks-without garden-which are opening personal close backyards have the frontage to narrow streets (7 m), ground floors which do not receive light are disadvantageous (Fig. 20). Ecological building groups in the area stated along the Larende street, except for single storey trade zone, are the flats over the ground floor that has frontage to south.

4th Region: Ecological sustainable design analysis around Ayanbey District: This region stated in the city border saves its natural character substantially (Fig. 5). Sampling area which has 26.74 hectares accommodates 1133 people with the density of *ca.* 42 people/ha. So, all the dwelling blocks in the area have the ecological density. All the single storied dwellings which have 0.10 Floor Area Ratio and are with garden have the ecological character (Figs. 21 and 22). 86 % of the area is allocated for green area use and 5 % of this ratio belongs to public and the rest belongs to private use (Table-6) (Fig. 23). 190 m^2 green area is per person.

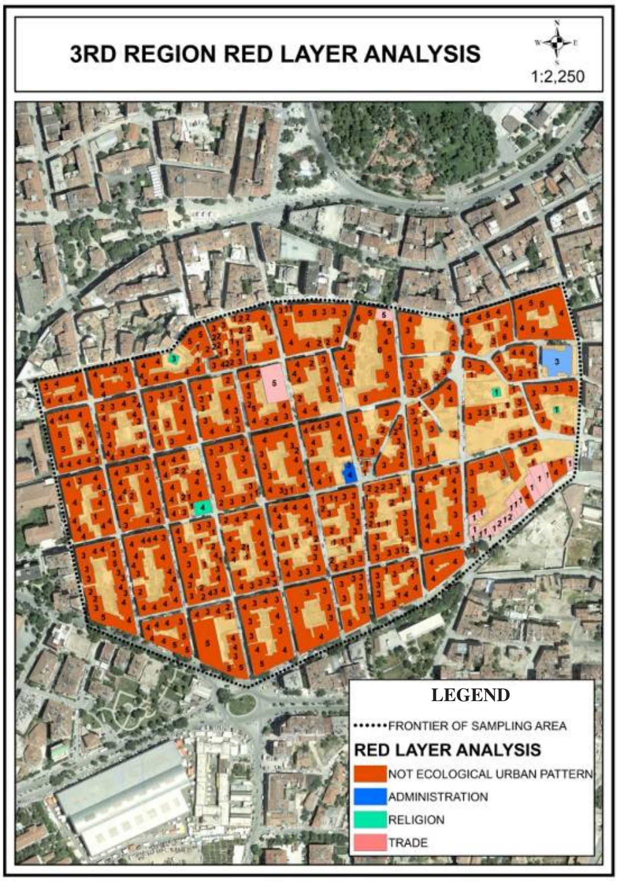

Fig. 18. 3rd region red layer analysis

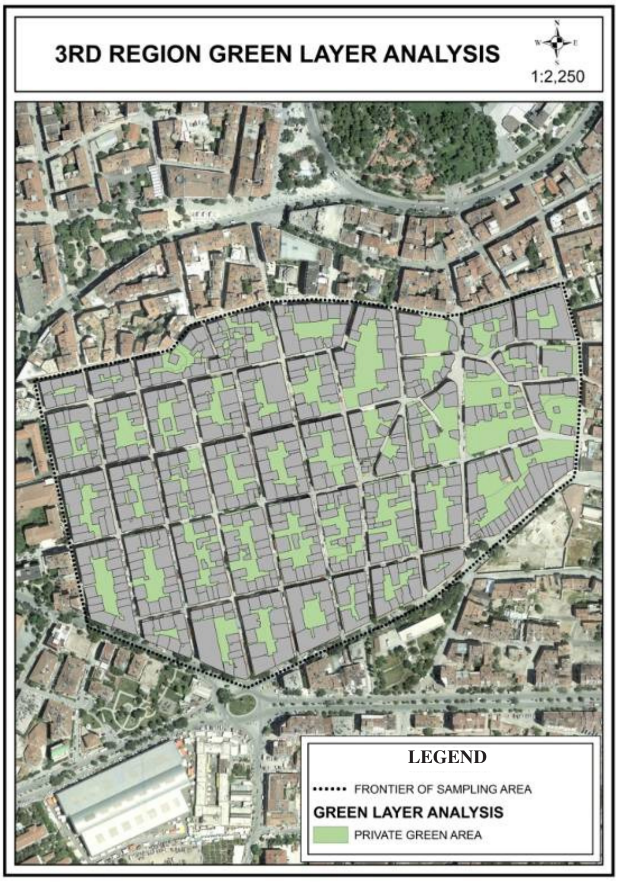

Fig. 19. 3rd region green layer analysis

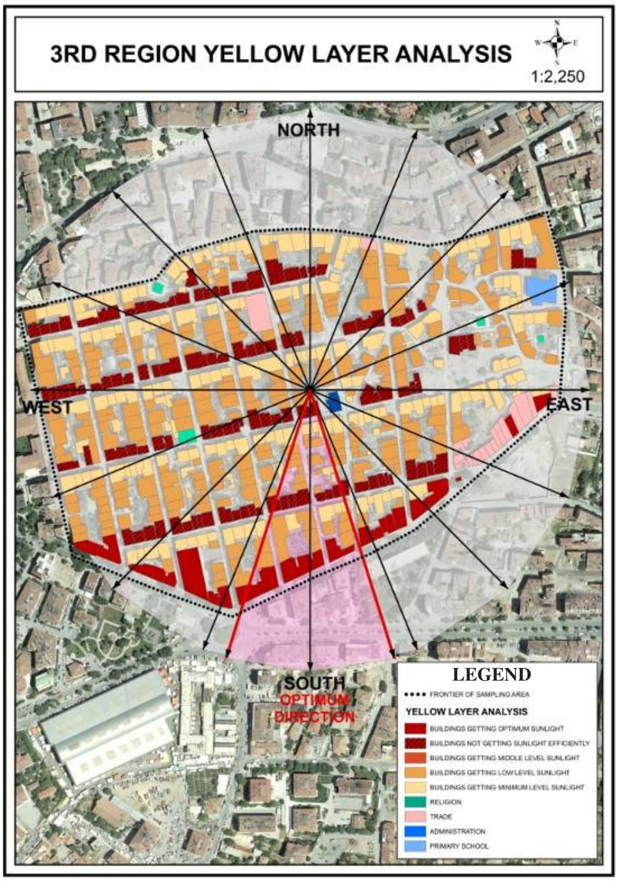

Fig. 20. 3rd region yellow layer analysis

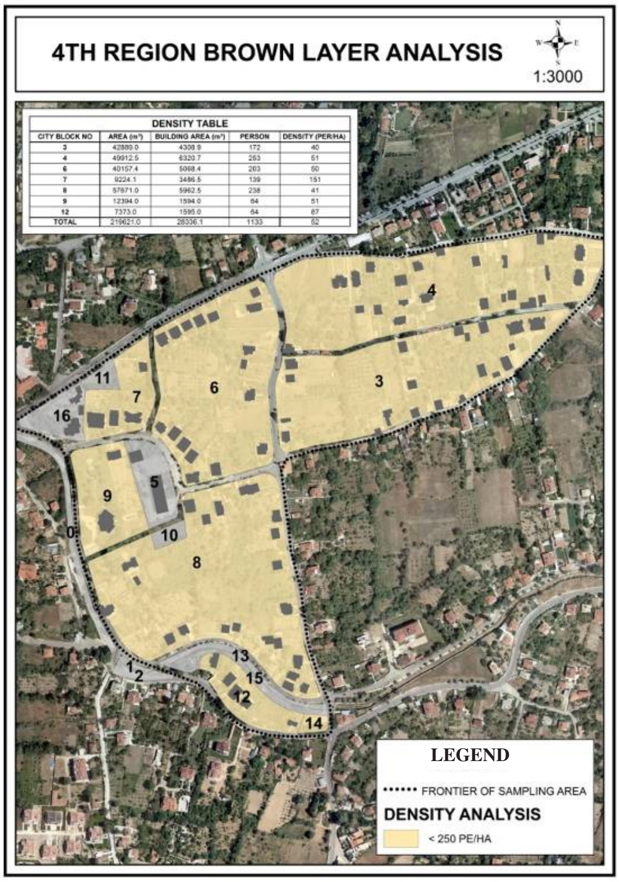

Fig. 21. (Ayanbey District) 4th region brown layer analysis

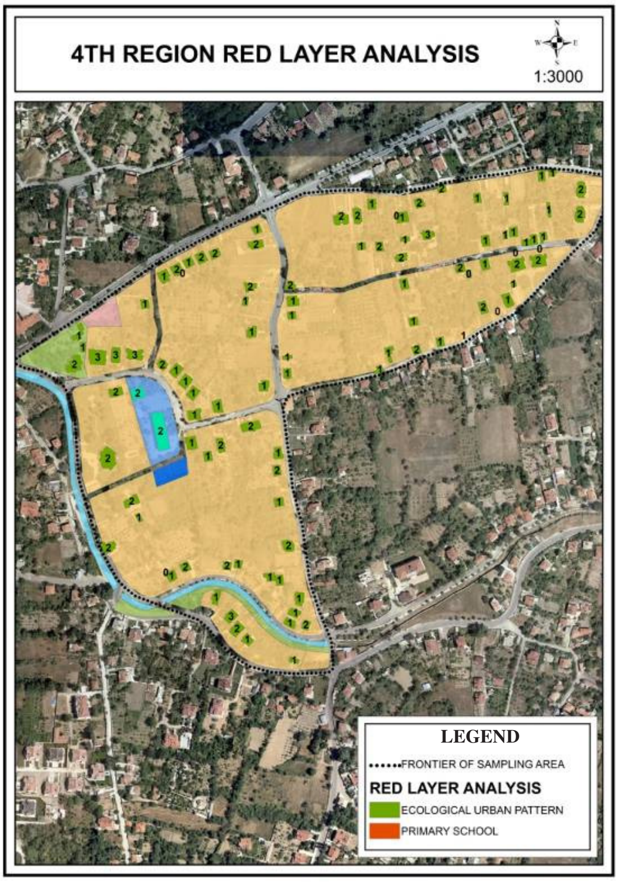

Fig. 22. 4th region red layer analysis

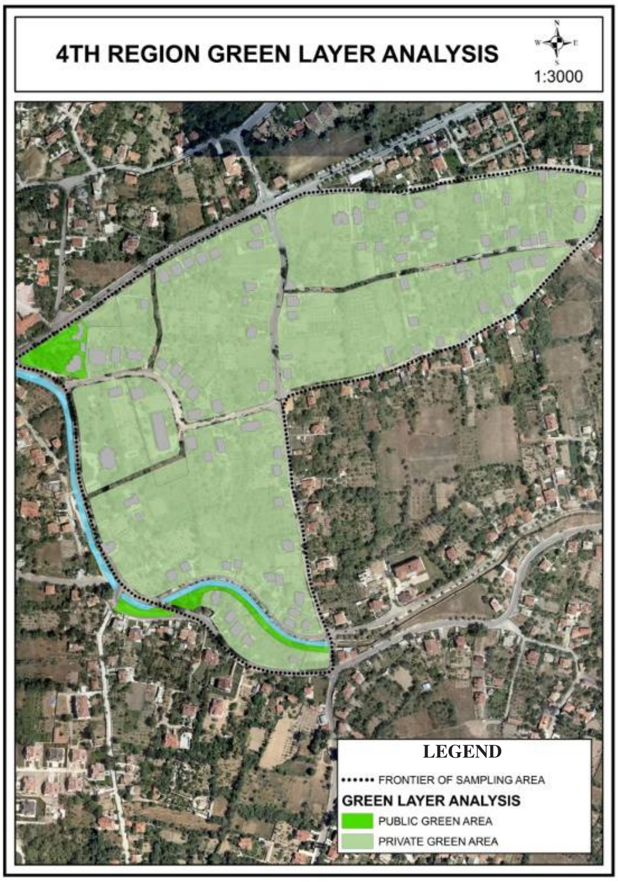

Fig. 23. 4th region green layer analysis

TABLE-6
4th REGION LAND USE SIZE

Land using	Area (m^2)	Percentage (%)
	Sizes of sampling area	
Building	19050.9	7.1
Hard ground	29207.4	10.9
Public green	12373.1	4.6
Private green	202497.6	75.7
Trade	1445.8	0.5
Primary school area	1185.1	0.4
Small rivers	1969.8	0.7
Total	267458.5	100.0

Because the area is single storied and with individual garden, other buildings, except for the ones in the same frontage line in the direction of north west and south west, has the ecological character in terms of insulation (Fig. 24).

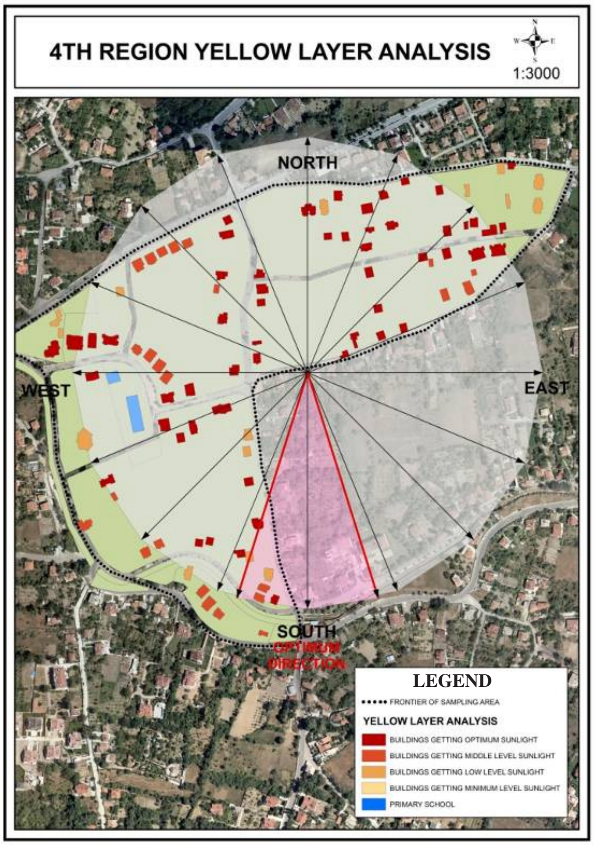

Fig. 24. 4th region yellow layer analysis

Comparison with pollution maps and quality parameters (EU, WHO, Turkey air quality standards): Aydin *et al.*[20] have reported field survey in five stations which are measured the air pollution in Konya with GIS. The four regions, which fit with the four of five stations, are criticized in this work in terms of ecology except for Ozalkent. According to that, annual approximate values of SO_2 (between 2004-2006) defeated the 20 μg/m^3 which belongs to the EU's the Longest Term Border Value (LTBV), (Fig. 25). In Nalçaci and Muhacir Bazaar regions which are the second and third regions in the work, annual *ca.* SO_2 value defeated 50 μg/m^3 which belongs to the WHO's the LTBV. The same problem has continued in the environment of first region.

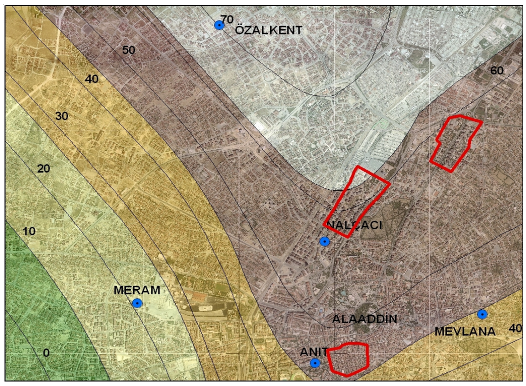

Fig. 25. Approximate SO_2 concentration pollution map in 2006 (μg/m^3)

As can be seen in the Fig. 26 PM_{10} values except for Meram region defeated the 40 μg/m^3, LTBV value determined by EU. It is seen that around first region and second region annual approximate PM_{10} value has defeated 60 μg/m^3, the LTBV value in the Turkey Air Quality Regulations.

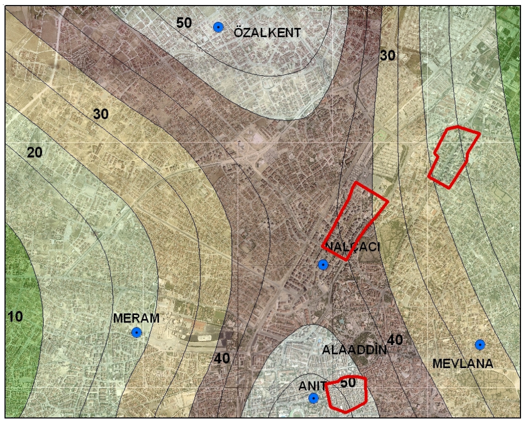

Fig. 26. Approximate PM_{10} concentration pollution map (μg/m^3)

Conclusion and evaluation

4th Region is ecological in terms of insulation, green area standard, permeable field ratio, criteria of structure and population density. This situation arises from the fact that the area is saved legally by the status of natural site area. In terms of PM_{10} and SO_2 ratios, Meram region is under critical values and does not have risk. First, second and third regions in the city center have the PM_{10} and SO_2 ratios over the Turkey Air Quality Regulations, WHO and EU Air Quality Border Values. SO_2 among them stems from coal burning and vehicle emission. On the other hand, the configuration concept which does not conform to the principles of sustainable urban design cannot get rid of air pollution. The contrary components to sustainable design criteria which are fixed after analysis; that they do not have chance to make use of natural sun energy because of dense configuration, that green area supply has low standard because of very few permeable fields, that gardens and backyards are used as parking area, that a lot of people use heating system with stove because people live in 3rd region belong to middle income class. For these reason, in first, second and third regions are possible to see that in the still terms when the air pressure is high, air pollution is seen by smog at the stagnant period in the winter. In these problematical regions, increasing vegetation density, providing with public encouragements about use of natural gas and renewable energy, attaching priority to public transportation, taking precaution to decrease traffic density in the large main roads which are wind corridor between industrial area and city centre (planning alternative routings), allocating areas in the city centre to open space use and appointing these areas with appropriate local vegetation must be among the indispensable plan application aims of local governments in Konya metropolitan municipality.

Depending on the implementation of sustainable urban design principles will be provided as well as effective saving in urban energy use and urban air quality will be in livable value.

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