

08

AN URBAN DESIGN PROJECT IN GAZIANTEP, TURKEY ON AIR QUALITY: THE "CITY IN NATURE, NATURE IN CITY" CONCEPT

Ahmet Hakan Biçkici¹, Sevcan Güvenç¹ & *Kivanc Ertugay²

¹ Department of Urban and Regional Planning, Faculty of Architecture and Design, Konya Technical University, Konya, Turkey

² Department of Urban and Regional Planning, Faculty of Architecture, Akdeniz University, Antalya, Turkey

ABSTRACT

This research described an innovative urban design project of Gaziantep province. The research brings out a creative nature-oriented solution approach to combat issues of air pollution experienced in major cities worldwide. A Spatial Strategy Plan prepared for Gaziantep city includes a sub-regions where the critical parts of the urban design process are elaborated. The crucial point that distinguishes the work from other urban design-related research is that the fundamental principles of the project were inspired by nature - lotus flower (water lily), dragonfly, beetle, butterfly (butterfly effect) and the Yin Yang philosophy. The creation of the main theme and the setup process of the urban design project is carried out in several stages inspired by Nature.

The hypothesis of the research using Nature as inspiration is to provide an alternative approach to resolve the problem of air pollution found in dense cities through macro and micro level of control in planning and urban design. The research had successfully identified nature inspired solution to the problem through literature review, observation and 3D simulation. The success of this project will inspire more researchers working in the field of urban design to have more research inspired from nature for a successful outcome.

Keywords: *Urban Design, Air Pollution / Low Air Quality, Inspiration from Nature, Nature oriented solution, lotus flower (water lily), dragonfly beetle, butterfly, butterfly effect, Yin Yang philosophy*

*Corresponding author: kivancertugay@akdeniz.edu.tr

INTRODUCTION

With the Industrial Revolution, the development efforts of cities worldwide to be globalised in the last century, have caused natural elements of urban spaces to be relentlessly ignored. Many natural factors such as the sun, climatisation, dominant wind direction and other natural elements in the built environment were generally ignored or were not given sufficient consideration during the urban planning and design process. The existing urban design process, over time, results in low-quality urban spaces.

Poor air quality, which is a problem of many worldwide cities, also emerges as one of the primary problems of many Turkish cities. A similar problem affected Gaziantep city (Figure 1).

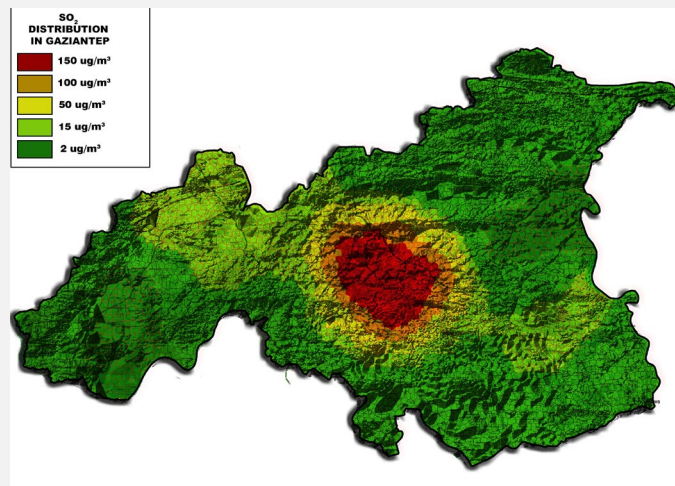


Figure 1: SO2 Distribution In Gaziantep (URL1)

Implementation of urban design processes that are not "compatible with nature" or, in other words, "in harmony with nature" had cause low-quality living spaces in terms of air quality in many cities. Can Nature inspire the way of creating or designing cities with no air pollution? This research, inspired by Nature, thus hypothesise that the solution of most problems we experience in cities may be hidden in Nature. In this context, this research focused on the planning and design process with inspiration from "Nature" in the city of Gaziantep to prevent air pollution. Gaziantep is located on the historical Silk Road (Figure 2) in the centre of Mesopotamia, which hosts the world's first settlements.

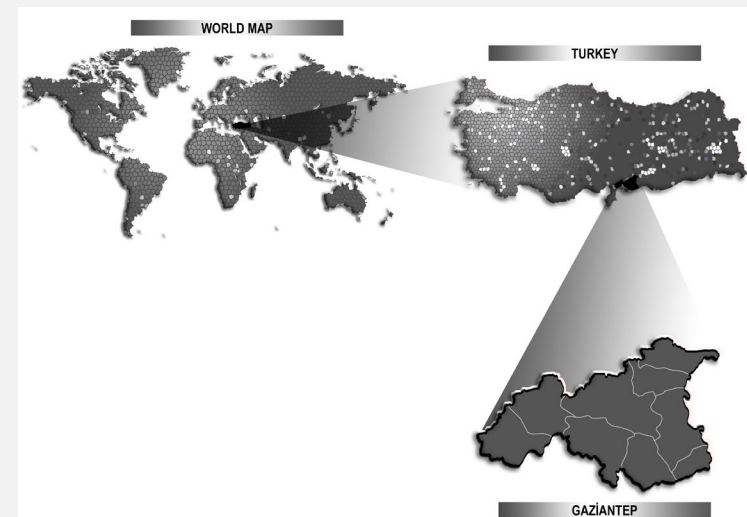


Figure 2: Gaziantep's position in the world and in Turkey

Gaziantep is located in the Southeastern Anatolia Region and has a surface area of 7642 km². As of 2019, with a population of 2,069,364 it is one of Turkey's largest 30 cities. Due to the continually increasing population in the urban area, environmental problems are therefore commonly observed mostly in the city centre (Çetinkaya, 2013). Factors such as the use of non-renewable energy resources, heavy traffic vehicles and presence of large industrial areas had caused a decrease in the air quality in the city (Şahin, 1989'dan Akt. İbret & Aydınözü, 2009).

Considering the short and long term problems caused by air pollution, a solution-oriented Spatial Strategy Plan was prepared in Gaziantep. After defining the macro scale strategies, the urban design project implemented in an area of 40 hectares in the city centre, which covers the most critical locations of the city, where both the population and vehicle density is the highest, and the air pollution parameters are highly concentrated.

The urban design project inspired by Nature came with the idea that air pollution emerges as a result of rupture from Nature and that the solution can also be found within the design solution inspired by Nature.

METHODOLOGY

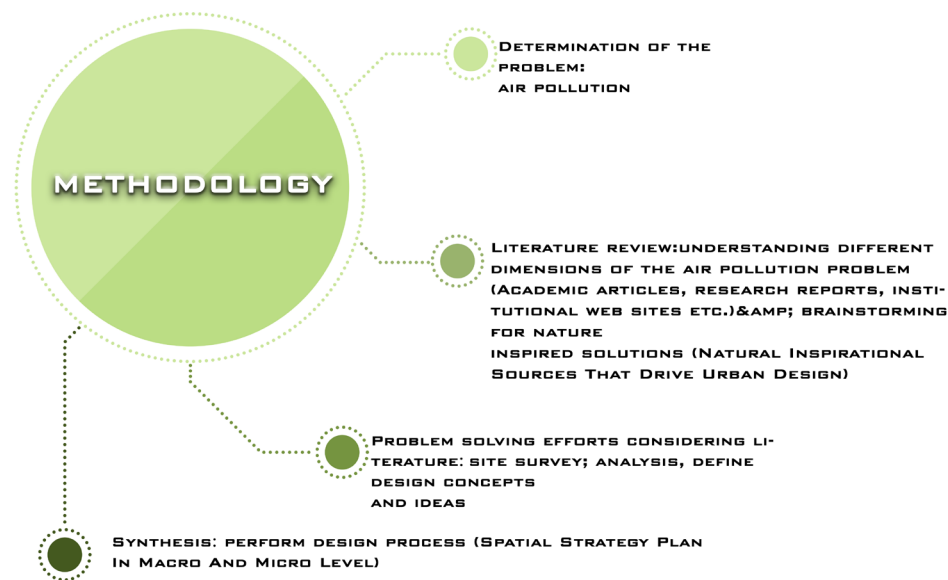


Figure 3: The methodological structure followed in the execution of the process

In the light of the above-defined air pollution problem, the research started with understanding the key factors that cause air pollution and how to eliminate it. The research continues with creating strategies at the regional and urban level to improve the air quality in the short/long term, which help to increase the living standards in Gaziantep city (see Figure 3).

While conducting this research, many works of literature, both global and local scale (Academic articles, research reports, institutional web sites and others.) discuss the different aspects of the air pollution problem, is analysed. The analyses were to improve the knowledge and awareness of problems of air pollution. Among the findings are (i) the leading causes of air pollution; (ii) measures taken against air pollution; (iii) heating methods in residential areas; (iv) the effect of housing and industry on air pollution; (v) the effect of transportation on air pollution; (vi) air pollution based on vehicle density and traffic-related pollution levels (Cuci & Polat, 2015); (vii) the boundaries of urban areas and their effect on air pollution; (viii) air pollution parameters (NO_x, SO₂, PM_{2.5}, PM₁₀); (ix) global clean cities and more.

Table 1 informed the primary sources and effects of pollutant parameters on human health. In this context, the pollutants caused by human activities seriously threaten human health, such as respiratory diseases and heart problems which causes severe deaths.

Table 1: Pollutant Parameters and Their Health Effects, URL2, Prepared by the authors.)

POLLUTANTS	MAIN SOURCE	HEALTH EFFECT
SULFUR DIOXY	FOSSIL FUEL BURNING	RESPIRATORY
NITROGEN AUXINS	VEHICLE EMISSIONS	ACID RAINS
PARTICULATE MATTER	CHEMICAL REACTIONS	CANCER AND HEART DISEASE
CARBON MONOXIDE	MISSING COMBUSTION PRODUCT	DECREASE IN OXYGEN CARRYING CAPACITY
OZONE	NITROGEN AUXINS	ASTHMA

Figure 4 also describes the main natural and artificial factors affecting air pollution in Gaziantep province. While some of these factors directly affect the air quality, some of them also affect indirectly.



Figure 4: Factors that affect air pollution in Gaziantep Province (Prepared by the authors, 2019)

According to the results obtained within the scope of KentAir Project conducted for Gaziantep province, the most important parameters that cause pollution in Gaziantep are SO₂, NO₂ and PM₁₀ (refer Figure 5). Based on the graph, the pollution rate of SO₂ is higher than PM₁₀ and NO₂. While the reasons for the formation of PM₁₀ and SO₂ are based on heating and industry, NO₂ is a pollutant caused generally by traffic.

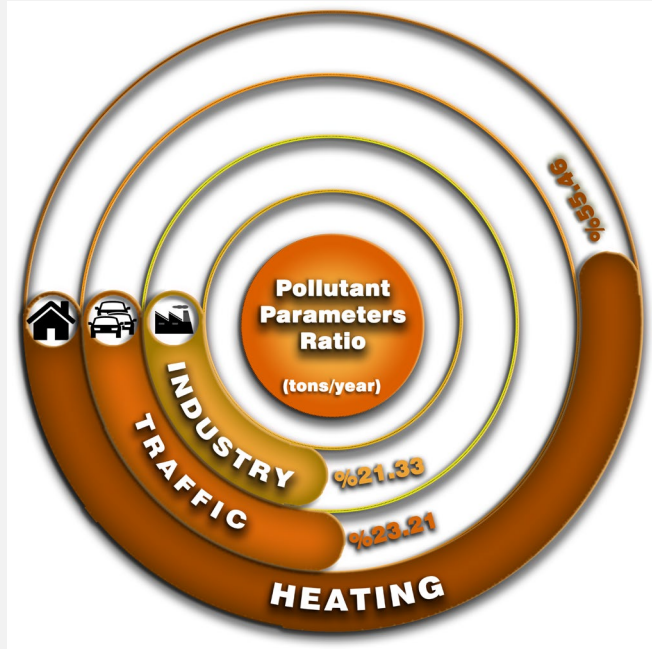


Figure 5: Gaziantep City Center Pollutant Parameters Ratio (Gaziantep Municipality, Environmental Protection and Control Department, KentAir Project, 2017)

Moreover, in-depth investigations, spatial analyses and face-to-face interviews (with public and relevant authorities) are also conducted on the field in Gaziantep between 21.10.2019 and 27.10.2019.

Some of the significant information obtained as a result of face-to-face interviews in Gaziantep is briefly shared below;

- One of the important periodic pollution factors is Sahara dust. Dust coming from Syria occur at certain times of the year, and the effect level varies depending on natural factors (wind, rain, and other modes.). (Oral Interview 1, 2019)
- There are six air quality measurement stations affiliated to the Ministry of Environment and Urbanization, one of these stations gives the results of measurement due to industry, one for traffic and the remaining four from heating (Oral Interview 2, 2019).
- According to the data obtained from the National Air Quality Monitoring Network of the Ministry of Environment and Urbanization, where the obtained data can be controlled, the air pollution levels seen in Gaziantep during the winter months, are higher.
- Apart from the measurement stations affiliated to the Ministry, Passive and Active Sampling Studies conducted by Gaziantep Metropolitan Municipality Department of Environmental Protection and Control also work on air quality measurement (Oral Interview 3, 2019).
- As a result of SO₂, NO_x and PM₁₀ measurements at 29 points in the city centre, the urban impact rates were determined as 41.71% for SO₂, 37.36% for NO_x and 20.92% for PM₁₀ (Gaziantep Provincial Directorate of Environment and Urbanization, 2016).

From the above findings and literature search, three main parts are formed for this research. In the first (1st) part, the natural inspirational sources that drive urban design is described in detail. In the second (2nd) part, the main principles of a solution-oriented Spatial Strategy Plan, which has been prepared in a macro scale to overcome the low air quality problem in Gaziantep, is described briefly. This process is the preliminary step before passing into the urban design scale at the micro-level. Finally, in the third (3rd) part of the research, the selected location of the urban design project and some examples of the design schemes and their explanations, are described.

NATURAL INSPIRATIONAL SOURCES THAT DRIVE URBAN DESIGN

During the urban design phase, the research takes inspiration from Nature. In this context, the lotus or water lily, which is generally mentioned, as the cleanest plant in the world, is one of the primarily inspired natural objects in the project.

Lotus flower is the cleanest plant in the world, living in dirty environments (swamps, ponds and other water bodies), but interestingly does not hold dirt and could remaining clean by the help of the hydrophobic structure on the surface of the flower (URL3). During the research, the lotus flower is regarded as the primary inspiration source in the conceptual structure of the project in Gaziantep region (see Figure 6). The vision of creating an urban environment that can remain “clean” in a dirty environment is accepted as the main structural idea of the urban planning and design process in Gaziantep.

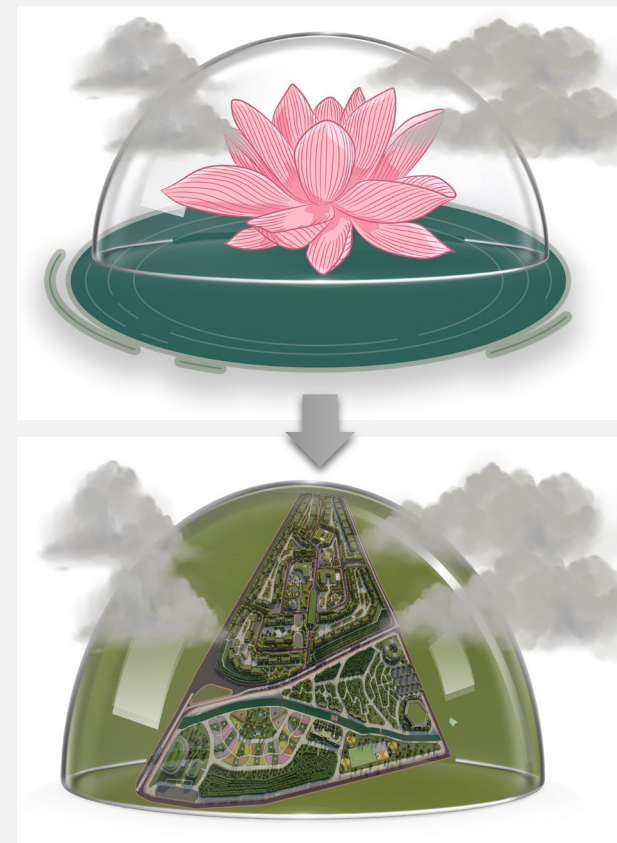


Figure 6: Reflection of the lotus flower philosophy on the project

The information gained from the lotus flower research as a hydrophobic structure on the surface of the flower which does not hold dirt is also found on the wings of the butterfly and dragonfly with specific geometrical structures (Başarır, 2015).

During the fictionalisation of the urban space, the geometric structures found on the wings of butterflies and dragonflies are integrated into the project study area, i.e. the proposed land use and transportation structure of the project. The regular geometric structures found on the wings of the butterflies and dragonflies are ingrained into the project in three stages; (1) the formation of primary veins that divide the wing segments into separate zones; (2) the emergence of equally-weighted barrier centres; and (3) the formation of secondary veins around these centres (Figure 7).

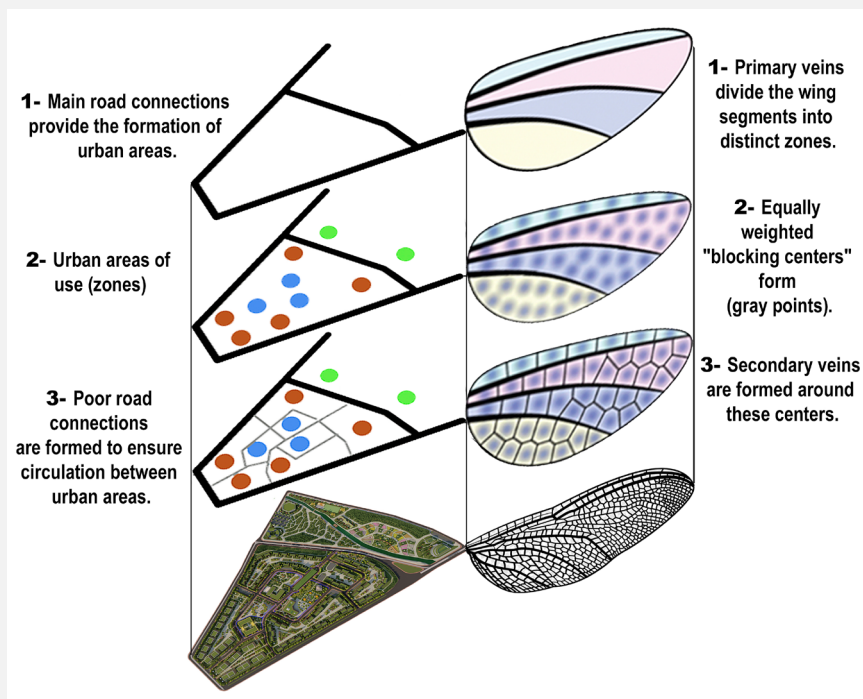


Figure 7: Reflection of dragonfly wing structure on the project

These regular geometric structures on dragonfly beetle help the conceptual setup of the urban design project to take shape in such a way that; (1) the formation of main transportation corridors, (2) the emergence of land use or urban areas between the main corridors and (3) the formation of 2nd and 3rd degree connections that will provide circulation between land use in an integrated manner.

One of the other natural conceptual ideas that affect the conceptual setup of the urban design project is the concept of "butterfly effect". Edward N. Lorenz (1963) noticed the butterfly effect while making weather calculations with his computer. He had been observing how a tiny natural event such as the wind created by the flapping wings of a butterfly can trigger more significant events such as changing the speed and direction of the wind (URL4). Based on this observation, ideas developed with this inspiration from Nature were accepted into the 40-hectare design area, as a symbolic centre of the urban design project as the flapping of the butterfly wing. The centre act as the impetus that may affect the prevention of air pollution in larger urban areas such as national or regional scale (Figure 8).



Figure 8: Reflection of the butterfly effect philosophy on the design

The final natural conceptual idea that affect the conceptual setup of the urban design project is the mental concept of "Yin Yang", which is emerging from Chinese mythology and basically explains that "the contrasts should be structures that complement each other, not contradict each other" or similarly in other words "There is evil in good, good in evil", (URL5). Inspiring from the mentioned Yin Yang concept, a similar approach of "city within the nature, nature within the city" is also tried to be reflected both in the conceptual setup of the urban design project and also in the physical plan (Figure 9).



Figure 9: Reflection of Yin Yang philosophy on design

NATURAL INSPIRATIONAL SOURCES THAT DRIVE URBAN DESIGN

Gaziantep city, like many metropolitan cities in the world and Turkey, has an air pollution problem and the reasons are generally similar to each other. The use of fossil fuels for heating and vehicles, Industrial production activities, the density of urban regions, the low amount of green/forest areas, lack of the recreational green corridors, desert dust coming from Syria (have a periodic effect) are among the most important reasons for low air quality in Gaziantep region (see Figure 10).

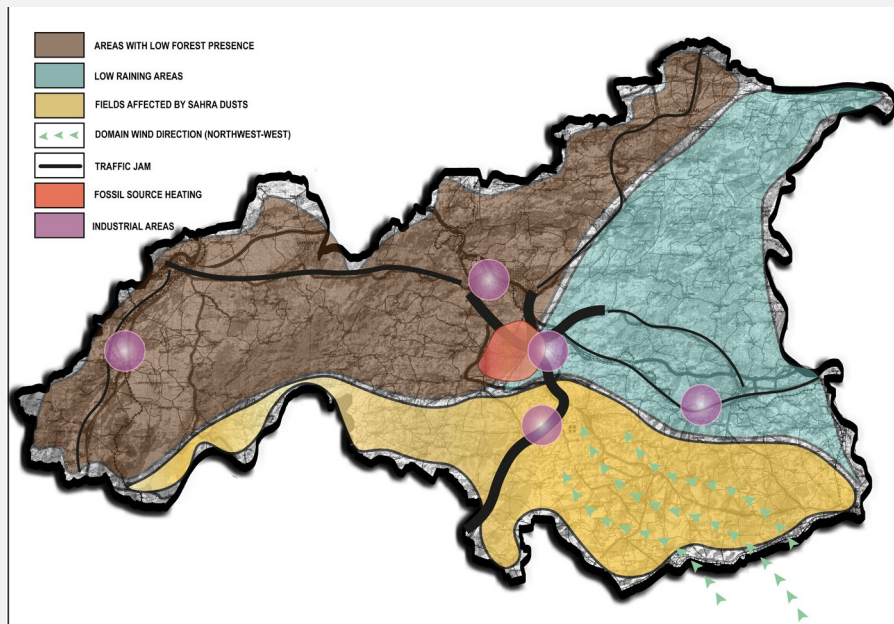


Figure 10: A synthesis map of Gaziantep that summarizes some of the spatial conditions of the site related with air pollution problem

Some of the macro scale measures that were proposed to be at 1/100.000 scale spatial strategy plan to overcome the air pollution problem are listed below (refer Figure 11);

- Renewable energy sources like the sun, the wind and other forms of natural energy, should be encouraged in order to prevent air pollution caused by heating (Yılmaz & Kösem, 2011'deakt. Seydioğulları, 2013).
- Exhaust filtering and inspection activities both for the motor vehicles and the industry should be carried out more effectively,
- Transition to hybrid electric vehicles (e-cars, e-bikes, e-scooters) should be encouraged as much as possible.
- The transition to sustainable industrial activities in the industry should be ensured, and businesses should be directed to pollution-preventing industrial activities by providing incentives.
- Ecological and low-carbon urban approaches should be adopted throughout the province
- Create green belts/corridors that help the city to breathe
- Increase green areas
- Consider natural ventilation
- Increase the attraction of pedestrian, bicycle, e-bike, scooter, and public transportation accessibility
- Decrease the attraction of motor vehicle accessibility.

- Motor vehicle traffic should be prevented and charged at the optimum level both in the city and in the city centre.
- Sustainable green energy usage
- Ecological /Nature based/Nature inspired urban design and architecture (Register, 1987'den akt. Çetinkaya & Ciravoğlu, 2016).
- Establishment of Global Clean Cities and Eco-efficiency Centres
- Creation of green urban corridors taking the dominant wind direction into account
- Increasing the use of renewable energy resources in the region.

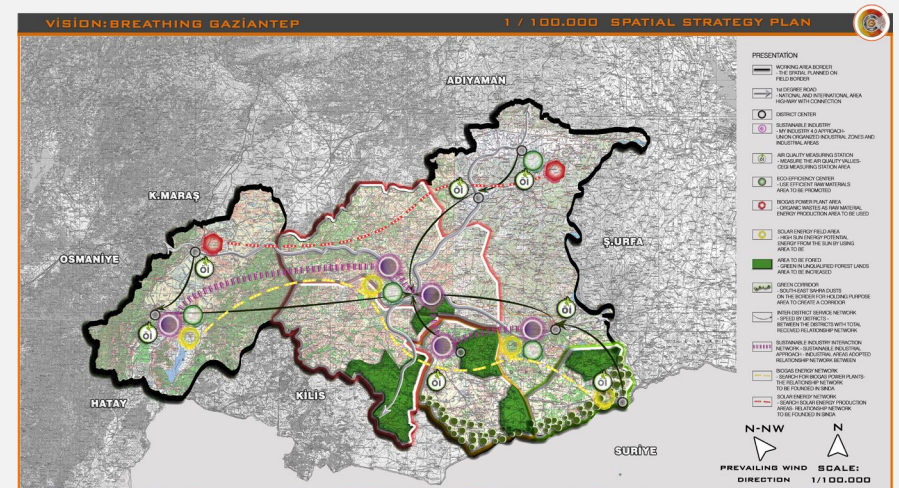


Figure 11: Gaziantep Spatial Strategy Plan

URBAN DESIGN PROJECT

For the selected area of 40 hectares under urban design project located in the city centre in Gaziantep region, the “nature-inspired” concept urban design as the solution to overcome the low air quality problem in cities is proposed (refer Figure 12).

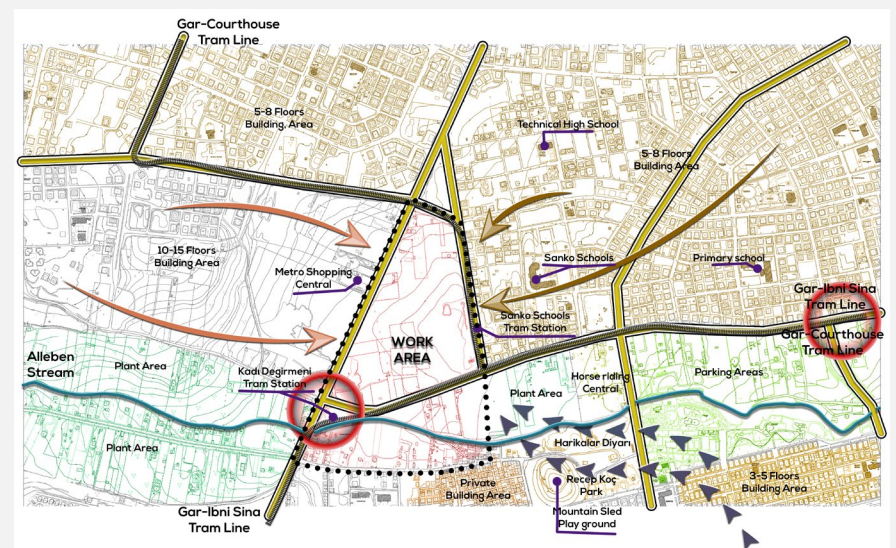


Figure 12: Workplace environmental analysis

The following points were considered in choosing the area for the urban design project:

- Located in the centre of the city and the area with the highest motor vehicle traffic
- Not structured according to the wind direction
- Located in the region with the highest air pollution level
- Suitable for new nature-inspired designs supporting the macro-level strategies
- Appropriate for regulating a compact city approach that comes from macro-level strategies
- Being an unconstructed or vacant area

The implemented urban design project in the selected area is given below (see Figure 13 and also the part “2.1.Natural Inspirational Sources That Drive Design” for the details of nature based inspiration):

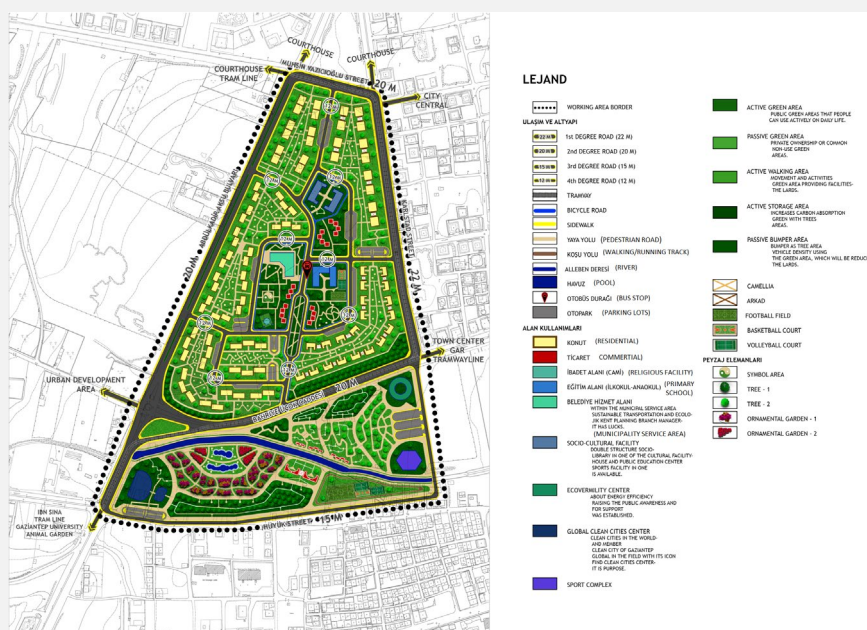


Figure 13: Urban design project

Summaries of examples on the design schemes and their explanations for the implementation of Nature-inspired urban design project as follows:

Increase Public Spaces: For the idea of creating an urban space with high air quality, many common/public spaces design for all are within the residential areas (Figure 14).



Figure 14: Increase public spaces

Consider Dominant Wind Direction: These areas are also open to the dominant wind direction from the north-northeast direction.

Low Rise Construction: Wind-blocking factors are reduced with low-rise construction in residential areas (Figure 15).



Figure 15: Consider Dominant Wind Direction – Low Rise Construction

Shaded Living And Transition Areas: Due to the hot and arid climate structure of Gaziantep, shaded living and transition areas are created, ensuring a comfortable circulation of pedestrians against climatic factors.

Provide Ecological Designed Circulation with Green Roofs and Green Corridors For The Pedestrians; Provide More Space For Bicycles/Scooters and Public Transportation; Provide Less Space For Cars with Pedestrian Connection: The 20-meter-wide shaded pedestrian corridors are formed in the central road network. The provision is to strengthen and facilitate the pedestrian connection between the recreation area located in the south of the design area / the residential area. This proposal will thereby slow down motor vehicle traffic and making it a safe place (Figure 16).

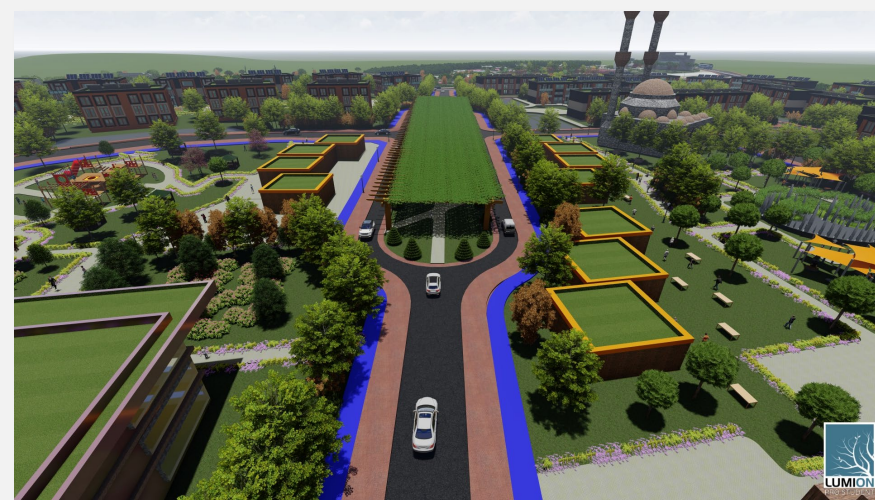


Figure 16: Shaded Living and Transition Areas

Combined/Mixed Use of Services: Combined/Mixed-use of commercial and service spaces are considered within easy reach of the residential areas, providing easy pedestrian circulation and preventing vehicle traffic (Figure 17).



Figure 17: Combined/Mixed Use of Services

Underground Parking Systems with Elevators: The design of corridors was decided in such a way that the vehicles can move both the most active and shortest in the area. Underground parking systems with elevators was also planned to reduce the massive scale of hard floors or carbon footprint in the parking areas. Bicycle and scooter paths, whose circulation is encouraged to expand widely with pedestrians, are positioned to ensure more effective ecological circulation in the area (Figure 18).

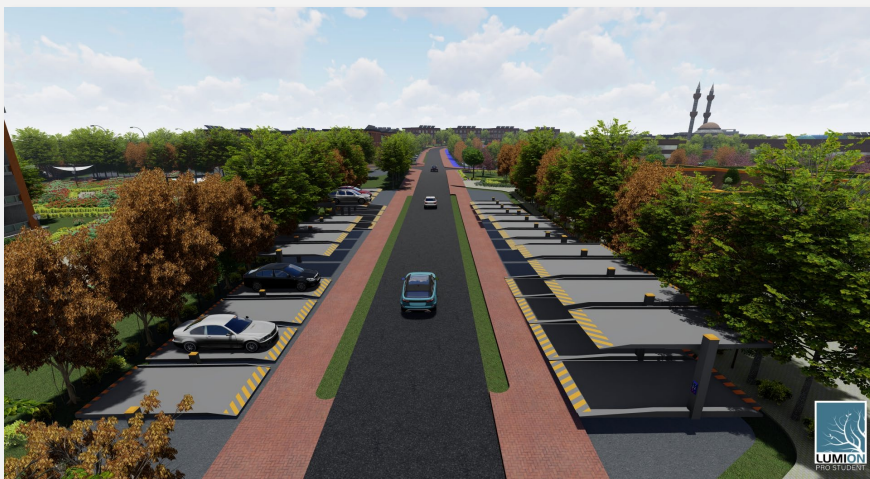


Figure 18: Underground Parking Systems with Elevators

Provide Participatory Planning To Reduce Air Pollution (Establishment of the Global Clean Cities and Eco-Efficiency Centres): The Global Clean Cities Centre and Eco-efficiency Centre are strategically established in the Spatial Strategy Plan. The two centres are both located in the recreation area in the south of the project site. These centres are to actively assist the public with information on the process of reducing air pollution, the benefit from incentives and ability to convey and listen to the public's suggestions and expectations as per the participatory planning approach (Figure 18).



Figure 19: Basic structure of the Global Clean Cities Association

Provide Effective Control and Intervene Problems on Site (Establishment of Sustainable Transportation Branch Directorate and Ecological Urban Planning Branch Directorate): Likewise, the "Sustainable Transportation Branch Directorate and Ecological Urban Planning Branch Directorate" is also included in the design. These directorates will monitor and control the ecological spaces designed as sustainable living spaces provided by the urban design project. Its establishment could assist the municipality in intervening any local problems on site. (These services is within the additional service building of Gaziantep Metropolitan Municipality) (Figure 20)



Figure 20: Establishment of Sustainable Transportation Branch Directorate and Ecological Urban Planning Branch Directorate

High Carbon Absorption / Create More Green Space Suitable For Recreational Activities: The proposed recreation area is divided into four sections as active stocking areas, active walking areas, passive buffer areas and active sports areas. With the designed active stocking areas with dense trees, high carbon absorption is provided for the passage of the polluted air coming in the direction of the north-northeast. In the area of active walking, there are places where the public can carry out their social, individual and commercial activities. With the wooded bumper area considered in the passive buffer area, vehicle density is reduced, and the feeling of calmness, reliable spaces are created. With the active sports area, green places are designed where sports activities can take place (Figure 21 and 22).

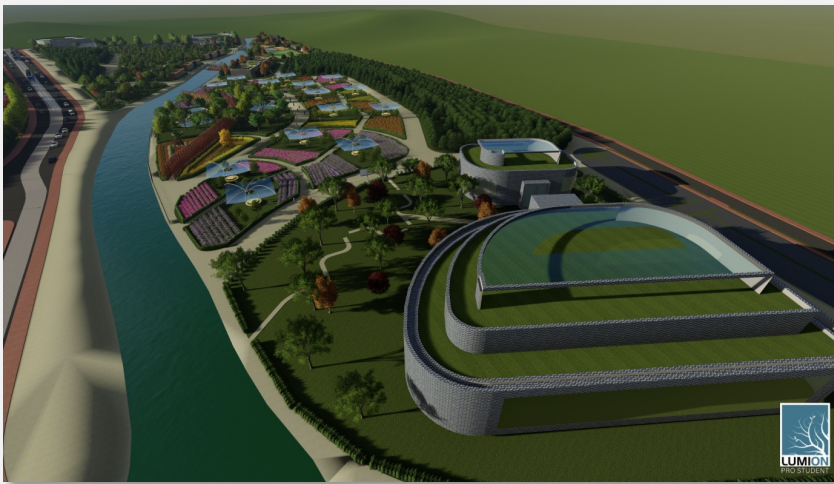


Figure 21: High Carbon Absorption / Create More Green Space Suitable for Recreational Activities



Figure 22: High Carbon Absorption / Create More Green Space Suitable for Recreational Activities

The urban design project implemented in the selected area is expected to be one of the exemplar projects inspired by Nature as natural resources. It produced nature-friendly solutions against air pollution in Gaziantep region. With a holistic approach, the solution takes into account the principles of ecological and sustainable urban design and universal design criteria.

CONCLUSION

Air pollution visibly manifests its existence all over the world and most likely will cause more and more problems in the future. If the execution of specific research and design process on its prevention is not carried out, poses major problems in Turkey and other countries. Hence, this research aimed to prevent the air pollution problem both in macro-level with the Spatial Strategy Plan and in micro-level with the urban design studies.

In overcoming the problem of air pollution, a Spatial Strategy Plan is prepared for Gaziantep city. As part of the Spatial Strategy Plan, only the vital parts of the urban design process in one of the sub-regions is explained in detail.

The important points that distinguish this study from other urban design-related research are that natural structures and their relationships inspired the fundamental principles of the project. Inspiration from Nature includes the structure and operation of the lotus flower (water lily), dragonfly beetle, butterfly and the butterfly effect as well as the Yin Yang philosophy. The creation of the central theme and the setup process of the urban design project are all carried out based on the sources inspired by Nature in several stages. During the design phase, the forms and structures of the lotus flower, which can remain clean even in dirty environments, has guided the project as the primary source of inspiration in the emergence of the idea of creating an urban space free from air pollution. The structure of dragonfly, beetle and butterfly wings, apart from the presence of the hydrophobic structure, also protects pollutants on the wings has guided the study, raising awareness about what Nature can bring to the design and how it can shape it (Figure 23). In the later stages of the design, the dragonfly beetle's unique wing structure is observed to be able to flap and change the speed of air. The wing structure had inspired the formation of the urban space and thus used in the formation of the sketch diagram and the construction of the design.

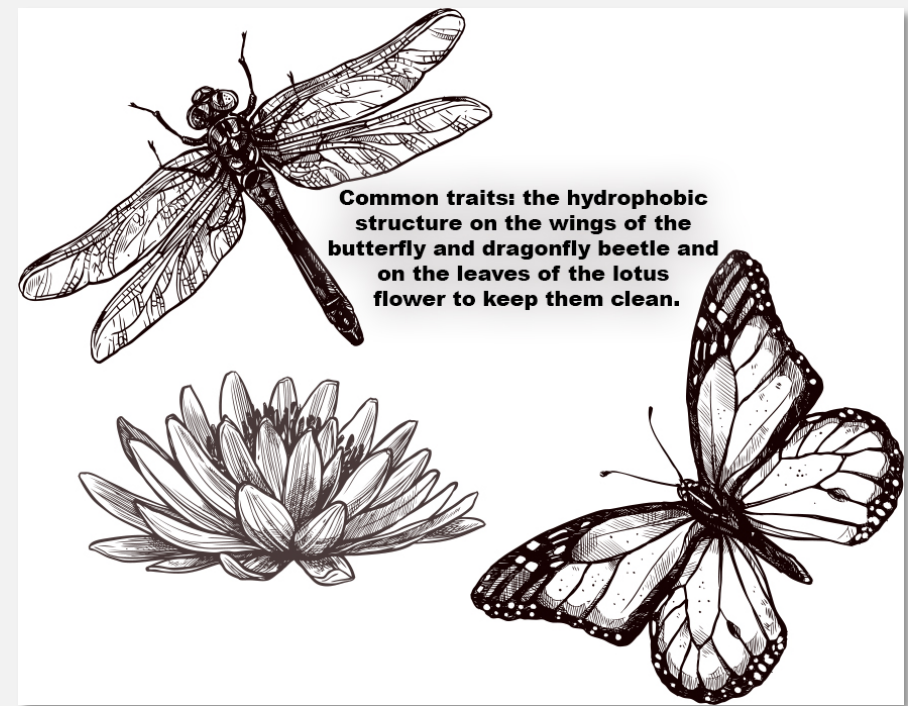


Figure 23: Common trait of the inspirational lotus, dragonfly beetle and butterfly (URL6)

Another form of influence that Nature added to the project was the idea of the butterfly effect. The butterfly effect is created by arranging the symbolic centre of the area to become a source of inspiration to the whole world by enlarging the affected area like the wing beat of a butterfly.

The final natural conceptual idea that affects the setup of the urban design project is the mental concept of "Yin Yang" philosophy from the Chinese mythology where "the contrasts should be structures that complement each other, not contradict each other". The Yin Yang concept, laid down the concept of "city within nature, nature within the city" is reflected both in the conceptual setup of the urban design project and the physical plan (see parts 2.1, 2.2. and 2.3 for details).

When all these facts are examined in an integrated manner, it is observed that Nature could have significant effects on the shaping of planning and urban design research. The cities created from Nature can be re-shaped by returning to Nature. In the formative stages of the project, it is realised that to establish a relationship with Nature and different parts of Nature could lead the project to different perspectives. Subtle details that are not observed or achieve in an ordinary urban design project can gain different depths and focuses when natural structures and related relationships in the universe are examined and integrated into the project. This approach or concept conducted by the study and research will hopefully inspire researchers working in the field of urban design more research to learn from Nature.

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More visual details of the project can refer to the multimedia link at <https://youtu.be/AOqFtxXZXNA>

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