World Academy of Science, Engineering and Technology
International Journal of Humanities and Social Sciences
Vol:6, No:7, 2012

Bioclimatic Principles and Urban Open Spaces: The Case of Xanthi

Maria Giannopoulou

***Abstract*—**Open urban public spaces comprise an important element for the development of social, cultural and economic activities of the population in the modern cities. These spaces are also considered regulators of the region's climate conditions, providing better thermal, visual and auditory conditions which can be optimized by the application of appropriate strategies of bioclimatic design. The paper focuses on the analysis and evaluation of the recent unification of the open spaces in the centre of Xanthi, a medium – size city in northern Greece, from a bioclimatic perspective, as well as in the creation of suitable methodology. It is based both on qualitative observation of the interventions by fieldwork research and assessment and on quantitative analysis and modeling of the research area.

***Keywords*—**Bioclimatic principles, Quantitative analysis, Sustainability, TownScope III, Urban open spaces

I. Introduction

OPEN public spaces are surfaces that are free, accessible and available to everyone, anytime. They are the main areas of social and cultural activity of the cities and contribute to upgrading the quality of the urban environment. They can be classified according to many different ways, with respect to their location, their frequency of use as well as the level of intervention in the city's life [1]. Bioclimatic design utilizes renewable sources of energy which can be incorporated in the aesthetics and operation of these spaces, contributing to the elimination of the air pollution, the improvement of the environmental quality, the balance of the ecosystems and energy savings [2]. The benefits of bioclimatic design can be environmental, energy, economic and social [3]. The main parameters that influence the environmental conditions of the open spaces are the seasonal and diurnal variations of the temperature, the incident solar energy, the relative humidity, the generated noise, as well as the glare and aesthetic quality of the environment and roadside buildings. Some bioclimatic criteria on which planning is based are the thermal, visual and acoustic comfort, the construction materials, the vegetation and water elements. The methodology that is usually followed in the planning process includes:

- Analysis of the character and structure of the wider area
- Collection and utilization of the local climate data in daily and seasonal basis
- Analysis of the surrounding area's attributes
- Use of appropriate tools to monitor and quantify the comfort conditions (bioclimatic indices, simulation models)

Giannopoulou M. is Assistant Professor, Department of Civil Engineering, Democritus University of Thrace, 67100 Xanthi, Greece (phone: +30-25410-29875; Fax: +30-25410-79701; E-mail: mgian@civil.duth.gr).

- Determination of the interventions and choice of suitable materials

Bioclimatic indices indicate the average sense of the thermal comfort of the open spaces based on selected meteorological parameters (temperature, humidity, wind speed), the thermal capacity of the users' clothing, the users' metabolic rate and the current human activities [4].

The simulation models of open spaces' conditions use hourly meteorological data for the air temperature, the total incident solar energy, the wind speed, the relative humidity, the brightness of the sky, the level of noise in space etc. The models vary depending on the prevailing conditions of the study area and are differentiated in cities, which correspond to different climate zones [5]. The paper focuses on the analysis and evaluation of the recent implementation by the Municipality of the unification of open spaces in the center of Xanthi, a medium size city in northern Greece, from the perspective of bioclimatic approach, as well as on the creation of relevant methodology. It is based both on qualitative observation of the interventions by fieldwork research and assessment and on quantitative analysis and modeling of the research area using the program TOWNSCOPE II [6].

II. Case Study

Xanthi, a city of approximately 55.000 inhabitants is situated in the north-eastern part of Greece in an altitude of 60-145 m. The large gradients have defined the form and the development of the historic core and the flat lowland zones its modern extensions. The central square is the traffic and functional heard of the modern city. It dates back to the second half of the 19th century and was the space where the flea market was taking place. The buildings around the square had direct access to it and accommodated administrative and social infrastructure functions. None of these buildings remain nowadays, except from the clock tower. Today, around the square particular unities of special uses exist, which are characterized by contrast, such as the block of administration buildings and open spaces in the west, in the most dynamic part or the commercial centre in the south, recreation uses and services in the north and the site of the flea market with specialized shops in the east. The urban morphology of the area is characterized by complexity and variety as it includes both modern high buildings of no particular aesthetics and older lower buildings with architectural interest [7].

The urban invention by the Municipality unified the central square with the open space and the square where the administrative buildings are located by the pedestrianization of some streets, restricting the movement of vehicles to the eastern side of the central square. The final configuration of the unified spaces covers an area of 30.000 m^2 (3 Ha) and includes the allocation of new activities (outdoor theatre, playground), incorporation of water elements (multi-level waterfall, fountain), creation of permanent structures (shading systems, arches, benches), point interventions of green, paving improvement or replacement of other urban infrastructure.

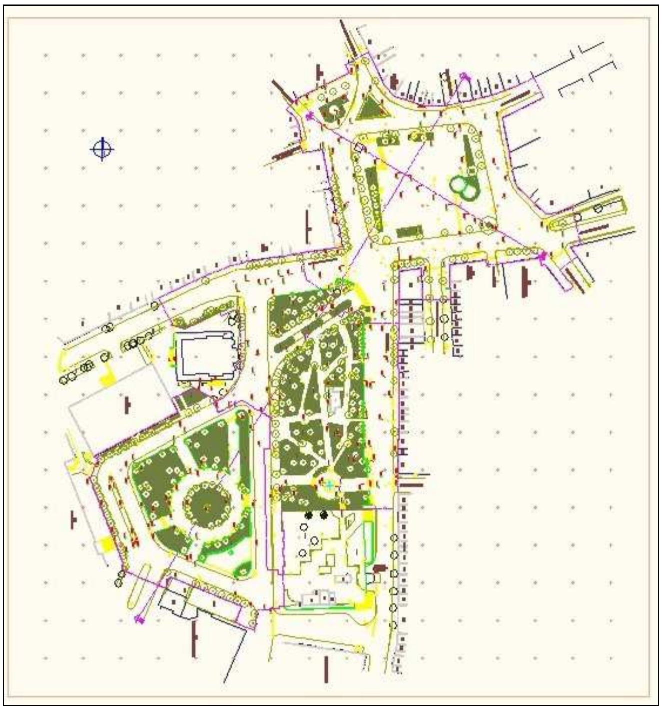

Fig 1 The total area of the urban invention of the central square

III. Methodology and Approaching Tools

The followed methodological approach for the assessment and evaluation of this intervention as for its basic bioclimatic parameters combines the qualitative observation of the interventions as well as the model that emerged from the quantitative analysis of local data with the TownScope III software. TownScope software was developed by LEMA – ULg and is a useful tool for urban planning decisions in the context of sustainable urban environment, as it identifies solar permeability and thermal comfort in an area while it receives and generates data in three dimensions.

For the quantitative analysis the following were used:

1. Basic background map of the area in .dxf form
2. Data for the identification f the area's geometry, expressed in points, polylines and zones in three dimensional space
3. Bioclimatic parameters (solar energy, sunshine, thermal comfort, visibility).

The digital background was created by the designing program AutoCAD. In addition to the aforementioned, there were also used:

- The two – dimensional layout plans of the new configuration
- The inventory of buildings and roads by the digitalization of aerial photographs and their introduction in the drawings
- The heights of the buildings and of various structures of the square that were taken from the regeneration study.

For the construction of the virtual model and the designing part of the three dimensional depiction, a new background was created based on the two – dimensional one, which was then converted to three dimensions and was saved as a .dxf file. For the creation of the 3 – D model, the following assumptions were made:

- The height of buildings is calculated using the number of the floors under the assumption that each floor has a height of 3.00 m.
- The buildings are considered three dimensional, solid, impervious to solar energy.
- The form of the roofs have no practical influence on the results of the model, as the key elements for the calculations are the height of the buildings, their relative position and their orientation.
- The flower beds do not contribute to the creation of thermal comfort as they are limited in number and size.

IV. Results

The bioclimatic regeneration of the open urban spaces is an opportunity for improving the comfort in them. The possible solutions vary depending on the local morphology, the climate and the aesthetic nature of the design proposal. Regardless the variety of the solutions though, for the creation of an attractive and comfortable environment, the seasonal use of space should be taken into account. Except from the acoustic comfort which is not affected by the season, the visual and especially the thermal comfort, require different approaches in relation to prevailing environmental conditions. The final solution should have a combined and integrated form and include all the special morphological and climatic features of the site. The results of the qualitative and quantitative approach of the regeneration are summarized below.

A. Qualitative analysis

The results of the qualitative analysis derived from fieldwork on the success or failure to integrate bioclimatic elements in the context of the new planning for each one of the main bioclimatic parameters that influence the function of open spaces.

Thermal comfort: there are no special configurations either of physical protection of space by planting evergreen trees or of technical one by placing artificial cut panels for the protection from cold northern winds during the winter. Moreover, only three shading devices with adjustable louvers have been constructed. Two of them are used by the cafeterias that are located there for the protection of their seated customers, while the third one offers shades to the passing – through pedestrians. Natural shading and cooling is ensured only to limited number of benches, and there are some benches that are protected from the wind, for the exposal of their users to the sunlight during the winter period.

Visual comfort: there are no unimpeded and aesthetical upgraded perspective views. The two massive arches and the shading systems contribute to the visual space fragmentation.

The visual impact is reinforced by the limited vegetation in the front of the facades of the buildings and on horizontal

World Academy of Science, Engineering and Technology
International Journal of Humanities and Social Sciences
Vol:6, No:7, 2012

surfaces, as well as by the formation materials of the new structures can cause glare. The artificial lighting of the space is sufficient and includes high lamps and floor lamps at the movement axes.

Acoustic comfort and water features: positive impact has the construction of a multi – level artificial waterfall made of granite in the southeastern side of the square, where the maximum traffic volume is recorded, as well as the fountain in its centre. These elements ensure at the same time a pleasant cooling sense to users during the summer months.

Vegetation: the planting of the site contributes very little to its bioclimatic operation. The placement of trees is limited in contrast to the formation of flower beds with seasonal plants and lawn that require constant watering. The raised part in the southwestern part of the regeneration area, which gathers the most significant vegetation, strengthens the use of space during summer as the cooling northern winds can be utilized to create more natural sun – protected areas. The playground and the outdoor theatre have been located in this part.

Use of materials and colors: the choice of coating by the use of slate and sandstones (brick stones) of red ocher color causes neither optical glare nor thermal disturbance conditions. Nevertheless, their use is particularly widespread without the intervention of water – penetrating materials (such as flower beds with soil or gaps between the brick stones). The choice of wood and stone for the construction of the final surfaces of the benches offers thermal and optical comfort in the area.

B. Quantitative analysis

The results from the quantitative analysis focus on various parameters (solar access, sunlight/ shading and thermal comfort) for the determination of the heat stress that the users of the site go through. The climate data that were used include measurements of the local meteorological station for the period 1961 – 2001 and evaluation of scaling climate data for each one of the measured parameters (Table 1). The measurements refer to the 15th of June, which according to the data is a representative summer day, particularly at three specific hours of a typical 24 – hour period (5:00, 11:00 and 17:00). The values of solar access are calculated using geographical data (longitude and latitude) and climate data (temperature and wind humidity, haze caused by pollution etc.). The program calculates the total, direct, diffuse and reflected soil access. The direct access is defined by the buildings' orientation and the geometry of the roads. The program also calculates the duration of sunshine period and shading period. The duration of shading is the inverse parameter of the duration of sunshine.

TABLE I
CLIMATE ATTRIBUTES OF THE CASE STUDY AREA

Month	Average temp (°C)	Absolute maximum temp(°C)	Absolute minimum temp (°C)	Relative humidity (%)	Rainfall (mm)
January	5,6	9,4	2	70,5	30,6
February	5,6	9,7	1,9	69,6	77,5
March	8,9	12,8	5	69,9	36,1
April	14,1	18,6	9,5	68,9	60,4
May	18,8	23,3	13,2	64,7	40
June	23,3	28,1	17,1	61,6	67,2
July	26,6	31,4	20,2	55,6	25,2
August	26,9	32,1	20,8	53,1	25,3
September	22,5	28,1	16,7	60,5	17,6
Octoberς	16	20,9	11,8	67,8	33,2
November	10	13,8	6,7	71,3	104,7
December	6,2	9,8	2,9	70,7	75,9

Source: www.cres.gr/kape/datainfo/clima.htm

The values of thermal comfort are determined by the rate of sweating, the sweating evaporated, the skin wetness and the temperature sensation. For the calculation of the values the data concerning solar permeability are processed in order to find the received radiation on six surfaces which represent the human body. The thermal comfort is affected by the layout, the orientation and the geometry of the buildings and the roads as well as by the various constructions that are located in open spaces (blinds, etc.).

The maximum value of solar access (total, direct and diffuse) occurs between 11:00 and 12:00 at space points that are not protected. The thermal load is found to be high due to the lack of sufficient shading or sun protection. In contrast to that, the reflected access declines during the day, with peak value during the first hour of sunshine (5:00) (Figure 2,3,4,5).

The maximum values of sunshine duration for each of the 24 hours occur between 11:00 and 12:00 (100% - sunlight throughout the course of an hour) in several parts of the site. For the whole day the sunshine duration reaches the 14,7 hours. The minimum values of shading duration for each of the 24 hours appear in correlation with the corresponding maximum values of sunshine duration. For the whole day the shading duration is 14,9 hours.

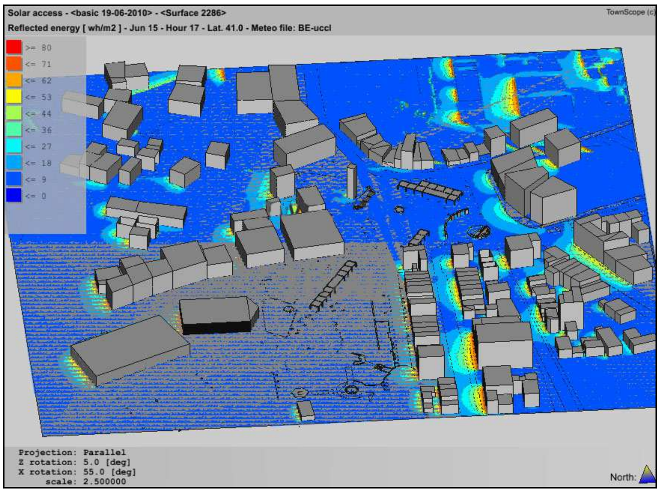

Fig. 2 Mapping solar access – Reflected energy, Jun 15, hour 17.00΄

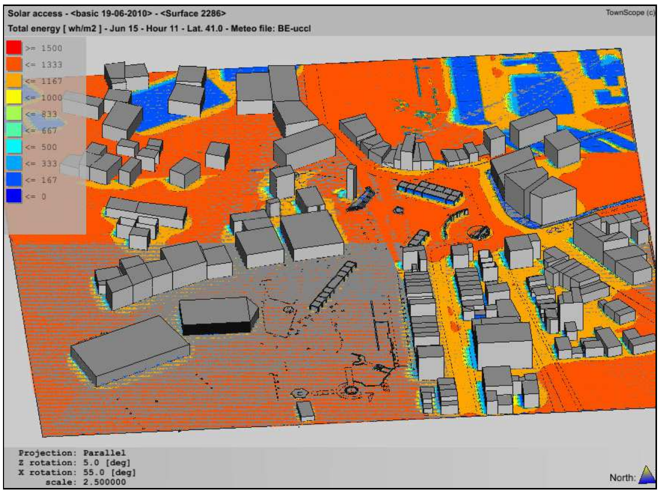

Fig. 3 Mapping solar access - Total energy, Jun 15, hour 11.00´

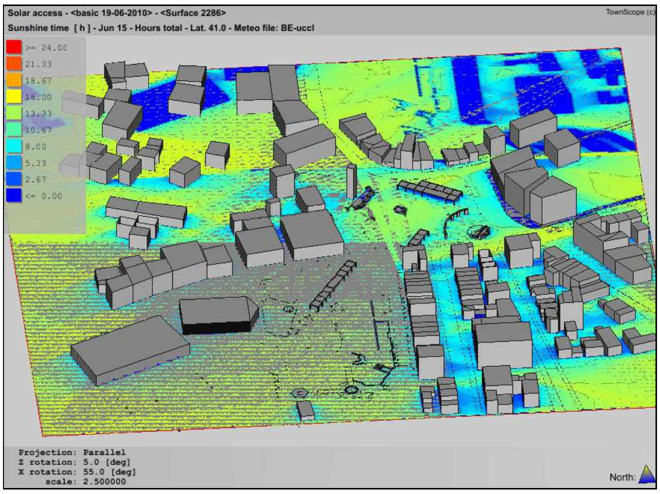

Fig. 4 Mapping solar access – Sunshine time, Jun 15, hours total

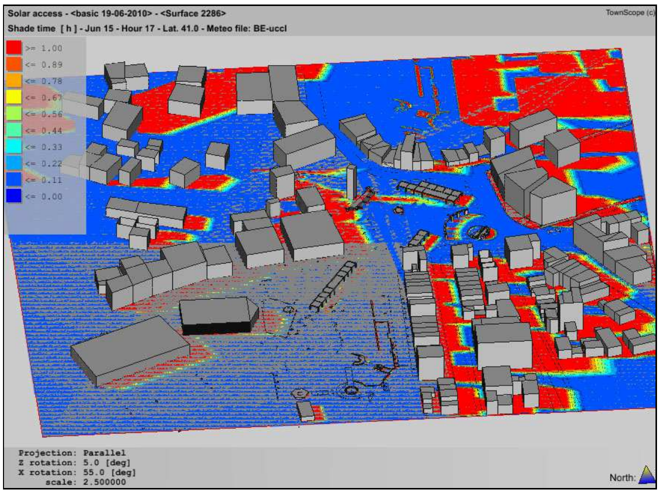

Fig. 5 Mapping solar access – Shade time, Jun 15, hour 17.00´

The values of thermal comfort indices sweating rate and sweating evaporated are within the limits of thermal comfort and as a result the thermal conditions can be characterized as satisfactory.

Their maximum values are recorded at 11:00, when the highest thermal load occurs, in regeneration areas that are not protected. Unlike those indices, the skin wetness and temperature sensation indices have maximum values outside the normal range.

V. Conclusion

This configuration considered in general terms the criteria of bioclimatic design (ratio of open and structured spaced, topographical data, properties of the materials used). Nevertheless, individual elements do not facilitate the use of the favorable characteristics of the local microclimate and do not provide the organic (thermal, visual, acoustic) comfort of space during all periods of the year.

Suitable bioclimatic techniques and methods for shading and solar protection, appropriate devices for wind protection, wind permeability and re – direction of the wind, proper use of the vegetation and intense use of water elements close to the axis of movement and stopping could be applied, providing protection of space users from the negative climatic characteristics and exposure to the positive ones, increasing its use throughout the year.

The bioclimatic design of open urban spaces is an important development towards the objectives of sustainability, as it contributes to energy savings and environmental protection. Environmental stimulation is a key reason for the use of spaces for different activities during the year and its careful planning could contribute to it with an environmental friendly differentiation, as the daily and seasonal changes need different solutions. The improvements brought by the bioclimatic approach are not characterized as scale changes for the modern environmental and energy problems, but the widespread application of the bioclimatic principles can have long term and permanent results.

References

[1] Maruani, T. and Amit-Cohen, I. (2007) Open space planning models: a review of approaches and methods, Landscape and Urban Planning, 81, 1-13.

[2] Giannopoulou, M. & Monokrousou K. (2010) Bioclimatic approach of urban spaces, International Congress of Landscape Architecture & Urban Environment, Kavala Institute of Technology, Department of Landscape Architecture, Drama, Greece, 12 –17 April, 187-198.

[3] Nikolopoulou, M. & Lykoudis, S., Thermal comfort in outdoor urban spaces: Analysis across different European countries, 2006, Building and Environment, 41/11, 1455-147.

[4] ISO 7730 (2005), Ergonomics of the thermal environment – Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria, Third edition.

[5] Katzschner, L. (2004), Open Space Design Strategies based on thermal comfort analysis, Proceedings of PLEA, vol.1, NL Technische Universität Eindhoven, pp. 47 – 52

[6] Teller J., Azar S. (2001), TOWNSCOPE II - A computer system to support solar access decisionmaking, Solar Energy Journal, Elsevier, 70/3, 187-200.

[7] Giannopoulou, M., Roukounis, Y. & Kordouli, V (2000), Urban environmental design approach in traditional complexes, in Proceedings of the 5th International Congress on Restoration of Architectural Heritage, Florence, 17 – 24 September.