A PROPOSAL OF URBAN OPEN TRADITIONAL SPACES UNDER THE PRINCIPLES OF ENVIRONMENTAL/BIOCLIMATIC DESIGN THE CENTRE OF KASTORIA CITY

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Abstract

The aim of this project is the bioclimatic rehabilitation and upgrading of the open spaces of the urban area, of the traditional and historical centre of the city of Kastoria, in Northern Greece. Special attention is paid to the contribution of green urban spaces in achieving better urban microclimate conditions. In the contemporary urban environment, where open spaces are rare, such interventions are considered as much needed.

The main characteristics of the design proposal are:

- Replacement of the hard materials that cover the square, removal of concrete and using of environmental friendly materials, which enhance the traditional character of the city and improve the bioclimatic conditions.

- Increase of green areas with planting trees, shrubs, climbing and seasonal plants and sod which unify the open spaces. The aim of this proposal is to increase the covering surfaces with plants because the green affects positive in the urban microclimate. It enchains an amount of 80% of solar radiation in order to make the evapotranspiration operations. These operations reduce the air temperature and enhance the urban atmosphere with vapor.

- Also, the proposal includes the increase of urban equipment in specific points of the city for relaxing and pleasure and the construction of shadowing systems, which promotes the stay in the area and creates comfort conditions to the pedestrians. Also, could be placed water elements for physical cooling.

Key words: *Kastoria, green city areas, urban open spaces in traditional cities, Heat Islands*

1. Introduction

The aim of this research is to investigate the opportunity for rehabilitation of open spaces in Kastoria, and especially to the old city. The paper studies the improvement of the urban equipment, the quality and the amount of green areas, the connection between the green spaces and the historical, cultural and physical areas.

The intervention aims at creating accessible areas to the citizens, to satisfy their needs for a friendly city and to contribute to a better urban microclimate with comfort conditions in the open spaces. The suggestion includes areas such as squares, courtyard of churches, schools, playgrounds, roads, uncovered city's blocks, areas of parking. In each case becomes analytic discussion and analysis for the improvement solution.

2. Methods

2.1 Factors that contribute the urban microclimatic conditions

The factors that contribute and form the microclimate conditions in an urban centre are categorized in two groups. These which associate with anthropogenic release of heat and air pollutants and that, refer to geometry characteristics of a city.

The heat release of anthropogenic sources depends on season, climatic conditions and the heating and cooling needs, the population density, the buildings' configuration and some economic factors.

The constructive materials, such as concrete and asphalt, absorb and store heat accordingly to its thermal capacity properties. Then, the stored heat is released slowly back to the surrounding environment and contribute to the maintenance of high temperature in the city, after the sunrise. [1]

The combustion of hydrocarbons, which come from humans' activities, releases greenhouse gases. The emission of such air pollutants affects the urban microclimate and behaves as a layer of insulation above the city, which enhance the phenomenon of urban heat island.

Also, the particulate maters (PM) and air pollutants from car emissions reduce the light transmittance and as a consequence, the sunlight which reaches the earth's surface is reduced. The intensity of sunlight in correspondingly circumstances in a suburban area would be heavier. For the case of Athens, it has been estimated that the reduction of sunlight due to air pollutants is about 5-15%. In addition, one more incidence, as regard the sunlight, is the fact that its composition is altered (reduction of direct sunlight and increase of diffuse sunlight). This enhances the need for sun protection and shadowing with appropriate provisions in the buildings. [2]

The geometry characteristics of a city that affect the urban microclimate are the buildings' density and the system of city's configuration, the geometry of urban canyons and the materials properties of the external surfaces.

There are factors that difference the urban microclimate from the rural and suburban microclimate conditions, such as the sunlight and the shadowing, the construction materials, the sky view factor, the air flow and the green spaces. The following paragraphs analyse these factors.

The temporary or permanent shadowing between adjacent surfaces reduces the incident solar radiation. In the winter period that reduced of sunlight affects negatively the thermal comfort conditions, while at the summer it is desirable and lead to less energy consumption for cooling and air conditioning.

The properties of construction materials contribute to the temperature rise in the urban centers. The common using materials in buildings and in encrusted open spaces (such as squares or pavements), are characterized by increased thermal capacity. So, big amounts of solar energy and heat are absorbed and storage during the day by the urban surfaces and emitted to the urban environment after the sunrise. As a consequence, the temperature of air inside the city remains in high levels for longer periods.

A crucial factor that impacts in the city's ventilation is the sky view factor (SVF). The reduced SVF is caused by the high and densely building urban centers and from the greenhouse gases that emitted by human activities. For small values of SVF is observed less heat emission of long wave radiation and as a result less ventilation and increase of the air temperature in the city.

Also, in the urban centers is observed heat exchange between buildings and surrounding area, which affect the thermal condition both in buildings' internal and external environment. The absorbed heat in the surfaces transmits by transfer in the cooler air or transfers into adjacent materials and areas. As a result, it is observed increase of air/surface temperature and downgrading of thermal comfort conditions.

The height and the density of the urban buildings affect the wind direction and speed of air. As a consequence, the ventilation in the city is districted and the air pollutants concentration rises. The temporary cities are characterized by limited green spaces and water surfaces. As a result the air temperature rises and the relative and absolute humidity decrease. The green elements can reduce the air temperature because of the shadowing and the process of evapotranspiration, while the water, because of evaporation and of storage big amounts of heat.

Also, in the urban centers can be observed reduced evaporation because of the quickly rainwater runoff from the non-hydrogenated surfaces. In an area without building structures the rainwater runoff is about 10-15%, while in the cities this amount reaches the 20-90% depending on the density of buildings and the distribution of rainfall. [3]

Finally, in the cities there is inflow of technical heat from human activities, such as traffic of vehicles, systems of heating and cooling, light of buildings etc.

2.2 Contribution of green areas in the urban environment

The beneficial contribution of green spaces in the urban environment can be classified in three categories. [4]

a. Ecological contribution in the urban environment
b. Social and aesthetic contribution
c. Economic contribution

The first category includes the consolidation of physic and urban environment. Specifically, it refers to control of the relative humidity and of the temperature, to air filtration, to oxygen production, to protection of radiation and to the control of air flow. Also, it relates with the control of lighting and shadowing, the ground humidity, the solar radiation and the air temperature, the decrease of noises and the surface runoff water.

A noteworthy effect of urban areas in the urban centers is the phenomenon of urban heat island. Warmer temperatures are observed in cities than in the suburban areas.

The plant covered surfaces have better albedo factor than the construction materials. Also shadow and reduce the air temperature because of the evapotranspiration, which consumes latent heat of vaporization. [1]

The social and aesthetic contribution refers to the pleasure time of city's dwells, to the strengthening of social relations, to the environmental education, to the psychological factors and to the sanative factors for patients. Also, it offers protection and escaping routes in dangerous circumstances such as earthquake, restricts violence and serves as a landmark for orientation.

Table 1: Basic types of green spaces

Green Areas	**Urban Green Spaces**	**Green Spaces of relaxation**	Parks and gardens, informal areas of relaxation, outdoor seating sport areas, playgrounds
		Symptomatic Green Spaces	Green neighborhood areas, Other random spaces
		Private Green Space	Residential yards and gardens
	Accompanying, Functional Green	**Productive Green Space**	Residues from agro-crop urban fields

	Spaces		distributions
		Landfills	Cemeteries
		Green Space of Institutes	Yards schools. Other sites of institutions
	Semi-natural ecosystems	**Soils with high moisture**	Open flowing water, swamps, marshes
		Forests	Deciduous forests, coniferous forests, mixed forests
		Other ecosystems	Moors, heaths, grassland, disturbed soils
	Linear green spaces		Banks of rivers and canals, transport axes. Other linear sites (slopes)

The economic contribution of green spaces in a city includes the energy saving in the buildings, the value increase of areas near to green areas, economic grains from the exploitation of trees, limiting spending for cleaning water and air pollutants and upgrading of work environment and the productivity of the workers.

2.3 Factors of bioclimatic design of outdoor urban space

The implementation of bioclimatic principles in the design of outdoor urban spaces aims to Thermal, Visual and Acoustic comfort conditions. The main factors that are taken into account during the design are:

- The urban morphology
- The insolation and the sun protection
- The ventilation and the wind protection
- The physical ventilation and the cooling based on emission of thermal radiation
- The physical lighting
- The properties of the external surfaces and of the construction materials
- The noise control
- The influence of water and vegetation in microclimate
- The use of Renewable Energy Sources

2.4. Description of research area

The city of Kastoria is in area of South West Macedonia in Greece and capital city of the homonymous county. It is amphitheater built on a peninsula and is surrounded by a lake, which has 620m altitude.

The problems in the study area as regard the environmental situation can be summarized in the following:

- Uncontrolled spread of urban fabric
- Exploitation and charge of water resources
- Lack of adequate road network, pedestrian safety problems
- Traffic problems
- Lack of parking
- Destruction and damage of cultural, historical and architectural monuments
- Lack of open spaces and degradation
- Deficiencies in infrastructure networks

3. Results and Discussion

This paper investigates the needs and the desires for urban green spaces using questioners in the local population. The research took place during the months October until December 2008, participated 40 people and the sample was randomly (52% women and 48% men).
In the diagrams below, it is observed the opinion and the attitude of the people toward the green areas in Kastoria.

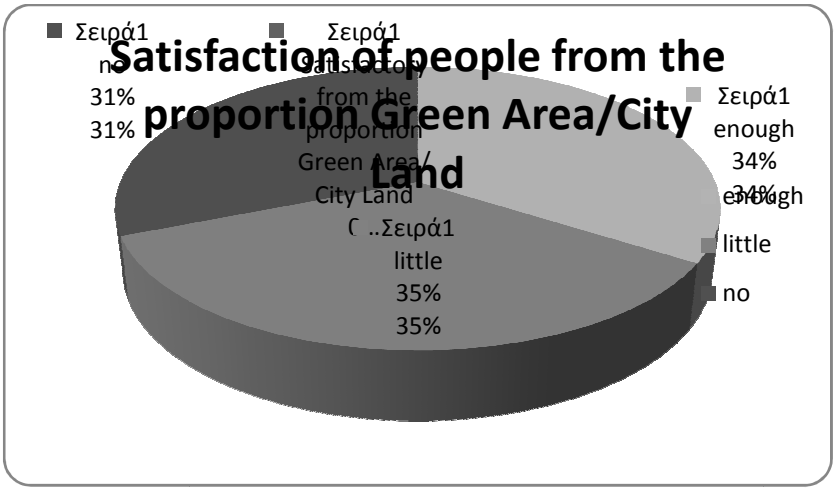

Figure 1: Satisfaction of people as regard the Green Areas in the city of Kastoria

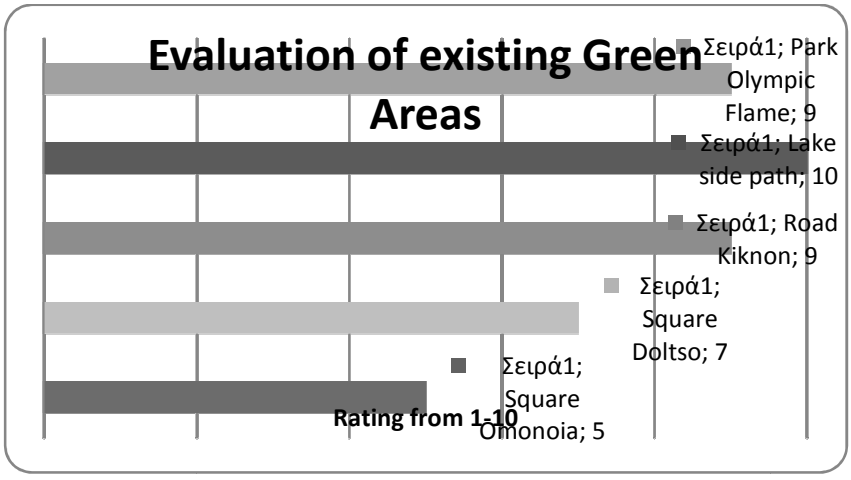

Figure 2: Evaluation of existing Green Areas

The aims of the rehabilitation interventions in the city of Kastoria are:

- Increase of urban green areas and replacement of hard surfaces by vegetation and environmental friendly materials
- Place of shadowing systems (trellises) in the areas of rehabilitation
- Use of water surfaces for cooling
- Improvement of public open spaces as regards the coating materials, the urban equipment, the quality and the amount of green and the connection between the open spaces
- Rehabilitation of uncovered areas and plots, and integration between the communal green areas (where it is feasible) so as to create a net of public open spaces
- Design and construction of pedestrian areas or altering the roads in quite traffic roads.
- Creations of new areas of parking in unused plots
- Planting of roofs, vertical walls and external areas

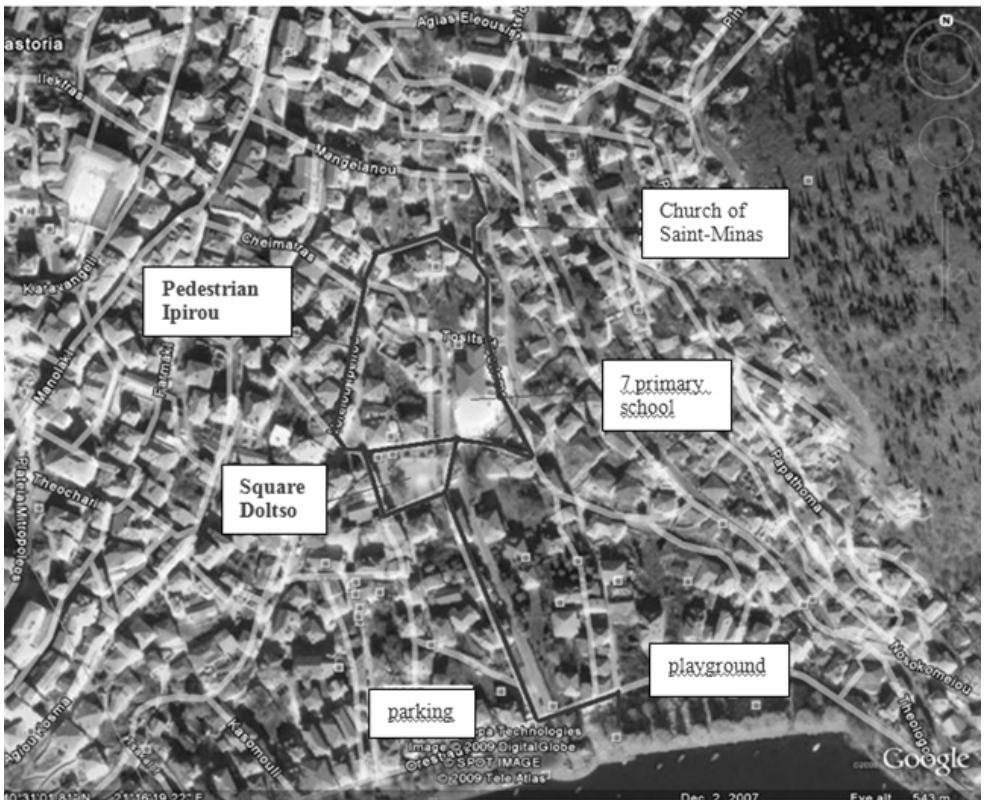

Figure 3: Case study area

3.1 Rehabilitation of square 'Doltso' in Kastoria

In the Fig. 4 below, it can be observed the insolation condition of the Doltso Square during the winter and summer period. It is imprinted the shadowed area from the adjacent buildings in 21 December and 21 June, respectively, at 15:00. These days are selected because they consist the two solstices, days when the rays of the sun directly strike one of the two tropical latitude lines.

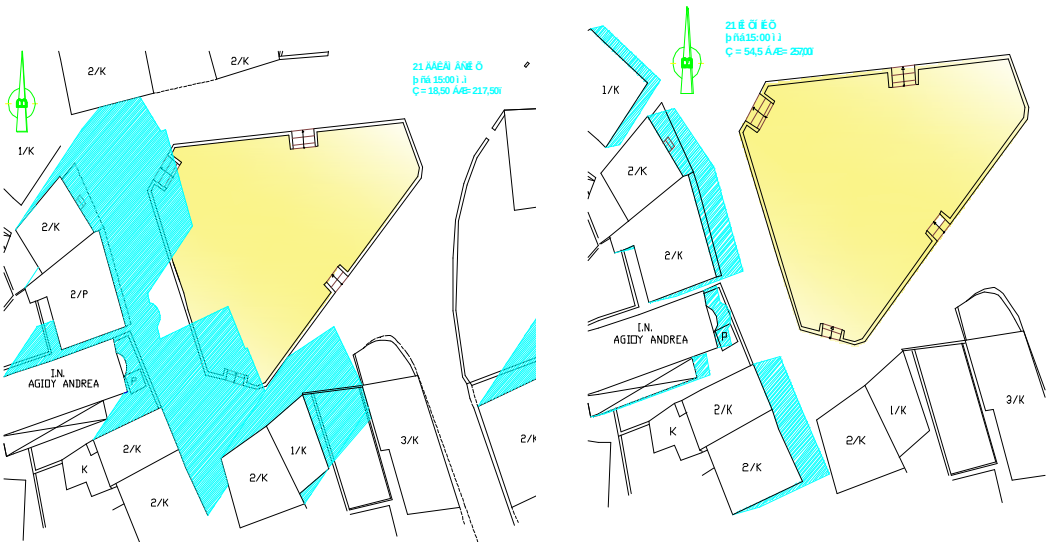

Figure 4: Shadowing of Doltso Square during the a) Winter and b) Summer period.

The shaded open blue area is shadowed, while the yellow is exposed to sunlight. As it is observed in the Figure 4 below, the square Doltso has no protection from sunny conditions, during the summer.

The main characteristics of the design proposal are:

- Replacement of the hard materials that cover the square, removal of concrete and using of environmental friendly materials, which enhance the traditional character of the city and improve the bioclimatic conditions.
- Increase of green areas with planting trees, shrubs, climbing and seasonal plants and sod which unify the open spaces. The aim of this proposal is to increase the covering surfaces with plants because the green affects positive in the urban microclimate. It enchains an amount of 80% of solar radiation in order to make the evapotranspiration operations. These operations reduce the air temperature and enhance the urban atmosphere with vapor.
- Also, the proposal includes the increase of urban equipment in specific points of the city for relaxing and pleasure and the construction of shadowing systems, which promotes the stay in the area and creates comfort conditions to the pedestrians. Also, could be placed water elements for physical cooling.

So, it is proposed to create a square with green elements. Specifically, there would be corridors for connecting the square with other spaces around of it and would be placed plates of slate as covered material. The slate plates would place in such way, so as to grow vegetation between the joints, and they would have sufficient size for facilitating the pedestrians. Also, these plates have low reflectance ratio (8-25%) and avoid dazzled problems.

For the square's shadowing are chosen plants (platani) and maples in the east and west, so as to create comfort environmental conditions during the day at summer period and to attract people even the midday time. Also, in the east side of the square can be placed a shadowing system (pergola) of wood and in the south west side a kiosk. In the pergola and in the kiosk could be placed table benches, so as to become relaxing points for the pedestrians and the visitors. Benches can be also placed at the square, in shadowed points by trees.

The constructive materials for the kiosk will be wooden frame and benches, tile for the roof so as to protect from the rain, and natural stone for the ground covering. The natural stone is regarded as material with low embodied energy. In the west side, could be plant climbing plants

(jasmine, honeysuckle) to intercept west winds and to create cooling conditions and thermal comfort conditions at the summer.

The square has four entrances, where can be placed steps for easy access to the visitors and ramps for easy and safety movement of the people with specific needs. The entrances would be bordered by rosemary (posmarinus offisinalis), a decorative, endemic, fragrant, flowering and evergreen plant. Each entrance will be connected by paved road with the others and with other spaces (small lake) and station points (kiosk, pergola).

For the paved roads can be used slate plates, colored gray, so as the surface temperature during the summer to be close to the air temperature. They placed on the ground with planting joints, so as to facilitate the water penetration and enrich the groundwater outlet.

In the center of the square, it can be created a small lake, which will contribute to the cooling. The lake, the trees, the climbing plants and the shadowing systems will create a pleasure environment. Around of the water surface, will be paved area with pergolas and benches. At the pergola's base will be planted climbing plants for moreover shadowing and cooling.

In the area following the paved region, will be placed gravel and will be planted appropriate plants such as formio, asplenio, alchemillia, agiougka and vempasko. The gravel is beneficial for these planting species.

The water surface enhances the cooling of an area because of the increasing evaporation. Also, the water has low reflectivity, until 30% in the period of maximum solar radiation, and high absorption which can reaches the amount of 90%. The absorption enhances, also, the evaporation from the water surface. As a consequence the air temperature is lower and the comfort conditions are better.

Radially around the water surface will be created small islands of green and will be planted pitosporos, effovia, choizia, holly, hibiscus and voutleia and around these will be planted in lower growth Hypericum, eleagkos, thorns, Selo, Ververidis, Lavender, Helichrysum. In North and Northwest side of the square will be planted evergreen shrubs so that they inhibited westerly winds. In particular, they will be planted laurel, taxos and Viburnum. These shrubs are fast developing, has high resistance to frost and wind and offer wind protection in the area. Along the west side will be planted maple and sycamore trees for shadowing during the summer months.

In the South-Eastern border line of the square will be location with a wooden trellis (pergola) and climbing plants (honeysuckle, jasmine) will be planted. So, at the summer their rich foliage will shadow the area under the trellis and will facilitate the stay of visitors. North-East will be planted deciduous (trees, maple). Their dense foliage provides protection from solar radiation during summer period, while allows south winds to flow through openings beneath the foliage and to create conditions of cooling. In winter the free trees by their leaves allowing the desired insolation in the square.

Finally, on the rest of the square's surface can be planted turf, and especially a mixture of Festuca arundinacea and Paspalum vaginatatum. This mixture has very drought resistant and withstands both in cold and in high temperatures. Also, it bears the shade and soil salinity, it has increased resistance to the touch of footfall and does not require maintenance.

The aim of this design proposal is the yearly contribution of plants in the area of square. Focusing on the plants properties (evergreen, deciduous, with a booming, low or high growth), the proposal try to create groups of plants with changing colors and shapes (like the color of flowers or autumn foliage in spring colors). The desirable result will be satisfactory in both summer and winter.

On the North-East side of the square there is a fountain which will be reformed, in order to be better integrated in the overall rehabilitation of the square.

In the square will be installed system of lighting, irrigation, water supplying with drinking water and a small network of channels below ground, where will be collected rainwater in a cistern for watering the plants. The system for collecting rainwater will be installed across the square. It is recommended to use sprayers that will be hidden (Pomp up), so when it is not in use to avoid destructions, and to activate during night hours. Finally, it is proposed a stone fountain with potable water to meet the needs of visitors.

Figure 5: Proposal for the area Doltso

3.2 Rehabilitation of pedestrian 'Ipirou' in Kastoria

The shadowing conditions are imprinted in the Figure 6, for the winter and summer season.

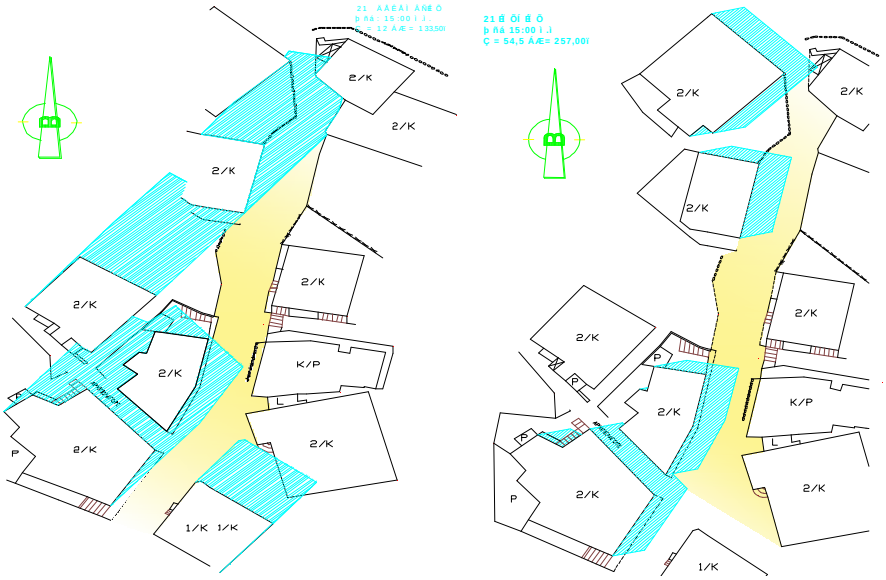

Figure 6: Shadowing of pedestrian Ipirou during the a) Winter and b) Summer period

The road in which refers the proposal is at the old town of Kastoria and it is on the northwest side of the square Doltso. The Street Ipirou has north-south direction, continues with east-west direction and is used both for passing cars and pedestrians. It is encrusted with slate and converted into a pedestrian zone, so as to be safety and comfort for a visitor to browse by foot in the old town. In the north-south road the thermal comfort conditions are satisfactory, while the ratio "Height of buildings/ Width of road', H/W is H/W=6/6=1. Unfortunately, it is observed lack of green spaces. In order to improve the thermal comfort conditions, it is suggested to be created green islands, along the road, in its middle, close to the halfway. At the one side, it will be left place of 3m width for moving emergency vehicles (ambulance, fire). Also, pitosporos-tree and stone parterres with flowers can be placed. The flowers can be medium or low growth, multi-annual, such as oleander, viburnum, boxwood, sedo, noon, pansies, salwa. The selection of evergreen – deciduous plants aims to have shadow during the summer and adequate solar radiation during the winter. Among the parterres, can be placed wooden pergolas with climbing plants (ampelopsi, ivy, honeysuckle, jasmine), which will facilitate the station of pedestrians.

The climbing plants shade and decorate the paths. They are on slight structural elements by wood, in order to comply with the local traditional architecture. Along the pedestrian area and under the pergolas, there will be seats to facilitate station and relaxing of the walkers.

Also, in appropriate points, across the old city, it will be built fountains with drinking water. The fountains contribute to the aesthetic and morphological character of the city.

The existing paved with slate is satisfactory, compatible with the traditional character of the old city and with sufficient thermal behavior. Nevertheless, it is placed in a way that creates tightness conditions and blocks the inflow of water in the aquifer. In order to improve the conditions at the paved area is proposed:

- Repositioning of plates with dry mounting, so as to be created joints and to be growth vegetation growth in the gaps or
- Placing of aged blocks for developing herbaceous vegetation in joints

The East-West direction road is exposed to sunlight throughout the day, without any shadowing; due to the orientation and lack of vegetation. So, it is suggested to be similar

interventions with the south-north road. Specifically, it will be placed more pergolas and dense scrubs, deciduous or evergreen. The dense scrubs ensure better thermal comfort conditions during the summer, while in the winter allow the impingement of solar radiation.

The main wind direction is north from the September until April. The planting of trees along the East-West direction road reduces the possibility of creation urban canyons, as the trees intercept the air flow.

Also, new lighting systems will be placed along the road to achieve satisfactory conditions of lighting. The lamps which are suggested to be used are low energy consumption.

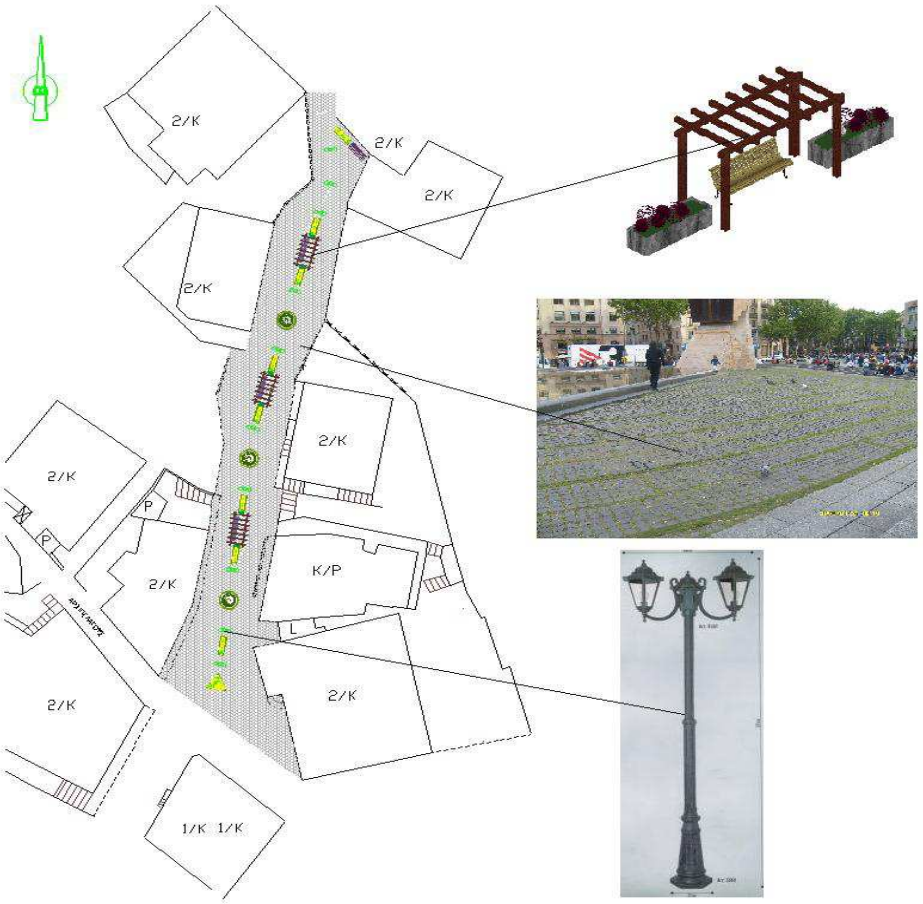

Figure 7: The proposal for the area Ipirou

3.3 Evaluation of the proposed interventions

A. Quality benefits

- The interventions to existing open spaces in Kastoria enhance the environmental, social and aesthetic value of the city. Also, they improve the thermal, acoustic and visual comfort conditions.
- The shadow-insulation systems in the outdoors improve significantly the life quality of residents. These areas will be accessible every time during the day and all the seasons.
- The replacement of previous covered materials with other more environmental friendly increases the steeping and aerating of the soil, reduces water runoff, enhances the underground aquifer and reduces dazzle.
- The creation of new parking spaces improves the traffic conditions.

- The interventions in the open spaces improve the microclimatic conditions at the external environment of the city and also effect positively in the conditions inside the buildings.
- The traffic interventions in the Old Centre and the conversion into pedestrian areas prevent the anchor moves in the region and facilitate the pedestrians.

B. Quantitative benefits

B1. Index of surface soil temperature

The maximum temperature of an external roof surface is given by the equation (Lawrence Berkley Laboratory):

$$\mathbf{T_{smax} = T_{amax} + [(1-r) \times I_o - T_{sky} \times h_r] / (h_c + h_r)} \quad \mathbf{(1)}$$

where:

T_{smax}: the maximum temperature of the external surface of the roof in ºC (and in this case the goal - maximum surface temperature of the square)

T_{amax}: the maximum air temperature in ºC

r: the reflectivity of the external surface of the roof (the square)

I_o: the intensity of incident solar radiation per unit area of roof in W/m^2

T_{sky}: the temperature of the sky (for simplicity is taken equal to [T_{amax} - 10]) in ºC

h_r: the coefficient of thermal transition radiation through the external surface. It is equal to the product of thermal emission e (the ability of a surface to impart heat by longwave radiation) for 6,1 W/m^2K which is the corresponding coefficient of a black body in W/m2K.

h_c: the coefficient of thermal transition by transfer, equal to 12.4 W/m^2K

By applying the above equation in the rehabilitation areas, it is calculated that:

Index of surface soil temperature			
Rehabilitation areas	***Existing situation (ºC)***	***After the proposal (ºC)***	***Temperature difference (ºC)***
Square of Doltso	63,05	61,7	1,58
Pedestrian Ipirou	63,66	60,83	2,83
Courtyard of school	72,04	58,24	13,80

Table 2: Comparison of surface temperature index before and after rehabilitation

B2. Index of thermal comfort (ASV)

Index of thermal comfort (ASV, Actual Sensation Vote)-Amount of satisfactory people

$$\mathbf{ASV = 0,036 Tair\_met + 0,0013 Sol\_met – 0,038 V\_met + 0,011 RH\_met – 2,197}$$

Tair_met: the air temperature by taking the mean maximum air temperature for July (the warmest months of the year) = $29,4^0$C

Sol_met: the total solar radiation (taking the worst-case = 1000 Wm-2)

V_met: wind speed m.sec-1, taken still air = 0,50 m/sec

RH_met: relative humidity = 41.5

Based on this index, we have the following diagrams

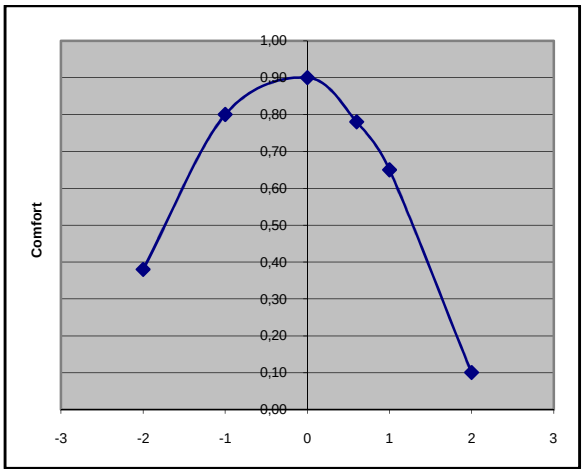

Figure 8: Index of thermal comfort-Summer

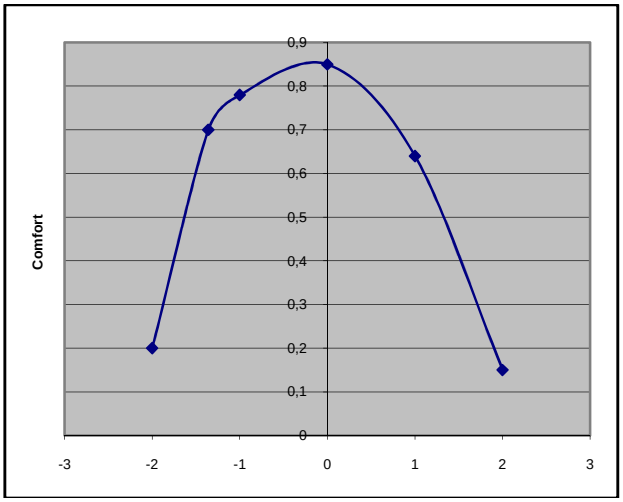

Figure 9: Index of thermal comfort-Winter

Index of thermal comfort (ASV)			
Season	***Existing situation***	***After the proposal***	***Difference between the amount of satisfactory people***
Summer	0,60 → 78%	-0,46 → 90%	12%
Winter	-1,36 → 70%	-1,25 → 75%	5%

Table 3: Comparison of thermal comfort index (ASV) before and after renovation of the area

4. Conclusion

In conclusion, the application of Bioclimatic principles and the principles of Environmental Design at the proposals for intervention in the central open spaces of the city of Kastoria, have hopefully achieved to prove that they contribute to the following:

- The creation of favorable microclimatic conditions for the residents and the visitors in Kastoria city.
- The percentage increasing of green, the improvement of street traffic, the creation of pedestrian roads, the planting of open spaces and the creation of new parking stations.

- The upgrading of environmental, social, functional and aesthetic value of existing public spaces.
- The encouraging of pedestrians to move through green paths.
- The removal of transversal movements.
- The minimization of noise problems.
- The creation of thermal, visual and acoustic comfort conditions in the urban environment.

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